Understanding Climate Change Impacts in Relation to Wellbeing for Nova Scotia

Final Synthesis Report

February 2022

Prepared for Nova Scotia Environment and Climate Change

ESSA

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Client Contact:
Satya Ramen
Suite 2085, 1903 Barrington St., Halifax, NS
Satya.Ramen@novascotia.ca

ESSA Contact:
Jimena Eyzaguirre
ESSA Technologies Ltd.
2695 Granville St. #600
Vancouver, BC V6H 3H4
(604) 733.2996

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ESSA Technologies Ltd.
Vancouver, BC Canada V6H 3H4
www.essa.com

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Glossary of Terms

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 (IPCC 2022).
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 (IPCC 2014b, 2018). 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 hazard	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 (c.f. IPCC 2014b, 2018).
Climate-related impact	A climatic event or trend that may have an impact on wellbeing. 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.
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 (IPCC 2014b, 2018) 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 (Jones et al. 2015).
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) (Jones et al. 2015). This movement moderates the supply of services from which people derive wellbeing. 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).
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 (Jones et al. 2016).

Manufactured capital	Manufactured assets, such as roads, vehicles, houses, machinery (Jones et al. 2015) that are built from inputs of materials (natural capital) using energy, labour, and production technologies that rely on human and financial capital (Maack & Davidsdottir 2015).
Natural capital	The stock of physical assets in the environment, the processes from which humans obtain benefits (Jones et al. 2015) 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.
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 wellbeing, 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 (IPCC 2014b, 2018).
Sensitivity (to climate hazards)	The degree to which a system is affected, either adversely or beneficially, by climate variability or change (IPCC 2014b, 2018). The term refers to the susceptibility of natural capital, manufactured capital, people, etc. to adverse or beneficial effects when exposed to a climate impacts. 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 (Jones et al. 2016). Examples of social capital in action include civic engagement, volunteerism, political engagement, club affiliations, family stability, trust for institutions (Maack & Davidsdottir 2015). 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 (WHO 2011).
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)
Wellbeing	Wellbeing 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 wellbeing is derived in the present and from which long-term sustainable wellbeing is derived for the future.

Vulnerability

The propensity or predisposition of exposed elements such as human beings, their livelihoods, and assets, as well as natural systems, to suffer adverse effects when impacted by hazards. Vulnerability to climate change is directly related to the susceptibility, sensitivity, and lack of resilience or capacities of the exposed system to cope with and adapt to extremes and non-extremes (SREX IPCC 2012, IPCC 2018).'

Executive Summary

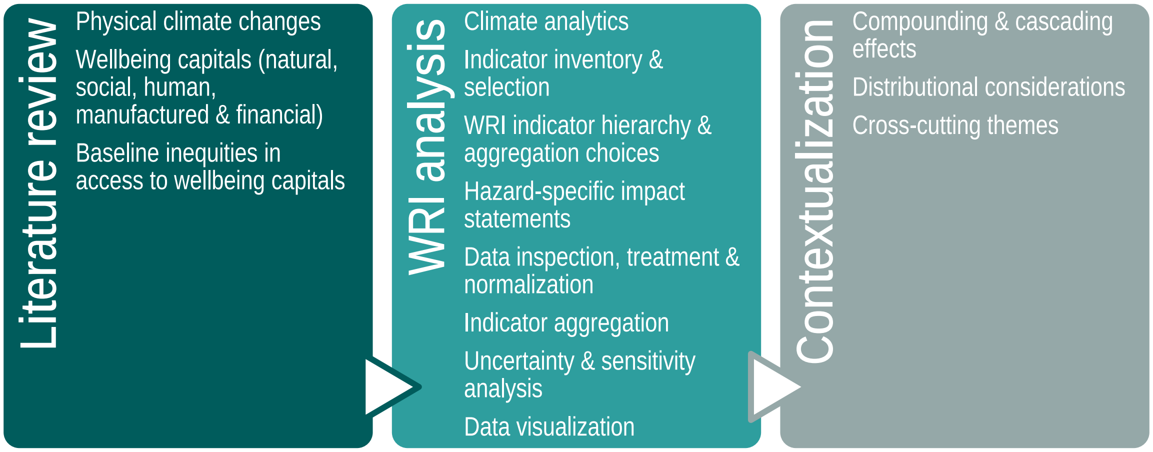
Introduction

Climate change and related hazards like drought, extreme storms, severe rainfall, and high temperatures will increase risks to Nova Scotians, affecting people's ability to live a good life. Climate change may also bring benefits, such as the potential for enhanced food production in a lengthened growing season, but capturing these benefits takes foresight and focused effort. The vulnerability of human populations to climate hazards and ability to capture opportunities are not distributed evenly. Individuals and communities facing systemic inequities, such as racialized and marginalized groups, tend to be more vulnerable to the impacts of climate change. In addition, many human pursuits that are intended to increase our short-term stocks of wellbeing can weaken our long-term resilience by, for example, degrading environmental conditions. Effective, efficient, and equitable climate change adaptation involves understanding what capital stocks and goods and service flows are at risk, where and to what extent, as well as where and how losses and disruptions are most likely to affect people's lives and wellbeing.

This study implements a "well-being at risk index" (WRI) to clarify relationships between climate change impacts and associated risks to the wellbeing of Nova Scotians. It does this using a suite of wellbeing indicators combined with regionally-downscaled climate indices to develop a spatially-explicit assessment of areas most at risk of loss and disruption to key determinants of wellbeing. This study is one input into a broader climate change risk assessment that the province of Nova Scotia is undertaking. There is no universally-accepted definition for human wellbeing. For the purpose of this report wellbeing has been defined by the province of Nova Scotia to characterize "how we are doing" as individuals, households and communities.

Approach

The province engaged ESSA Technologies Ltd. (ESSA) to undertake this study, which we completed between November 2021 and February 2022. The study involved literature reviews and quantitative analysis, with key research activities summarized in the diagram below.



For the WRI analysis specifically, we used a composite index (the WRI) to evaluate how census divisions (CDs) of Nova Scotia differ in terms of relative consequences for wellbeing from climate change. The WRI adopts a hierarchical structure, with four sub-indices (Climate Impacts, Exposure, Sensitivity and Low Coping Capacity), five pillars (one each for the five capitals), 14 sub-pillars (to capture key dimensions of wellbeing), and numerous indicators. Climate projections for three future timeframes under two global emissions pathways (RCP4.5 and RCP8.5) were used to develop 51 indicators to populate the Climate Impact Sub-index, with uncertainty in the projections captured using the 5th and 95th percentile values. A total of 175 indicators were researched and constructed for the Exposure, Sensitivity and Low Coping Capacity Sub-indices. Nineteen individual climate-related impacts and corresponding impact statements were defined (e.g., drought, fluvial flooding, sea-level rise and coastal flooding, vector-borne diseases, and wildfire). Impact statements determined which specific indicators to include in the WRI across all sub-indices.

Nova Scotia's changing climate

Based on observed historical data, climate change is already impacting Nova Scotia and the impacts are projected to increase over the coming decades. Compared to 1981-2010 levels based on RCP8.5 (high emissions scenario), Nova Scotians can expect an average mean annual temperature increase of up to 4.5°C by 2065-2095, an increase in the length of the growing season, a decrease in days requiring indoor heating, and an increase in days requiring indoor cooling. The frequency of extreme hot days and heatwaves are projected to increase, while extreme cold days and cold waves are expected to decrease.

Precipitation is projected to increase province-wide, especially in winter, but snowfall as a proportion of total precipitation will decrease. The wettest season will shift from fall to winter. Extreme rainfall events will become more intense.

The province will experience increased storm activity (e.g., Hurricane Juan) and heavier rainfall, with the extent of flooding from storm surges dependent partly on the slopes of coastal lands. Under RCP8.5, sea level rise is expected to increase 68 – 100cm by 2100, with the highest increases projected along the Atlantic seaboard, especially around Cape Breton and Halifax. Nova Scotia has already experienced changes in ocean conditions, including increased ocean temperatures and ocean acidification, decreased marine oxygen levels, and algal blooms. These changes are expected to continue.

Climate change and wellbeing capitals

The wellbeing of Nova Scotians can be regarded in terms of people’s access to five “capitals”: natural capital (nature’s benefits), social capital (safe communities and healthy relationships), human capital (fulfilling livelihoods, educational opportunities, and physical and mental health), financial capital (economic stability), and manufactured capital (supportive infrastructure and homes). These capitals comprise both stocks and flows, the amounts and quality of which can degrade or improve human wellbeing. The impacts of climate change interact with wellbeing capitals in multiple ways, as illustrated in the table below.

Definition	Relationship to wellbeing	Example stocks	Example flows from the stock
Natural Capital			
The stock of physical assets in the environment and the processes from which humans obtain benefits and that sustain life on the planet.	Access to nature’s benefits	Area of wetlands Forested land Parks	Moderated rates of freshwater pollution Harvestable volumes of timber
Examples of climate change interactions: ↓ seasonal availability and quality of freshwater; ↑ in forest disturbances; Δ species ranges, composition, and primary productivity; ↓ air quality from smog and wildfire smoke affecting health; ↑ risk of flood waters breaching green and grey coastal protection			
Social Capital			
The stock of contacts, trust, reciprocity, and mutual understanding associated with social networks. Social capital can be eroded by inequitable distribution of other capitals.	Safe communities with trusted institutions and relationships	Trust in institutions Social networks Civic engagement	Crime rates
Examples of climate change interactions: ↓ feelings of personal safety; ↑ difficulty providing aid to those in need following climate-related disasters; ↑ inequities in distribution of climate change risk among individuals and communities; ↑ motivation to take collective action			
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 health.	Healthy, fulfilling lives with opportunities to learn, contribute and play	Working population Skills/expertise	Rates of volunteerism Rates of chronic disease and premature mortality
Examples of climate change interactions: ↓ mental and physical wellbeing; Δ in food and water security; ↓ engagement in cultural, spiritual, ceremonial and subsistence practices; ↓ access to health services; worse impacts for people with underlying health conditions, who already face barriers to affordable housing, food and water security, healthcare, and emergency response services			
Financial Capital			
Money that facilitates the interaction of other forms of capital by funding the activities that might be required for the services to be acquired, realized, managed, or improved.	Economic security and living standards	Net financial assets (e.g., stocks, bonds, cash)	Trade with other regions Investment levels
Examples of climate change interactions: ↑ disturbances to resource-based industries, with implications for production and income; ↑ pressure on the fishing industry from reduced quality and quantity of valuable marine species; ↑ pressure on forestry due to droughts, fires, insect outbreaks, and shifts in species distributions; ↑ length of growing seasons combined with increased business risk from extreme events; ↑ risk of business interruption for local retail outlets and services (e.g., tourism-related services)			
Manufactured Capital			
Manufactured assets, such as roads, vehicles, houses, machinery that are built from inputs of materials (natural capital) using energy, labour, and production technologies that rely on human and financial capital	Good homes, the provision of goods and services, and supportive infrastructure	Supply of housing Road network Power stations Public transit fleet	Rates of transit use Electricity use Potable water consumption
Examples of climate change interactions: ↑ loss and damage to homes, workplaces, critical infrastructure, and equipment; ↑ attention to disaster recovery, infrastructure hardening and ongoing maintenance; ↑ consideration of physical relocation of structures and entire communities in at risk zones			

How Nova Scotians experience and react to a changing climate depends on their socio-economic context. Colonialism, neocolonialism, racism, sexism, ageism, poverty, ableism, and intergenerational trauma are among the forces shaping the lives of African Nova Scotians, Mi'kmaq, racialized peoples, immigrants, individuals living on low incomes, individuals living with disabilities, older adults, youth, and women, with particularly impactful influences on those living at the intersection of these different experiences. Importantly, social and economic contexts influence the geographic location of people and physical assets as well as people's access to wellbeing capitals. The table below offers examples of several factors that illustrate the importance of wellbeing capitals and how structural barriers for individuals and communities affect how they access and enjoy them. The examples below include some intersectionality considerations, and it is important to remember that each capital affects the others; they are not independent. These patterns come into play in how impacts from climate change are felt from person to person, and community to community; they will also shape people's ability to successfully adapt to a changing climate. Illuminating such patterns and their causes should inform climate change risk assessments and the development and implementation of adaptation policies and programs. Indeed, a robust approach to sustainable adaptation tackles the root causes of climate change vulnerability.

	Natural Capital	Social Capital	Human Capital	Financial Capital	Manufactured Capital
Mi'kmaq	• Mi'kmaq historically settled along coasts and estuaries, with waterways serving as transportation corridors and food sources • Suffered land dispossession and loss of freedom to move • Salt marshes support cultural identity	• Holistic concept of safety • Overrepresentation in the justice system • Legacy of colonial violence, including loss of language, traditional livelihoods, & the right to practice traditional ceremonies	• Understandings of a good life and health combine mental, physical, emotional, cultural, and spiritual dimensions • Dominant narratives fail to recognize agency of Mi'kmaw communities • Barriers to health care and educational attainment	• Higher rates of poverty, as measured by material deprivation • Higher unemployment rates and significant wage gaps	• Higher rates of living in housing in need of repair
African Nova Scotians	• Siting of toxic and polluting industries near Black communities • Heritage site of Africville threatened by sea level rise	• Anti-black racism experienced as part of daily life • Reduced access to social services • Legacies of intergenerational trauma	• Lack of Afrocentric learning, underrepresentation in education system • Over 3 times more likely to be food insecure than white families	• Wage gap and higher rates of poverty	• Limitations to public infrastructure, e.g., access to transportation options, clean drinking water
Youth		• Rural youth have lower access to services • Influenced by social norms of what is high quality of life in rural communities	• Use of food banks across campuses, food insecurity Rural youth have higher levels of stress and health issues • Rural youth have less access to educational opportunities	• Student indebtedness for post-secondary education • Rural youth have higher levels of poverty, less access to employment	• Rural youth have less access to recreational facilities, transportation options
Older Adults		• Negative age stereotypes affect social participation • Issues of elder abuse and neglect • Ageist and ableist assumptions related to vulnerability undermine confidence, dignity & independence	• Fastest-growing age group • Negative age stereotypes affect health care access & outcomes • Access to information and social contact in the digital age	• Many seniors fall into low-income category	• Older adults often face limited options for adequate, quality housing and long-term care

	Natural Capital	Social Capital	Human Capital	Financial Capital	Manufactured Capital
		• Rural areas can be service-poor for older adults			
Poverty / Income Inequality	• Less access to green spaces and parks	• Stigma associated with poverty contributes to physical and social marginalization • Disenfranchisement and experience of powerlessness and low status with decision-makers • Challenges with social and health care access • Can compromise personal safety and security	• Education levels are lower in rural areas • Access to nutritious and healthy food is a challenge • Childhood poverty affects child development, school readiness, educational & health outcomes • Childhood poverty linked to women's poverty • Unpaid caregiving is more common for women	• Rural areas have higher rates of poverty than urban	• Housing quality is lower in rural areas • Lower transportation access and options • Less access to recreational facilities
Disabilities		• 2 to 3 times as likely to have unmet health care needs • Poorer quality health care and less access to preventative care by women • Women are more likely than not to experience intimate partner violence	• Systemic and institutional barriers to education, increased risk of bullying and exclusion by peers	• More likely to be employed in low skill or precarious jobs • Twice as likely to live below the poverty line • Face higher costs of living	
Immigrants			• University degrees, accreditations, work experience from elsewhere devalued • Immigrant racialized youth face challenging education experiences (e.g., exclusion) • Challenges navigating health services can compromise health outcomes	• Employer discrimination against accented English channels immigrants to survival jobs, particularly women of colour • Recent immigrants have twice the unemployment rate as Canada born • Racialized immigrants face largest wealth gaps	

Results from the Wellbeing-at-Risk Analysis

- To facilitate interpretation, we present results for four climate impact categories based on whether impacts are expected to improve (be beneficial to) or deteriorate (adversely affect) wellbeing and whether impacts are expected to increase or decrease over time.
- Eleven drivers of climate impacts are “increasingly adverse”: Drought; Pluvial Flooding; Fluvial Flooding; Heat extreme – agriculture; Heat extreme – ecosystems; Heat extreme – human health; Heat extreme – transportation infrastructure; Cooling demand; Agriculture pests & diseases; Shifting ecoregions; Vector-borne diseases; Sea-level rise & coastal flooding; and Wildfire.
- Three drivers of climate impact are “decreasingly adverse”: Heating demand; Heavy snow; Freeze-thaw cycles.
- Two drivers of climate impact are “increasingly beneficial”: Growing season; Summer tourism & recreation. One driver of climate impact is “decreasingly beneficial”: Winter tourism & recreation.

<u>Wellbeing deteriorating impacts from climate change</u>

For median projections (50th percentile) under **RCP 8.5**:

- Pluvial and fluvial flooding are the two climate hazards of greatest concern by the **2030s** in that they present the most potential adverse consequences for wellbeing because of climate change. Compared to other hazards, there are more regions of the province with relatively higher levels of sensitivity to both forms of flooding, and relatively lower levels of coping capacity. Exposure scores for both forms of flooding are also relatively high across CDs and climate impact scores are 4^{th} and 1^{st} highest. Digby, Annapolis, Pictou, Colchester, and Halifax are most vulnerable. Pluvial flooding is the highest rated climate hazard by 2030s; wellbeing dimensions that most drive results include exposed agricultural land (natural capital), sensitive wetlands (natural capital) and social support & sense of belonging as part of low coping capacity (social capital).
- By **2050s** fluvial flooding remains a high priority climate hazard. However, pluvial flooding moves down in relative importance and wildfire becomes the highest-rated climate hazard, with large projected increase in fire weather and the lowest coping capacity across the province. Wellbeing dimensions that most drive results include exposed tree area (natural capital), sensitive population density (human capital) and social support & sense of belonging as part of low coping capacity (social capital). Digby, Shelburne, Pictou and Cumberland are most vulnerable.
- By **2080s** climate-related impacts driven by high temperatures rise to the top and include extreme heat (for agriculture), extreme heat (for transportation infrastructure), increased cooling demand (for buildings), and extreme heat (for ecosystems). By 2080s, the top-rated climate hazard is heat extremes for agriculture. There are more regions of the province where the impact of climate change on extreme heat for agriculture presents relatively more risk to wellbeing than the other hazards. Digby, Annapolis, Cumberland, and Guysborough are most vulnerable. For extreme heat (for agriculture) wellbeing dimensions that most drive results include exposed agricultural land (natural capital), sensitive affordable foods (financial security) and social support & sense of belonging as part of low coping capacity (social capital).
- The biggest threat to wellbeing across the majority of Nova Scotia by 2080s arises from projected increases in surface air temperatures, and in particular extremes.

For median projections (50th percentile) under **RCP 4.5**:

- In comparison to RCP8.5, pluvial and fluvial flooding remain among the top-rated climate hazards through to the 2080s. These hazards present more potential adverse consequences for more regions in the province.
- Sea levels are expected to rise less under RCP4.5 compared with RCP8.5. However, in relative terms, the risks to wellbeing from sea level rise (SLR) and coastal flooding become more consequential under RCP4.5 by 2080s when compared with other climate impact drivers.
- Heat extremes for agriculture remains among the top-related climate hazards by 2080s but other heat-related hazards become less consequential. Fire weather and wildfire are less important as drivers of wellbeing loss under RCP4.5 compared to RCP8.5
- Under RCP4.5 the biggest threats to wellbeing across the majority of Nova Scotia by 2080s arise from a mix of temperature and precipitation.

Wellbeing improving impacts from climate change

For median projections (50th percentile) under **RCP 8.5**:

- By **2030s**, within the type of impacts with **beneficial consequences expected to increase**, extended growing season is the climate-related impact with the potential to bring the largest benefits to wellbeing. Relative to extended summer recreation and tourism season, more regions of the province have high levels of exposed capitals and the coping capacity in place to take advantage of the opportunity afforded by a longer growing season. Halifax, Lunenberg, and Cape Breton are the most exposed CDs, with Kings, Hants, Antigonish, and Cumberland presenting most coping capacity in relative terms.
- For **all three time periods**, more regions are expected to experience larger changes in the climate drivers for a longer growing season compared to summer tourism & recreation. Wellbeing dimensions that most drive results include exposed agricultural land (natural capital), sensitive affordable foods (financial capital) and unemployment rate as part of coping capacity (financial capital).
- By **2030s**, within the type of impacts with **negative consequences expected to decrease**, heating demand is the climate-related impact with the potential to bring the largest benefits to wellbeing. Relative to freeze-thaw cycles and heavy snowfall, heating demand has both the highest exposure and vulnerability scores. The capitals exposed to heating demand (requiring heating) are also the most sensitive compared to those exposed to heavy snowfall or freeze-thaw cycles. Halifax, Pictou, Colchester, and Kings are the most exposed CDs. Digby, Cumberland, Queens, and Victoria are the most sensitive.
- Heating demand remains the top-rated decreasing adverse impact **to the end of the century**, although the relative benefits anticipated decline over time. Wellbeing dimensions that most drive results include exposed buildings (manufactured capital), sensitive dwellings in major need of repairs (manufactured capital) and social support & sense of belonging as part of low coping capacity (social capital).

For median projections (50th percentile) under **RCP 4.5** there are no differences in priorities that emerge under RCP 4.5 relative to RCP 8.5.

Cross-cutting themes – top-down approach

We reviewed the relative rankings for each CD based on aggregate scores for the WRI and each Sub-index (i.e., climate impact, exposure, sensitivity, and low coping capacity), for each category of impact, based on the sum of WRI scores in 2030s, 2050s, and 2080s). For median projections (50th percentile) under RCP 8.5:

- Halifax, Cumberland, Cape Breton, and Colchester are among the top five CDs for both positive impact types (decreasing-adverse & increasing-beneficial). Halifax, Cumberland, and Pictou are among the top five CDs for both negative impact types (increasing-adverse & decreasing beneficial) and Pictou. The table below identifies top-rated CDs by category of climate impact.

	Predominantly Adverse	Predominantly Beneficial
Increasing	Cumberland Halifax Digby Annapolis Pictou	Halifax Kings Cumberland Colchester Cape Breton
Decreasing	Cumberland Halifax Pictou Cape Breton Colchester	Halifax Hants Lunenburg Cumberland Pictou

- Another way to view this is that these CDs are the regions most impacted by climate hazards should they occur today, reflecting a need for adaptation. Determinants of exposure, sensitivity, and low coping capacity contributing to the current adaptation need should be addressed as a priority to both reduce current and future risks to wellbeing. This study provides detailed results at the CD level on underlying elements of wellbeing that may be most influential in determining relative risks from climate change.
- Wellbeing dimensions that most drive results for *increasing adverse outcomes* attributable to climate change are exposure of food (natural capital) in Halifax, perceived mental health as a sensitivity (human capital) in Cumberland and democratic engagement (social capital) contributing most to low coping capacity in Digby.
- Wellbeing dimensions that most drive results for *decreasing beneficial outcomes* attributable to climate change are exposure of residents (human capital) in Halifax, recreation & leisure as a sensitivity (natural capital) in Hants and internet reliability (manufactured capital) contributing most to low coping capacity in Guysborough.
- Wellbeing dimensions that most drive results for *decreasing adverse outcomes* attributable to climate change are exposure of housing (manufactured capital) in Halifax, perceived mental health as a sensitivity (human capital) in Cumberland and discrimination (social capital) contributing most to low coping capacity in Digby.
- Wellbeing dimensions that most drive results for *increasing beneficial outcomes* attributable to climate change are exposure of residents (human capital) in Halifax, food as a sensitivity (natural capital) in Kings and educational attainment and education quality (human capital) contributing most to low coping capacity in Antigonish.

Cross-cutting themes – bottom-up approach

The preceding analysis is based on all climate-related impacts and all regions of the province – i.e., taking a top-down perspective considering the full distribution of estimated WRI results. We also undertook a bottom-up analysis that considers similarities across CDs – specifically, the number of times the same result is found across all CDs.

The list of top ranked CDs using the bottom-up approach is almost identical to that derived from the top-down approach. The one exception is that Cape Breton (in the bottom-up approach) is included under predominantly beneficial impacts instead of Pictou (in the top-down approach).

The following series of tables identifies the top-ranked climate impact and associated CDs for each of the four impact categories, for both 2030s and 2080s.

- In the earlier part of the century, several CDs 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 early part of the century, more CDs will experience less heating demand and freeze-thaw cycles than heavy snow. By the 2080s reduced heating demand will be less important than reduced freeze thaw cycles for more CDs.
- A lengthened growing season is more important than summer tourism & recreation in providing increasing beneficial impacts to wellbeing for more CDs.

Increasing adverse climate impacts most frequently ranked 1st, 2nd, and 3rd highest by a Census Division (across all 18 CDs)				
Impact Rank	Impacts in 2030s (#CDs)	Associated Census Divisions	Impacts in 2080s (#CDs)	Associated Census Divisions
1st	Heat extreme – agriculture (4)	Annapolis, Cumberland, Hants, Kings	Heat extreme – agriculture (4)	Annapolis, Antigonish, Cumberland, Kings
2nd	Shifting ecoregions (5)	Annapolis, Guysborough, Halifax, Queens, Victoria	Agriculture pests & diseases (3)	Digby, Queens, Victoria
			Fluvial flooding (3)	Halifax, Lunenburg, Richmond
3rd	Pluvial flooding (4)	Colchester, Kings, Pictou, Yarmouth	Heat extreme – human health (3)	Colchester, Hants, Pictou
Decreasing adverse climate impacts most frequently ranked highest by a Census Division (across all 18 CDs)				
Impact Rank	Impacts in 2030s (#CDs)	Associated Census Divisions	Impacts in 2080s (#CDs)	Associated Census Divisions
1st	Heating demand (8)	Digby, Guysborough, Lunenburg, Pictou, Queens, Richmond, Victoria	Freeze-thaw cycles (9)	Antigonish, Cape Breton, Cumberland, Halifax, Hants, Inverness, Kings, Pictou, Victoria
	Freeze-thaw cycles (6)	Antigonish, Cape Breton, Cumberland, Halifax, Hants, Kings	Heating demand (6)	Annapolis, Colchester, Digby, Lunenburg, Queens, Richmond
Increasing beneficial climate impacts most frequently ranked highest by a Census Division (across all 18 CDs)				
Impact Rank*	Impacts in 2030s (#CDs)	Associated Census Divisions	Impacts in 2080s (#CDs)	Associated Census Divisions
1st	Growing season (11)	Annapolis, Cumberland, Digby, Guysborough, Kings, Lunenburg, Pictou, Queens,	Growing season (11)	Annapolis, Cumberland, Digby, Guysborough, Kings, Lunenburg,

		Richmond, Shelburne, Yarmouth		Pictou, Queens, Richmond, Shelburne, Yarmouth
Decreasing beneficial climate impacts most frequently ranked highest by a Census Division (across all 18 CDs)				
Impact Rank*	Impacts in 2030s (#CDs)	Associated Census Divisions	Impacts in 2080s (#CDs)	Associated Census Divisions
1st	Winter tourism & recreation (18)	All	Winter tourism & recreation (18)	All

Results of our exploration of the most influential wellbeing dimensions by sub-pillar associated with increasing adverse impacts most frequently ranked 1st by a CD are summarized in the following table. These results show that:

- Natural Capital, particularly Provisioning Services, is most exposed to the top climate impacts in both the early part of the century and the latter part. Manufactured Capital, particularly Buildings, is most exposed to cooling demand in the early part of the century, although cooling demand is no longer a top climate impact by the 2080s. Provisioning and Regulating Services as well as Habitat & Biodiversity are the types of Natural Capital that will also become associated with top climate impacts in the latter part of the century.
- Financial and Human Capital contribute more sensitivity than other capitals to the top climate impacts in the early part of the century, through the Economy, Financial Security, and Health. In the latter part of the century, Natural Capital's contribution to sensitivity increases, linked to Habitat & Biodiversity and Regulating Services.
- Social Capital, via Personal Safety & Security and Relationships, will be a top contributor to low coping capacity to heat extremes-agriculture across both periods. Manufactured and Natural Capital will also play a role in the first part of the century and Manufactured Capital will become a more frequent top contributor to low coping capacity in the last part of the century.
- Lack of capacity to deal with cooling demand in the early part of the century will be driven by Personal Safety & Security. Lack of capacity to cope with extreme heat affecting ecosystems by 2080s will be driven by the Infrastructure and Economy. Lack of capacity to cope with shifting ecoregions by 2080s will be driven by the Economy, Knowledge & Skills, and Personal Safety & Security, corresponding to Financial and Social Capitals.

Most influential wellbeing-dimensions by Sub-index associated with *increasing adverse impacts* most frequently ranked 1st by a CD (unweighted)				
Impact Rank*	Impacts in 2030s (#CDs)	Most influential Sub-pillar (#CDs)	Impacts in 2080s (#CDs)	Most influential Sub-pillar (#CDs)
1st	Heat extreme – agriculture (4)	**Exposure:** Provisioning Services (4) **Sensitivity:** Economy (3); Financial Security (1) **Lack of Coping Capacity:** Infrastructure (1); Personal Safety & Security (1); Relationships (2)	Heat extreme – agriculture (4)	**Exposure:** Provisioning Services (4) **Sensitivity:** Economy (3); Financial Security (1) **Lack of Coping Capacity:** Infrastructure (1); Personal Safety & Security (2); Relationships (1)
	Cooling demand (3)	**Exposure:** Buildings (3) **Sensitivity:** Financial Security (1); Health (2) **Lack of Coping Capacity:** Personal Safety & Security (3); Provisioning Services (1)	Heat extreme – ecosystems (3)	**Exposure:** Provisioning Services (2); Habitat & Biodiversity (1) **Sensitivity:** Economy (2); Habitat & Biodiversity (1) **Lack of Coping Capacity:** Infrastructure (3); Economy (1)

			Shifting ecoregions (3)	**Exposure:** Provisioning Services (2); Habitat & Biodiversity (1) **Sensitivity:** Regulating Services (2); Habitat & Biodiversity (1) **Lack of Coping Capacity:** Economy (1); Knowledge & Skills (1); Personal Safety & Security (1)

Compounding and cascading impacts

Compound effects occur, for example, when more than one climate hazard results in the same impact chain occurring simultaneously, thus amplifying the overall impact (e.g., the same climate drivers that cause high and extreme high temperatures can also cause drought and wildfire). Climate hazards can also occur in sequence, acting as a series of toppling dominos that accumulate and intensify. Cascading effects are indirect consequences of direct effects. Climate change can produce compounding or cascading effects in several ways.

The WRI cannot be used to measure the degree to which compounding hazards amplify absolute risk, but it can be used to shed light on the implications for relative risk across CDs if the impact statements for individual compounding hazards are combined. The study report includes an illustration of these compounding impacts on WRI scores by combining “drought” and “wildfire” impact statements. When the combined scores for exposures, sensitivities, and levels of coping capacity are subjected to both climate hazards simultaneously (the combined climatic driver indicators), the relative risks change. Some CDs are relatively worse-off in the presence of the compound hazard than they are under each individual hazard (e.g., Colchester, Halifax). For other CDs, the relative risk is unchanged (e.g., Richmond, Victoria), for yet others (e.g., Shelburne, Queens) it is reduced.

When constructing the impact statements that drive the hazard-specific results of the WRI, cascading effects are largely captured. Looking at “high and extreme high temperatures” in the WRI for example, the aggregate impact statement for that hazard captures potential consequences for employment and economic output with knock-on consequences for household incomes arising from morbidity and mortality health outcomes for exposed populations. The statement also captures the knock-on effects of those health outcomes for emergency services and hospitals. Furthermore, the impact statement differentiates between health consequences for the elderly and outdoor workers, as well as perceived health status. The knock-on consequences of heat stress for agriculture and cooling demand for the affordability of local foods and utility bills, respectively, are also captured.

Distributional analysis

We assessed the distributional implications of WRI results for Black, Mi’kmaw communities and self-identified Aboriginal populations, women and Nova Scotians over 65 in three ways: 1) by cross-referencing the prevalence of Black, female, and older Nova Scotians as well as Mi’kmaw communities across CDs most affected by climate-related impacts, 2) by exploring how the vulnerability (sensitivity and coping capacity) to the two most consequential climate-related impacts varies across the groups of interest, and 3) by undertaking sensitivity tests on a generalized Low Coping Capacity Sub-Index to understand how existing inequalities and disparities shape wellbeing outcomes. Results from this analysis indicate the following:

- The potential exists for disproportionate impacts (adverse or beneficial) on Black individuals and Black females in Halifax; older Nova Scotians in Cumberland; older Nova Scotians, older females, Black Nova Scotians, and Black females in Digby; older Nova Scotians and older females in Annapolis; older Nova Scotians in Lunenberg; women in Cape Breton; women and Black Nova Scotians in Colchester. Mapped overlays of the locations of 13 Mi'kmaw communities and satellite locations in relation to climate hazards confirms the presence of these communities in census divisions estimated to experience the largest potential deteriorations in wellbeing caused by climate change.
- Dependency on agriculture and forestry is low by females (1.6% of the female workforce) and Black Nova Scotians (1.4% of the African Nova Scotian workforce), but higher for self-identified Indigenous people, mainly due to their involvement in fishing, hunting, and trapping. Benefits from a longer growing season do not look significant.
- The diversity of employment sources for female Nova Scotians, Black Nova Scotians and for self-identified Indigenous people is significantly lower than the total labour force in the province (21% lower, 8% lower and 52% lower, respectively). Greater diversity reduces the sensitivity of employment generally to climate-related damage or disruption to work that may disproportionately impact one or more sectors of the economy.
- A greater proportion of self-identified Indigenous people are living in dwellings in need of major repairs than the general Nova Scotia population (15.9% versus 8.6%). Homes in need of major repairs will be less resilient to extreme events like floods and their occupants more sensitive to these hazards.
- As measured by three indicators (low-income status, disposable income and educational attainment), general coping capacity among our social groups of interest is lower than the general population, and more so for Black Nova Scotians than for self-identified Indigenous people, with Black-females faring better than Indigenous females, and older Nova Scotians faring worse in general. Lower coping capacity may indicate less ability to deal with adverse consequences of flooding and less ability to take advantage of any benefits from climate change impacts.
- Eliminating disparities across CDs for five indicators pertaining to social support, participation in democracy, sense of belonging, and median after-tax income for individuals results in the largest increases in coping capacity, as measured by our generalized Low Coping Capacity Index.

<u>Information gaps, study limitations, conclusions, and recommendations</u>

The study highlights information gaps related to knowledge of the impacts of climate change on elements of the five capitals and on data gaps that limited the accuracy or completeness of indicators and metrics of climate hazard exposure, sensitivity, or low coping capacity. For example, in relation to the first type of gap, there is a lack of specific information about the potential opportunities for Nova Scotia from the impacts of climate change, such as those that could arise from extended growing seasons and comparative advantages in attracting tourists. Additionally, equity-based impacts of climate change are poorly studied or understood in Nova Scotia and in Canada more broadly. The lack of readily accessible Intensity-Duration-Frequency (IDF) projections at the right scale or baseline and projection data for indicators of wind speed / pressures, wind-driven rain, and freezing precipitation meant that we could not include important hazards in the study.

The WRI analysis undertaken for this study is an attempt to address some of the criticisms of climate change risk assessments, such as their tendency to ignore or not fully integrate non-climate factors that shape climate change vulnerability. Nevertheless, our study and approach have limitations related to scenarios, data inputs and mechanisms of climate impact. For example, one limitation of our study is that Nova Scotian society, economy and nature base are static through to the end of the century. This means that exposure, sensitivity, and low coping capacity sub-indices do not vary over time, and we are essentially overlaying future climate conditions on today's Nova Scotia. Other limitations are noted and guidance on improvements provided.

The following conclusions emerge from our analysis:

- Pluvial flooding, fluvial flooding, wildfire, and extreme heat (agriculture) are the climate hazards of greatest concern for the end of the century.
- Results show a need for an adaptive approach to climate change adaptation since the nature of the threats and opportunities shifts over time and global greenhouse gas emissions pathways.
- Some regions in Nova Scotia have a substantial need for adaptation to address impacts experienced now and in the near-term.
- The impacts of climate change on wellbeing will fall disproportionately on individuals and communities with historic and ongoing disadvantages. Deeper, intersectional, and systematic exploration of the more specific ways racialized and marginalized individuals and communities currently experience wellbeing and vulnerability to climate hazards is critical to inform socially-just adaptation measures.
- Several opportunities exist to prepare Nova Scotians for the impacts of climate change and protect or enhance wellbeing, including broadly-based actions to continuously enhance coping and adaptive capacity. According to our analysis, enhancing belief in government, work-life balance, personal safety and security, incomes and income equality, educational outcomes and quality, and housing affordability would help position Nova Scotians to better cope with today's climate-related impacts and future climate impacts.

The study also lists issue areas for continued attention, to monitor and where exploration of adaptation options is warranted. The ESSA team recommends the following priority issues to inform the province's climate change adaptation choices, with equity and social justice forming a cross-cutting theme for each:

1. Natural capital resilience to climate hazards of high concern. In particular, the focus should be on two ecosystem types: i) wetlands and ii) forests.
2. Climate resilience of Nova Scotia's housing / residential sector, particularly regarding flood risk, sea-level rise, wildfires, and extreme heat.
3. Climate resilience of Nova Scotia's healthcare system, particularly regarding physical and mental health risks from flooding, extreme heat, and wildfires, as well as capacity to manage compounding hazards.

1 Introduction

Climate change and related hazards like drought, extreme storms, severe rainfall, and high temperatures will increase risks to Nova Scotians, affecting people's ability to live a good life. There is an increasing desire to inform decisions about climate change adaptation at regional and local levels by drawing clear linkages between climate change related impacts and hazards and human wellbeing. This desire arises from the recognition that the potential exists for humans to respond more readily to risks (and take advantage of potential opportunities) when they can easily understand how those risks will directly affect them and the people, places, and things that they care about.

The vulnerability of human populations to climate hazards is not distributed evenly. Individuals and communities facing systemic inequities, such as racialized and marginalized groups, tend to be more vulnerable to the impacts of climate change. In addition, many human pursuits that are intended to increase our short-term stocks of wellbeing can weaken our long-term resilience by, for example, degrading social and environmental conditions (SREX IPCC 2012; IPCC 2013). For decision-makers to address such challenges, it is important to understand what capital stocks and goods and service flows are at risk, and where and to what extent, as well as where and how losses and disruptions are most likely to affect people's lives and wellbeing. **This study implements a "well-being at risk index" (WRI) to clarify relationships between climate hazards and associated risks to human wellbeing**. It does this using a suite of wellbeing indicators combined with regionally downscaled climate indices to develop a spatially explicit assessment of areas most at risk of loss and disruption to key determinants of wellbeing.

This study, focused on WRI, is one input into a broader climate change risk assessment that the province of Nova Scotia is undertaking. By applying a wellbeing framework to the task of assessing climate change impacts, the province aims to generate insights on how climate change might affect the ability to achieve or make improvements to the individual and collective wellbeing of Nova Scotians, such as progress on social, environmental, and economic goals. Other studies contributing to the province's efforts include 1) public opinion research investigating what matters most to Nova Scotians in relation to wellbeing and 2) research on capacities needed for resilience and/or transformation of socio-ecological systems in the face of climate change.

1.1 Purpose and Outline of this Report

The primary purposes of this report are to assist the province of Nova Scotia in identifying climate adaptation activities, making informed decisions about prioritizing those activities in a way that best addresses the needs of Nova Scotians, and to help the province meet its obligations to keep the public appraised of critical risk information. We begin with a brief overview of Nova Scotia's changing climate (Section 2) with a focus on physical impacts like increasing air temperatures, changing precipitation patterns, changing storm extremes, sea level rise and ocean conditions, then summarize the ways these impacts will affect the things that contribute to people's wellbeing (Section 3), namely:

- **Natural Capital**
- **Social Capital**
- **Human Capital**
- **Financial Capital**
- **Manufactured Capital**

Section 4 provides a brief overview of social equity dimensions that are important to consider in understanding patterns of vulnerability to climate change, including the uneven access to the capital stocks and flows needed to cope with climate hazards and adapt to the rapid changes on the horizon. In Section 5, we introduce the analytical framework and methodology underlying the well-being at risk index (WRI), which relies on the identification, itemization, and selection of key indicators as well as the development of a suite of climate hazard data. Section 6 then reports the results of combining these indicators with climate hazard data to show how the WRI varies spatially across census divisions using maps and tables. Section 6 also provides a quantitative distributional analysis showing how selected social groups in Nova Scotia are unequally vulnerable to climate change. Section 7 identifies study limitations and information gaps uncovered during the background research and development and analysis of the WRI, while Section 8 provides conclusions and recommendations on priority issues based on results from the WRI analysis.

2 Physical Changes to Nova Scotia's Climate

Section Summary

Based on observed historical data, climate change is already impacting Nova Scotia and the impacts are projected to increase over the coming decades. This section briefly reviews the physical climate changes that are projected to occur in the province, it does not review the anticipated impacts of those changes, which are covered in subsequent sections. The purpose of this section is not to provide an exhaustive review, but to offer a sufficient overview, situating other parts of this report and the study results in the broader context of projected physical changes.

Changing Temperatures

Between 1948 and 2016, the average annual temperature in Atlantic Canada increased by 0.7°C, with some parts of the region experiencing increases as high as 1˚C. In Halifax, the current rate of warming is projected to increase, with observed mean annual temperatures (MATs) from recent decades currently tracking projected rates. Compared to 1981-2010 levels based on RCP8.5 (high emissions scenario), Nova Scotians can expect an average mean annual temperature increase of up to 4.5°C by 2065-2095, an increase in the length of the growing season, a decrease in days requiring indoor heating, and an increase in days requiring indoor cooling. The frequency of extreme hot days and heatwaves are projected to increase, while extreme cold days and cold waves are expected to decrease.

Changing Precipitation

Precipitation is projected to increase province-wide, especially in winter, but snowfall as a proportion of total precipitation will decrease. The wettest season will shift from fall to winter. Extreme rainfall events will become more intense.

Storms and Changing Ocean Conditions

Nova Scotia receives the highest number of storms in Canada due to its proximity to the Gulf Stream. The province will experience increased storm activity (e.g., Hurricane Juan) and heavier rainfall, with the extent of flooding from storm surges dependent partly on the slopes of coastal lands. Under RCP8.5, sea level rise is expected to increase 68 – 100cm by 2100, with the highest increases projected along the Atlantic seaboard, especially around Cape Breton and Halifax. Nova Scotia has already experienced changes in ocean conditions like increased ocean temperatures, ocean acidification, decreased marine oxygen levels, and algal blooms, and these changes are expected to continue.

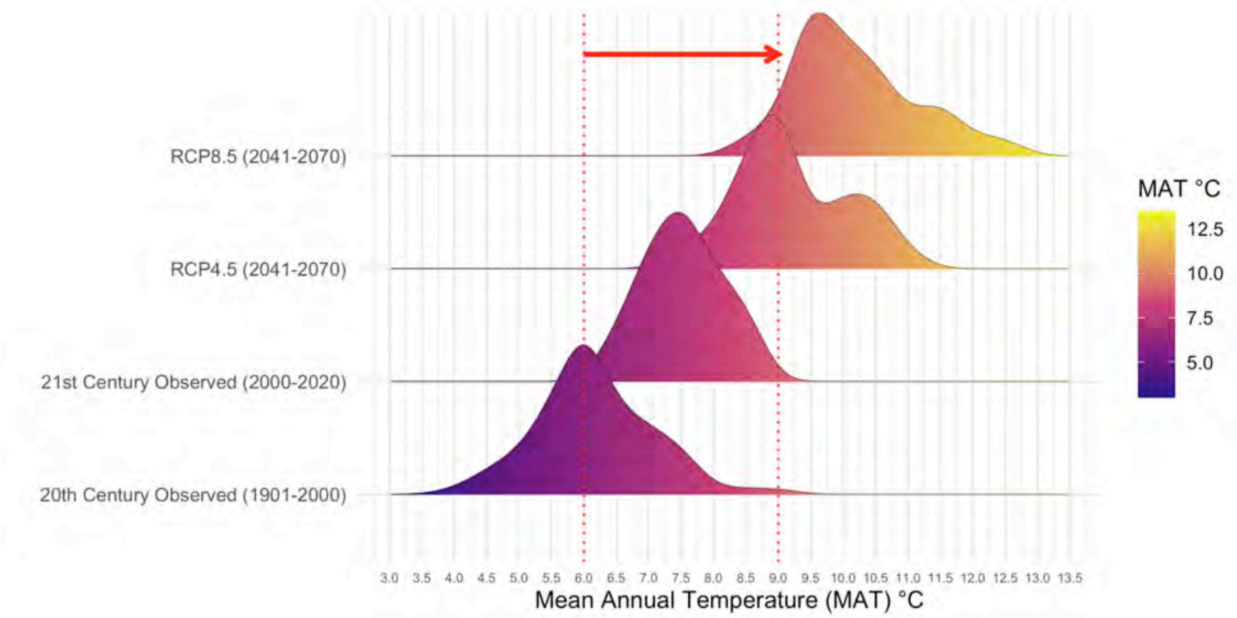
With the August 2021 release of the Intergovernmental Panel on Climate Change's (IPCC's) sixth assessment report (AR6), concerns about the current and projected implications of a warming environment are at the forefront of people's minds. The IPCC is an organization made up of 195 international governments. It is the leading body of scientific assessment and information dissemination regarding climate change. The IPCC has issued assessment reports in 1990, 1995, 2001, 2007, 2014, and will issue its most recent assessment in 2022. This study began in 2020 prior to the release of AR6 and while some statements from AR6 have been incorporated to support a contemporaneous narrative, most content and all data analyses are based on outcomes of the fifth Assessment Report (AR5).

Since 2011, the measurement year reported in AR5, global atmospheric greenhouse gas (GHG) concentrations have continued to increase, with annual averages now reaching 410 parts per million (ppm) for carbon dioxide, 1866 parts per billion (ppb) for methane, and 332 ppb for nitrous oxide (IPCC 2021). Compared to the preceding decades since 1850, global warming has increased during each of the last four decades (IPCC 2021). These warming temperatures are driving further changes to the climate, such as changes to precipitation patterns, glacial retreat, sea level rise, and warming oceans.

The last two IPCC reports use Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) to illustrate projected future climates under different GHG emission scenarios. From a planning perspective, partly as a precaution against the lag between GHG mitigation commitments and mitigation actions (Metro Vancouver 2016), it has been suggested that particular attention should be paid to the RPC8.5 scenario (now most closely represented by the SSP5-8.5 scenario in the IPCC's AR6 report), which represents the highest GHG level and radiative forcing considered in AR5. Global emissions are still rising along this high emissions trajectory. Even under the most optimistic scenarios involving immediate and drastic global emissions reduction, the future climate of Nova Scotia will be substantially different from the past.

To place the magnitude of projected temperature increases into perspective, it is illustrative to compare climate projections to Halifax's observed 20th century temperature distribution (Figure 2-1). Based on Adjusted and Homogenized Canadian Climate Data (AHCCD), the average mean annual temperature (MAT) in Halifax during the 20th century (1901-2000) was 6.0°C and ranged from roughly 4.0-9.0°C. Under the RCP4.5 emissions pathway, which is more optimistic than RCP8.5 in terms of future emissions concentrations in the atmosphere, the 30-year average MAT centred around 2055 (2041-2070) will be at the high end of the 20th century MAT distribution. In other words, optimistically, on average, mean annual temperatures in the 2050s are projected to be like the warmest years experienced in the 20th century. Many built and natural systems are designed for and adapted to climatic conditions that occur within the normal distribution of historical climate, and it is significant that, by the 2050s, approximately half of the years will be 'off the hot tail' of the 20th century's MAT probability distribution.

Figure 2-1. Observed and projected frequency distributions of mean annual temperature (MAT) in Halifax, NS



This diagram illustrates where along the observed 20th century MAT frequency distribution temperatures are projected to be in the 30-year period centred around 2055 (2041-2070) under RCP4.5, which is a more optimistic scenario than RCP8.5 (also shown at top for illustration). The mean MATs for these two distributions are shown as dotted red vertical lines. Projections for 2041-2070 under RCP4.5 are calculated relative to the 21st century observed data. For the observed data, the frequency distributions and mean value are Adjusted and Homogenized Canadian Climate Data (AHCCD). For the projected data, the mean value for 2041-2070 under RCP4.5 is the model ensemble mean, while the frequency distributions for RCP4.5 and RCP8.5 are from a single model and are shown primarily to illustrate that variability (i.e., the shape of the frequency distribution) is also projected to change. It is not recommended to combine all models into a single frequency distribution, so we used MPI-ESM-LR-r3 for these two distributions (the #1 ranked model for the Eastern North America "Giorgi region" – see Giorgi and Francisco 2000).

Climate change is not only a future concern in Nova Scotia but rather is currently ongoing and has been so for several decades. On multi-decadal timescales, climate models have accurately replicated observed changes in global temperature (Flato et al., 2013), and this appears to be the case for the Halifax region where projected increases in MAT are roughly consistent with observed increases over the last 50 years. For example, extrapolating from observed data and assuming a linear trend, Figure 2-2 shows that MAT will reach the projected value of 9.0°C for the 2050s (RCP4.5) by around 2066, which is within the 30-year period used for averaging these data (2041-2070). Note that linear extrapolation and the use of RCP4.5 are likely conservative, and these are used here only to demonstrate the point that observed temperature trends in the Halifax region are roughly tracking modelled projections. In fact, climate models project future warming at a higher rate (accelerating) than observed in the past.

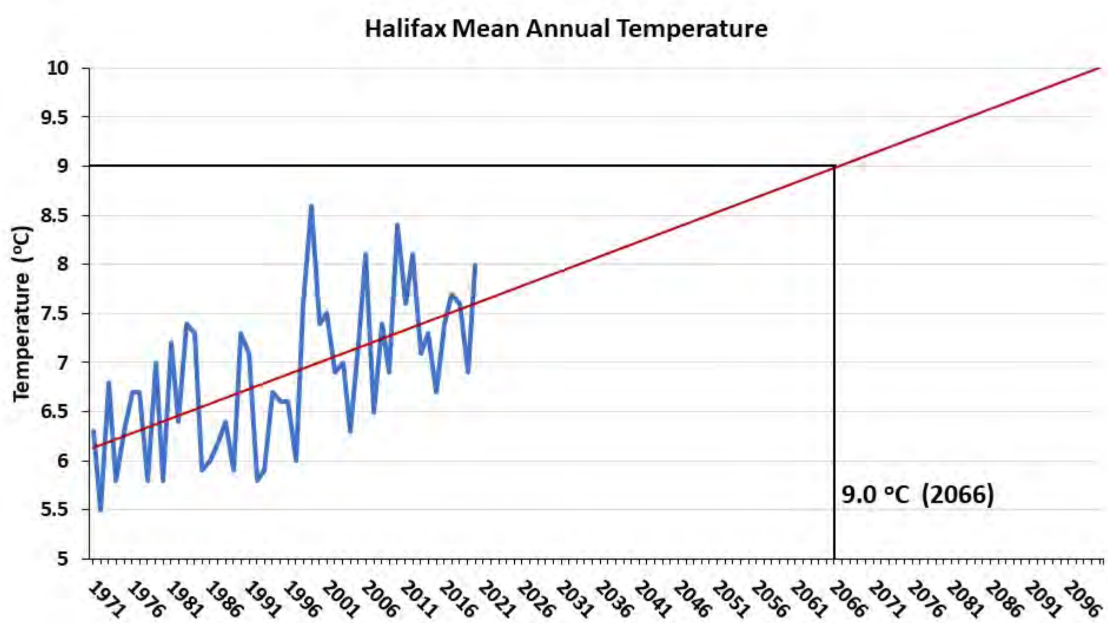
Past Findings: Adapting to a Changing Climate in Nova Scotia Report (2005)

Nova Scotia Environment's 2005 report "Adapting to a Changing Climate in Nova Scotia: Vulnerability Assessment and Adaptation Options" used the IPCC's Special Report Emissions Scenarios (SRESs) rather than the Representative Concentration Pathways (RCPs) scenario framework used in this report.

Nevertheless, some of the key messages outlined in the report are highlighted below. Since 2005, our understanding of the impacts has improved, but projections are still generally consistent with the overarching changes (increasing air temperatures, increased frequency and severity of storms, sea level rise, etc.). The following subsections detail newer projections.

- Average summer temperatures in Atlantic Canada could increase by 3-4°C by the 2080's.
- Nova Scotia is projected to see an increase the frequency and severity of coastal storms.
- Higher ocean levels have already resulted in the flooding and retreat of beaches, in one case at a rate of 8 metres per year, and particularly in coastal areas comprised of loose sand and gravel.
- As ocean levels rise under a warming climate, sensitive, low-lying coastal ecosystems like salt marshes, lagoons, and barrier beaches are at greater risk of inundation, erosion, and land loss.
- Increasing temperatures may impact ocean hydrodynamics and currents, leading to habitat loss and disruptions to life cycles.
- Altered temperature, precipitation, and wind regimes may increase soil erosion and run-off, which subsequently impacts habitat availability, wildlife, and increases sediment in run-off.
- Higher air temperatures and lower than typical springtime precipitation may result in increased risk of summertime droughts and forest fires.

Figure 2-2. Observed mean annual temperatures (MAT) in Halifax, NS from 1971-2020 with linear trendline extrapolating MAT



Climate change has manifested in several ways for Nova Scotia, presenting both challenges and opportunities to the province's residents in terms of wellbeing (ECCC 2020, Lemmen et al. 2016). Nova Scotians are, and will continue to be, most impacted by changing air temperatures, changing precipitation patterns, more frequent and intense storms, rising sea levels, and changing ocean conditions (Lemmen et al. 2008, Reid et al. 2019; NSE 2005).

Although the literature tends to more frequently cover extreme events and climate-related disasters, there are also slower onset impacts like growing season shifts that have significant implications for Nova Scotia. What follows in sections 2.1 to 2.4 are summaries of the current state of knowledge relating to five physical climate variables: air temperature, precipitation patterns, storm intensity, sea level rise, and ocean conditions. Other variables may be more or less relevant in some geographic areas, but this review is not intended to be exhaustive, it is meant to provide readers with a broad contextual overview to support interpretation of results presented later in this report.

2.1 Changing Air Temperatures

Temperature-related climate hazards & impacts:

- Extreme heat/cold
- Slow onset warming
- Growing season shifts
- Drought
- Wildfires
- Freezing rain
- Snowstorms

The annual average temperature in Atlantic Canada has warmed by 0.7ºC between 1948-2016, with some parts of the region seeing increases as high as 1ºC annually (Zhang et al. 2019). Relative to 1986-2005 temperatures (20-year average), projections indicate that mean annual temperatures could increase by 1.5ºC to 5.2ºC by 2081-2100 depending on the GHG emissions scenario used for the projections (Zhang et al. 2019). Unlike other parts of Canada, seasonal averages in Atlantic Canada have historically shown larger temperature increases in summer and autumn than in spring and winter (see Table 2-1), so the projected warming will also lead to a longer growing season (Zhang et al. 2019).

Like the rest of Atlantic Canada, Nova Scotia's air temperatures are also increasing, and this has been shown consistently across multiple studies. In 2005, based on Special Report Emissions Scenarios (SRES), which were superseded by Representative Concentration Pathways (RCP) in the IPCC's fifth assessment, the average summer temperatures in Atlantic Canada were projected to increase by 3-4ºC from 2005-2021 (Nova Scotia Environment 2005). Using 30-year averages, a more recent study shows that Nova Scotia's mean annual temperature rose from 6ºC in 1961-1990 to 6.7ºC in 1991-2020 (Garbary and Jill 2021).

Projected changes will make annual occurrences of extreme temperatures more common (ClimAction Services 2017). In Nova Scotia, incidences of extreme heat are already rising compared to the 1980s, with projections generated in 2011 suggesting 13.7 more days per year with temperatures over 30ºC by the 2080s using a high emissions scenario (from 2.4 days to 16.1 days) (Richards and Daigle 2011). Incidences of extreme heat will become more common, and cold extremes will be less cold (Zhang et al. 2019).

The literature also suggests air temperature changes will increase the risk of wildfire and drought in some regions (ClimAction Services 2017, Zhang et al. 2019). Recent modelling suggests that evaporation and water deficits are more likely to drive drought conditions than changes in summer precipitation (A. Cadel, pers. comm), which is not projected to decline much (See Table 2-4). Summertime droughts tend to be more common in inland regions and the Annapolis Valley, Northumberland Shore, and Cape Breton (NSE 2005, Lemmen et al. 2008). Wildfire risk is exacerbated by the fact that Nova Scotia's mixed forests are ill-equipped to handle changing climate conditions and require time before more fire-resistant hardwood species become established (Whitman et al. 2015). Increasing temperatures will also affect forests through changes in forest composition, growth and productivity, and incidences of insect infestations; resultant changes in soil properties that affect root anchorage will increase the risk of blowdown during storms (Steenburg et al. 2012, Taylor et al. 2019).

Warming air temperatures will affect snow cover and sea ice. From 1981-2015, snow cover decreased by 5% – 10% across most of Canada, with eastern Canada particularly affected (Derksen et al. 2019). In Atlantic Canada, projections suggest continued decreases in snow cover with 15% to 30% cumulative losses between 2020 and 2050 (Derksen et al. 2019). As a result of warmer air temperatures and warming sea surface temperatures, winter and spring sea ice has also been decreasing at a rate of 7.5% per decade in eastern Canada since 1969 (Derksen et al. 2019). Some modelling indicates sea ice in most of the Gulf of St. Lawrence will be almost entirely absent by 2100 (Lemmen et al. 2016 – citing Senneville et al. 2014), while others suggest winter sea ice may no longer form in the region by 2040 – 2050 (Daigle 2020).

Reduced polar sea ice is linked to "Arctic amplification", or higher rates of warming in northern latitudes, compared to tropical latitudes, over long time periods. Associated with Arctic amplification, but at a shorter time scale, is the injection of polar air southward into mid latitudes, sometimes referred to as an "Arctic outbreak". This influx of cold air can contribute to periods of extreme wintertime weather for the Atlantic region, including anomalous periods of extreme cold temperatures and winter storms (Walsh 2014).

Table 2-1. Annual and seasonal observed changes in temperatures for different regions in Canada between 1948 and 2016.

	Change in Temperature (°C)				
Region	Annual	Winter	Spring	Summer	Autumn
British Columbia	1.9	3.7	1.9	1.4	0.7
Prairies	1.9	3.1	2.0	1.8	1.1
Ontario	1.3	2.0	1.5	1.1	1.0
Quebec	1.1	1.4	0.7	1.5	1.5
Atlantic	0.7	0.5	0.8	1.3	1.1
Northern Canada	2.3	4.3	2.0	1.6	1.7
Canada	1.7	3.3	1.7	1.5	1.7

Source: Zhang et al. (2019) in Bush and Lemmen (2019)

Table 2-2 shows projected values for several air temperature variables for Nova Scotia averaged across 27 GCMs. These projections, which were prepared for this study using IPCC AR5 data, tell a story that is consistent with prior documentation cited above, with a mean annual temperature increase of 4.5°C (range from 6.6°C to 11.1°C) by 2065-2095 (RCP8.5), an increase in the growing season, a decrease in days requiring indoor heating, and an increase in days requiring indoor cooling. Extreme hot days and heatwaves are projected to increase, while extreme cold days and cold waves are expected to decrease.

Why 27 General Circulation Models (GCMs) in the ensemble?

Climate Data Canada (CDC) recommends the use of model ensembles for projections. As part of this study, we used all the BCCAQv2 models that were made available by the Pacific Climate Impacts Consortium (PCIC) as of December 2019. This ensemble of 27 models yields similar results to the ensemble of 24 BCCAQv2 models that Canadian Centre for Climate Services provides on the CDC website. For example, there is less that 0.1˚C difference between CDC and our projections of mean annual temperature, and less that 1% difference between CDC and our projections of mean annual precipitation for the Halifax census division (2065-2090, RCP8.5).

Fewer GCMs can also be selected, for instance, following PCIC's ranked list of 12 models for Eastern North America (based on Giorgi and Francisco 2000). This ranking is done for 5 "Giorgi regions" and there are only 12 models because the ranking refers to an old version of the PCIC data when fewer GCMs were available. The reason for the ranking is if storage of the full ensemble is not feasible for users, a subset of GCMs can be chosen following the order listed. Since we had no storage challenges, we did not consider this option.

Table 2-2. Projections for several key air temperature indicators in Nova Scotia

	Base	RCP4.5		RCP8.5	
	2010	2065	2095	2065	2095
General					
Annual Mean Temperature (°C)	6.6	8.5 (7.2 - 9.8)	9.2 (8.1 - 10.3)	9.2 (7.7 - 10.9)	11.1 (9.9 - 12.7)
Summer Mean Temperature (°C)	16.9	18.9 (17.2 - 20.6)	19.5 (18 - 21)	19.5 (17.7 - 21.5)	21.6 (19.9 - 23.3)
Winter Mean Temperature (°C)	-3.8	-1.6 (-3.9 - 0.7)	-0.9 (-3.1 - 1.3)	-0.9 (-3.3 - 1.4)	1.3 (-1.1 - 3.3)
Annual Growing Degree Days > 5°C	1727	2131 (1846 - 2443)	2273 (2023 - 2555)	2275 (1935 - 2680)	2758 (2435 - 3167)
Annual Heating Degree Days < 18°C	4244	3642 (3256 - 4050)	3450 (3110 - 3794)	3468 (2986 - 3916)	2938 (2534 - 3307)
Annual Cooling Degree Days > 18°C	84.5	202 (107 - 328)	250 (154 - 374)	252 (129 - 419)	440 (292 - 635)
Extremes					
Annual Hottest Day (°C)	29.6	31.7 (29.2 - 34.8)	32.3 (29.9 - 35.3)	32.4 (29.7 - 35.7)	34.4 (31.8 - 37.6)
Annual Coldest Night (°C)	-21.9	-18.6 (-23.4 - -14.6)	-17 (-21.8 - -13.4)	-17.3 (-22.8 - -13.2)	-13.6 (-18.3 - -10)
Heatwave Number	1.0	4.7 (1.3 - 9.4)	6.2 (2.6 - 10.2)	6.2 (2 - 11.1)	8.5 (4.7 - 12.4)
Coldwave Number	1.1	0.1 (0 - 1.4)	0 (0 - 0.9)	0 (0 - 1.2)	0 (0 - 0.2)
Annual Number of days with Max Temp > 30°C	0.9	5.3 (1.1 - 15.9)	8.4 (2.6 - 19.7)	8.3 (1.8 - 23.1)	22.5 (9.4 - 42.7)
Annual Number of days with Min Temp < -15°C	14.8	5.9 (1.2 - 15.1)	3.9 (0.5 - 10.9)	3.8 (0.5 - 13.2)	0.7 (0 - 4.7)

Table 2-2 projections are for 1981-2010 (base), 2035-2065 (2065) and 2065-2095 (2095), and RCP4.5 and RCP8.5 with General Circulation Model (GCM) ensemble ranges shown in parentheses (results for 90% of GCMs fall within these ranges). These data were prepared for this study by Climate Resources Consulting using an ensemble of 27 statistically downscaled GCM projections from the Pacific Climate Impacts Consortium (pacificclimate.org)

2.2 Changing Precipitation Patterns

Precipitation-related climate hazards & impacts:

- Flash floods
- Landslides
- Slow onset changes
- Growing season shifts
- Freezing rain
- Snowstorms
- Drought

Nationally, Atlantic Canada has experienced the second greatest increase in precipitation over the last ~70 years (ClimAction Services 2017, Zhang et al. 2019). Zhang et al. (2019) found that, between 1948-2012, average annual precipitation rose by 11.3%, with the highest increases occurring in summer and fall, although winter and spring precipitation are also expected to increase (Table 2-3). As climate change progresses, the region can expect to experience heavier precipitation events over shorter time periods, compared to the current trend of more frequent precipitation spread over several days (ClimAction Services 2017). Recent studies suggest that relative to 1986-2005 levels, average annual precipitation in Atlantic Canada could increase by up to 5% by 2050, and 4.7% or 12.0% for 2081-2100 depending on projected emissions (Zhang et al. 2019, Howarth et al. 2021).

Table 2-3. Annual and seasonal (normalized) percent changes in precipitation for different Canadian regions, 1948-2012.

	Change in Precipitation (%)				
Region	Annual	Winter	Spring	Summer	Autumn
British Columbia	5.0	-9.0	18.2	7.9	11.5
Prairies	7.0	-5.9	13.6	8.4	5.8
Ontario	9.7	5.2	12.5	8.6	17.8
Quebec	10.5	5.3	20.9	6.6	20.0
Atlantic	11.3	5.1	5.7	11.2	18.2
Northern Canada	32.5	54.0	42.2	18.1	32.1
Canada	18.3	20.1	25.3	12.7	19.0

Source: Zhang et al. (2019) in Bush and Lemmen (2019)

In the past, in Nova Scotia, the frequency of heavy precipitation events that led to flooding was *relatively* stable (when compared to current and projected conditions under climate change), and measures could be taken to plan and respond to these events. Climate change has and continues to change precipitation patterns, including for extreme weather events, making it more difficult to anticipate and manage impacts (NSMA 2015). Spring and fall are projected to see a shift in the prominence of snow to rain because of warming temperatures

(Zhang et al. 2019), but more frequent Arctic outbreak may result in more extreme winter storm events (Walsh 2014). Landslides are also likely to increase in frequency in response to erosion-related reductions to slope stability, resulting in part from heavier precipitation and flooding events (Cloutier et al. 2017).

Table 2-4 shows projected values for several precipitation variables in Nova Scotia, averaged across 27 GCMs. Like the air temperature data presented in Table 2-2, we prepared these data for this study using IPCC AR5 projections. Also similarly, these projections tell a story that is roughly consistent with prior documentation cited above, with an average annual total precipitation increase of 141mm, from 1,316mm to 1,457mm, by 2065-2095 (RCP8.5). The number of wet days is projected to increase, on average, by over 4 days annually, with greater increases occurring in spring and fall (1.2 and 1.8 more days respectively) than in summer and winter (0.5 and 0.6 more days respectively). This projection is slightly different from the historical observations of Zhang et al. (2019) for Atlantic Canada, where the greatest increases were seen in summer and fall. Despite different rates of increase for each season, the general seasonal pattern remains roughly the same over time with most wet days occurring in fall and winter in the base case (1981-2010), 2035-2065, and 2065-2095 (RCP8.5). Extreme rainfall events will become more intense, with the maximum 1-day rainfall increasing by 10mm by 2065-2095, and the maximum 5-day amount by over 15mm. Although precipitation is expected to increase, the number of annual snow days is expected to decrease from 38.9 to only 17.2 on average for 2065-2095 (a reduction of over 21 days).

Table 2-4. Projections for several key precipitation indicators in Nova Scotia

	Base	RCP4.5		RCP8.5	
	2010	2065	2095	2065	2095
General					
Annual Total Precipitation (mm)	1315.5	1388.6 (1155.3 - 1647.6)	1399.4 (1172.7 - 1676.4)	1401.2 (1171.7 - 1669.2)	1456.5 (1224 - 1714.3)
Summer Precipitation (mm)	259.0	269.9 (171.2 - 411.4)	269.5 (169.8 - 407.8)	266.7 (169.4 - 415)	278.3 (171.7 - 431.3)
Winter Precipitation (mm)	376.3	403.5 (299.8 - 518.9)	413.6 (300.3 - 538.5)	411.7 (300.1 - 560.1)	435.7 (321.5 - 571.6)
Annual Number of Wet Days > 20mm	15.9	17.7 (11.9 - 24.7)	18.2 (12.3 - 25.4)	18.3 (12.2 - 25.1)	20 (13.8 - 26.7)
Summer Number of Wet Days > 20mm	2.9	3.1 (0.8 - 6.4)	3.1 (0.8 - 6.4)	3 (0.7 - 6.5)	3.4 (0.9 - 6.9)
Fall Number of Wet Days > 20mm	5.0	5.4 (2.4 - 8.9)	5.5 (2.5 - 9.2)	5.4 (2.4 - 8.9)	5.6 (2.5 - 9.4)
Winter Number of Wet Days > 20mm	4.3	5 (2.2 - 8.5)	5.4 (2.5 - 8.9)	5.4 (2.4 - 9.4)	6.1 (2.9 - 9.8)
Spring Number of Wet Days > 20mm	3.2	3.8 (1.3 - 7.1)	3.9 (1.3 - 7.2)	4 (1.3 - 7.4)	4.4 (1.7 - 7.9)
Annual Snow Days	38.9	28.7 (17.9 - 40.7)	25.4 (15.5 - 36)	25.3 (14.4 - 37.9)	17.2 (8.4 - 27.7)
Extremes					
Maximum 1-day Rainfall (mm)	53.2	57.2 (40.6 - 98.1)	58.3 (41.7 - 100.3)	59.5 (41.7 - 101.4)	63.2 (44.8 - 106.7)
Maximum 5-day Rainfall (mm)	90.0	96.1 (70.2 - 150.3)	97.7 (71 - 153.2)	99.1 (72.4 - 155.4)	105.2 (77 - 162.2)

Table 2-4 Climate projections are for 1981-2010 (base), 2035-2065 (2065) and 2065-2095 (2095), and RCP4.5 and RCP8.5 with General Circulation Model (GCM) ensemble ranges shown in parentheses (results for 90% of GCMs fall within these ranges). These data were prepared for this study by Climate Resources Consulting using an ensemble of 27 statistically downscaled GCM projections from the Pacific Climate Impacts Consortium (pacificclimate.org)

2.3 Increased Intensity of Storms

Storm-related climate hazards & impacts:

- Short-duration, high intensity rainfall
- Tropical cyclones
- Flash floods
- Freezing rain
- Snowstorms/blizzards
- Landslides
- Storm surges
- Strong winds

Nova Scotia receives the highest number of storms in Canada due to its proximity to the Gulf Stream (NSE 2005). Over the past few decades, the province has already experienced several notable tropical cyclones, such as hurricane Juan, in 2003, which hit just south of Halifax and caused significant damage (Lemmen et al. 2016). Climate change has caused cold ocean waters that would typically weaken storms as they approach to warm, causing stronger storms to hit the province's coast (NSE 2005). Consequently, Nova Scotia will see increased storm activity and heavier rainfall, with the extent of flooding from storm surges depending partly on the slopes of coastal lands (Rapaport et al. 2013), tidal range and geomorphology (rocky coastlines versus silty, flat coastlines) (Howarth et al. 2021). Intrusion of polar air into mid latitudes resulting from Arctic outbreaks will also contribute to periods of extreme wintertime weather in the Northern Hemisphere, especially the Atlantic region (Walsh 2014).

Since 1948, average summertime and wintertime wave heights in Atlantic Canada have grown by 2 cm and 20 cm per decade, respectively (Howarth et al. 2021). Reductions in the amount of sea ice and a shortened ice season will promote the development of higher-energy waves, increasing the extent of coastal erosion, and further disturbing marine habitats along some of Nova Scotia's coasts (Murison 2017). In conjunction with increased precipitation, these storms will contribute to more coastal inundation and flooding from storm surges, pluvial flooding, coastal erosion, and landslides (NSE 2005, Lemmen et al. 2016, Cloutier et al. 2017). Wind speeds over land are also projected to increase by 3.7 to 7.0 km/h by the end of the century (ClimAction Services 2017).

2.4 Sea Level Rise and Changing Ocean Conditions

Sea level-related climate impacts:

- Coastal floods
- Coastal erosion
- Saltwater intrusion

As temperatures warm, rising sea levels will continue to impact Nova Scotia's coastal areas. Globally during the 20th century, sea levels rose at an average rate of approximately 1.3 mm/year from 1901 to 1971, with that rate increasing to approximately 1.9 mm/year between 1971 and 2006, and again increasing to 3.7 mm/year between 2006 and 2018 (IPCC 2021). At large scales, sea level rise occurs primarily due to ocean thermal expansion and discharge from melting land ice such as from mountain glaciers and Arctic and Antarctic ice sheets (James et al. 2014, James et al. 2021). This increase varies in magnitude and spatially due to several factors, including vertical land motion and absolute sea surface elevation (Greenan et al. 2019a).

Interannual variation in the North Atlantic Oscillation (NAO) and its influence on the Atlantic Meridional Overturning Circulation (AMOC) (Goddard et al. 2015) also contribute to this variation. Goddard et al. (2015) showcased a rare (1 in 850 years) extreme sea level rise (SLR) event where the sea level along the Northeast coast of North America rose by 128 mm within only a 2-year period (2009-2010), primarily driven by a large negative NAO and a reduction in AMOC (Goddard et al. 2015). Their analysis predicted that similar extreme sea level rise events along the Atlantic coast are projected to increase in frequency and magnitude because increased atmospheric greenhouse gas (GHG) concentrations are projected to weaken the AMOC, and because of increased thermal expansion and melting of land ice (Goddard et al. 2015).

The most recent sea level rise estimates for Nova Scotia are from James et al. (2021), which include contributions from glaciers and thermo-steric expansion of the ocean. These data indicate about a 68 – 100cm increase for the province by 2100 under RCP8.5 (Figure 2-3). Table 2-5 shows projected average values with GCM ensemble ranges in 2095 for each census division (CD), which were calculated using the James et al. data by interpolating to 2095 with linear regression and averaging projected SLR at evenly spaced points along the coastline within each CD. These values are consistent with prior studies, which suggest sea levels along the coast of Nova Scotia would rise by at least 75 – 100 cm by 2100 under a high emissions climate scenario (Rapaport et al. 2013, Cohen et al. 2019).

In Halifax, sea levels are projected to rise by 20 cm within the next two to three decades, increasing the number of anticipated flood events that exceed the city's 2.3 m flood level by a factor of four (Cohen et al. 2019). Results from James et al. (2021) may underrepresent the extent of sea level rise in some locations because they do not consider contributions for melting sea ice in Antarctica, and because most digital elevation models (DEMs) are limited, containing large errors and biases in representing different terrain elevations, particularly in highly populated areas (Kulp and Strauss 2019). These values also do not consider storm tides, which have reached heights of up to 1.6m in recent history (Hurricane Juan, Halifax 2003).

Figure 2-3. Projected sea level rise for Nova Scotia in 2100 using RCP8.5.

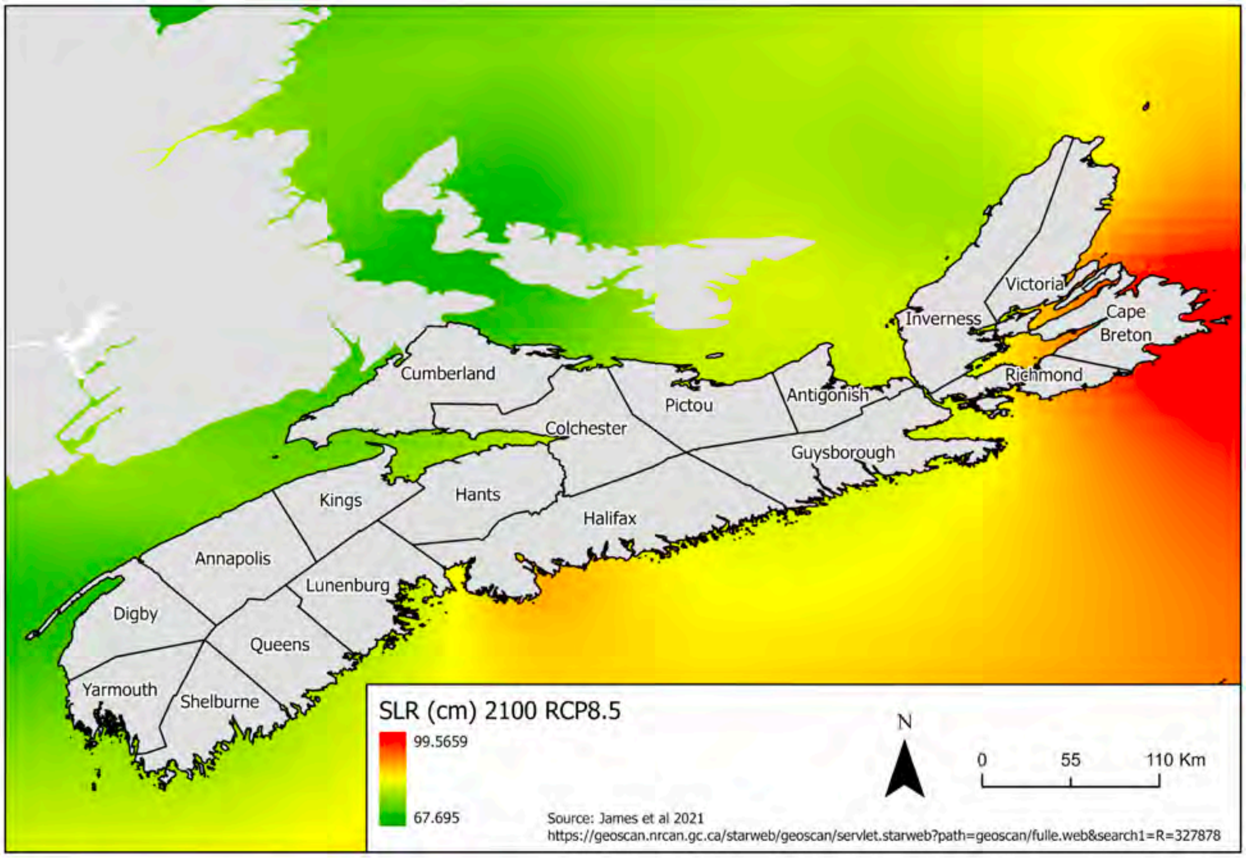


Figure 2-3 is produced using data from James et al. (2021). James et al. (2021) incorporates sea level projections from IPCC AR5 (Church et al., 2013a), including contributions from glaciers and thermo-steric expansion of the ocean. The local contributions to sea level rise associated with glacial isostatic adjustment were updated with the NAD83v70VG vertical land motion (Robin et al., 2020). Sea level projections in James et al. (2021) are relative to the average sea level over the base period 1986-2005. We used the James et al. time series to interpolate for 2095 using linear regression. Sea level rise values from James et al. (2021) do not include: 1) storm tides, which have occurred up to 1.6m in recent history (Hurricane Juan, Halifax 2003), or 2) additional global mean sea level rise of up to 70cm by 2100 that may arise from instability in the Antarctic ice sheet. These data should also be considered alongside local knowledge of wave climate and storm tides to assess potential future water levels at specific coastal locations. Note that James et al. (2021) is currently the definitive work on sea level rise in Canada, but AR5 sea level rise projections are conservative compared to those derived using AR6, which we calculate to be approximately 6.7cm higher in 2100 than for AR5.

Table 2-5. Projected average sea level rise in 2095 (RCP8.5) with GCM ensemble ranges

Census Division	2095 RCP8.5 Mean (cm)	2095 RCP8.5 Range (cm) (90% of ensemble results)
Annapolis	57.6	31.2 – 84.3
Antigonish	61.9	35.4 – 88.5
Cape Breton	73.3	46.5 – 100.2
Colchester	59.7	32.6 – 87.0
Cumberland	56.5	29.4 – 83.7
Digby	55.0	28.9 – 81.6
Guysborough	63.2	36.6 – 89.8
Halifax	64.3	37.2 – 91.6
Hants	59.7	32.5 – 87.0
Inverness	61.8	35.1 – 88.4
Kings	57.8	30.8 – 85.1
Lunenburg	61.3	34.5 – 88.4
Pictou	61.2	34.4 – 88.1
Queens	60.8	34.5 – 87.5
Richmond	67.2	40.4 – 94.1
Shelburne	60.5	34.0 – 87.5
Victoria	66.2	39.2 – 93.2
Yarmouth	58.9	32.6 – 85.7

Table 2-5 is based on analyses for this study by Climate Resources Consulting using data from James et al. (2021). The average values per census division (CD) were calculated using the average projected sea level rise at evenly spaced intervals along each CD's coastline. James et al. (2021) incorporates the most recent sea level projections from IPCC AR5 (Church et al., 2013a), including contributions from glaciers and thermo-steric expansion of the ocean. The local contributions to sea level rise associated with glacial isostatic adjustment were updated with the NAD83v70VG vertical land motion (Robin et al., 2020). Sea level projections in James et al. (2021) are relative to the average sea level over the base period 1986-2005. We used the James et al. time series to interpolate for 2095 using linear regression. Results from averaging SLR by census division as we did for this table should be considered only in relative, not absolute, terms. Nova Scotia has wide variation in coastal geomorphology, which means the averages and ranges presented in this table may not encompass actual SLR values at specific locations. Also, sea level rise values from James et al. (2021) do not include: 1) storm tides, which have occurred up to 1.6m in recent history (Hurricane Juan, Halifax 2003), or 2) additional global mean sea level rise of up to 70cm by 2100 that may arise from instability in the Antarctic ice sheet. These data should also be considered alongside local knowledge of wave climate and storm tides to assess potential future water levels at specific coastal locations.

The rise in sea levels around the province is exacerbated by the sinking of the coast in the southern region of Atlantic Canada resulting from the continued response to the historical ice sheet retreat in this region, which results in glacial isostatic adjustment (Rapaport et al. 2013, DFO 2018a, Cohen et al. 2019). Glacial isostatic adjustment (GIA) (also known as post-glacial rebound, or PGR) has been modelled in Atlantic Canada and has shown great spatial variation (James et al. 2014, Greenan et al. 2015, James et al. 2021). Subsidence (sinking) of land occurs at a rate of roughly 2 mm/year in some parts of the region including along the coasts of Nova Scotia. For example, modelled results for Halifax for the period between 1950 – 2050 show land subsidence of 2.2 mm/year according to Greenan et al. (2015), while areas like the Gulf of St. Lawrence experience land uplift by about 2 – 5mm/year (Greenan et al. 2015, Greenan et al. 2019a). Flooding and wave action accompanying rising sea levels will increase coastal erosion, altering sedimentation, and modifying coastal ecosystems (Lemmen et al. 2016).

Changes in fluvial, pluvial, and coastal flooding are expected to be one of the top impacts resulting from climate change in Atlantic Canada, as increased rainfall, rapid-onset snowmelt, sea level rise, as well as events like hurricanes and storms become more frequent and severe (Environment Canada 2010, Knuston 2021 [online]). Most communities in Nova Scotia are situated along the coast, making the projections of low-lying coastal area flooding more concerning (Rapaport et al. 2013). Higher sea levels can expose coastal areas to greater storm surges (DFO 2018a). Modelled 40-year (hindcast) return levels of extreme storm surges for Atlantic Canada, performed by Bernier et al. (2006), show storm surge levels that reach up to 1.3 metres along the northern coasts of Nova Scotia (Bernier et al. 2006). It is anticipated that storm surges will become stronger and more frequent as sea ice cover diminishes, but their potential effect on extreme water-level events is not known because projections are not yet robust (Bush and Lemmen 2019). Saltwater intrusion from rising sea levels will impact surface and groundwater quality (NSMA 2015, Lemmen et al. 2016). The ecology of coastal areas in Atlantic Canada is also expected to be more significantly impacted by sea level rise than for other parts of the country (ClimAction Services 2017).

In addition to sea level rise, Nova Scotia has already experienced other changes in ocean conditions such as increased ocean temperatures, ocean acidification, decreased marine oxygen levels, and algal blooms (Bush and Lemmen 2019, Reid et al. 2019). For example, increasing air temperatures are contributing to rising sea surface and deep seawater temperatures, which will have implications for physical oceanic processes and species (DFO 2018a). More frequent and longer marine heatwaves, defined as sea surface temperatures that exceed the 90th percentile of observed temperatures for a minimum of five days, pose risks to marine habitats and species (Howarth et al. 2021).

The ocean's uptake of atmospheric carbon dioxide (CO_2) is strongly, and positively linked to its acidification. CO_2 dissolved into the ocean forms carbonic acid which can be corrosive to organisms including molluscs, crustaceans, and corals (DFO 2018a). Decreases in ocean pH (increased acidity) have been observed along Canadian coasts with the north Atlantic region experiencing the largest decreases (Greenan et al. 2019a). There are no discernable trends in nutrient concentrations throughout the waters of Atlantic Canada (Greenan et al. 2019a), but ocean water in the Nova Scotia shelf region is particularly sensitive to acidification due to its limited buffering capacity, which is attributed to large freshwater nutrient inputs and exposure to high-CO_2 hypoxic waters from the Gulf of St. Lawrence (Gledhill et al. 2015; Azetsu-Scott 2019). Since 2015, phytoplankton abundance, a measure of ocean productivity, has declined throughout the waters surrounding the province to below-average levels (DFO

2018a). Ocean acidification may also lead to algal blooms that have the potential to harm or kill fish (Haigh et al. 2015, Bush and Lemmen 2019).

Ocean oxygen concentrations have also decreased, in part due to reduced solubility of oxygen in warmer upper-ocean waters, anthropogenic nutrient inputs that enhance remineralization and reduce pH, and due to density stratification from freshwater inputs that disrupt vertical mixing and reduce ventilation (DFO 2018a, Greenan et al. 2019a). At extremely low oxygen levels (hypoxic conditions), which have been observed in the Gulf of St. Lawrence, species growth, reproduction, distribution, and survivorship can be reduced or altered (DFO 2018a). For some coastal waters around the province, many of these changing ocean conditions have led to the decline of eelgrass beds, which play an important role in water filtration, sediment stabilization, and as nursery and feeding habitat for several economically and recreationally significant fish species, like Atlantic cod and white hake (DFO 2018a).

3 Impacts of Climate Change to the Wellbeing of Nova Scotians

Section Summary

The wellbeing of Nova Scotians can be regarded in terms of people's access to five "capitals": natural capital (nature's benefits), social capital (safe communities and healthy relationships), human capital (fulfilling livelihoods and educational opportunities), financial capital (economic stability), and manufactured capital (supportive infrastructure and homes). This section provides a snapshot inventory of the five capitals in Nova Scotia and discusses some of the ways climate change will affect that inventory.

Natural Capital
Climate change will decrease access to natural capital through shifts in the seasonal availability and quality of fresh water, more frequent forest disturbances, changes to species ranges, composition, and primary productivity affecting harvest opportunities, more frequent air quality issues from smog and fire smoke affecting health, and increased risk of flood waters breaching of existing natural and built infrastructure that protects coastal communities.

Social Capital
Climate change impacts to social capital may include reduced feelings of personal safety and increased difficulty providing aid to those in need following climate-related disasters, as well as unequal distribution of community risk based on disparities in access to political influence. Social capital also shapes approaches to climate change adaptation, including motivation to take collective action and information-seeking behaviour to support climate action.

Human Capital
Human capital will be affected by reductions in mental physical and wellbeing because of enhanced exposure to extreme conditions such as heatwaves, floods, and storms. These events coupled with gradual changes in climate may alter food and water security, reduce air quality, increase exposure to contaminants and diseases, limit engagement in cultural, spiritual, ceremonial and subsistence practices, and reduce access to health resources via damage to critical infrastructure. The impacts of climate change will be worse for those with underlying health conditions and those who already face barriers to affordable housing, food and water security, healthcare, and emergency response services.

Financial Capital
Financial capital will be reduced through disturbances to resource-based industries. The fishing industry will face reduced quality and quantity of valuable marine species from disruptions to ocean environments. Forestry will be impacted by droughts, fires, insect outbreaks, and shifts in species distributions. The agricultural industry will experience altered growing regimes and crop damage from flash floods and pest outbreaks. Changing precipitation and storm activity may alter or reduce energy production and natural resource extraction. The impacts of climate change exacerbate the risk of business interruption for local retail outlets and services (e.g., tourism-related services).

Manufactured Capital
Manufactured capital may be impaired by damage to homes, workplaces, critical infrastructure, and equipment due to sea-level rise, flooding, and intense storms. Opportunities to limit exposure to these climate-related hazards include land use planning, zoning restrictions and the provision of updated, publicly-available hazard maps. Disaster recovery offers a window to build with climate resilience in mind. Physical relocation of structures and entire communities may also be necessary in cases of repeated events causing persistent loss and damage. Infrastructure hardening and ongoing maintenance lessen structures' sensitivity to climate damages.

As a coastal province with an elongated landmass stretching approximately 580 km, and with more than 60% of the population (CBCL 2009) and several economic activities taking place along or adjacent to these coasts, Nova Scotia is particularly exposed to the impacts of climate change (NSE 2005, Rapaport et al. 2013). The extent of impacts will vary from region to region but will likely result in evolving long-term and permanent effects to the province's environment, economy, and ways of life (Savard et al. 2016). The physical effects of climate change reported in the previous section will therefore have wide-ranging impacts on the **wellbeing** of Nova Scotians.

There is no universally-accepted definition for human wellbeing. For the purpose of this report wellbeing has been defined by the Province of Nova Scotia to characterize "how we are doing" as individuals, households and communities.[1] Informed by the Organization for Economic Cooperation and Development's (OECD's) Better Life Initiative[2] and the New Zealand Living Standards Framework[3], the project team at Nova Scotia Environment and Climate Change also identified 12 domains of wellbeing that capture outcomes, across generations, for individuals, households and communities 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.

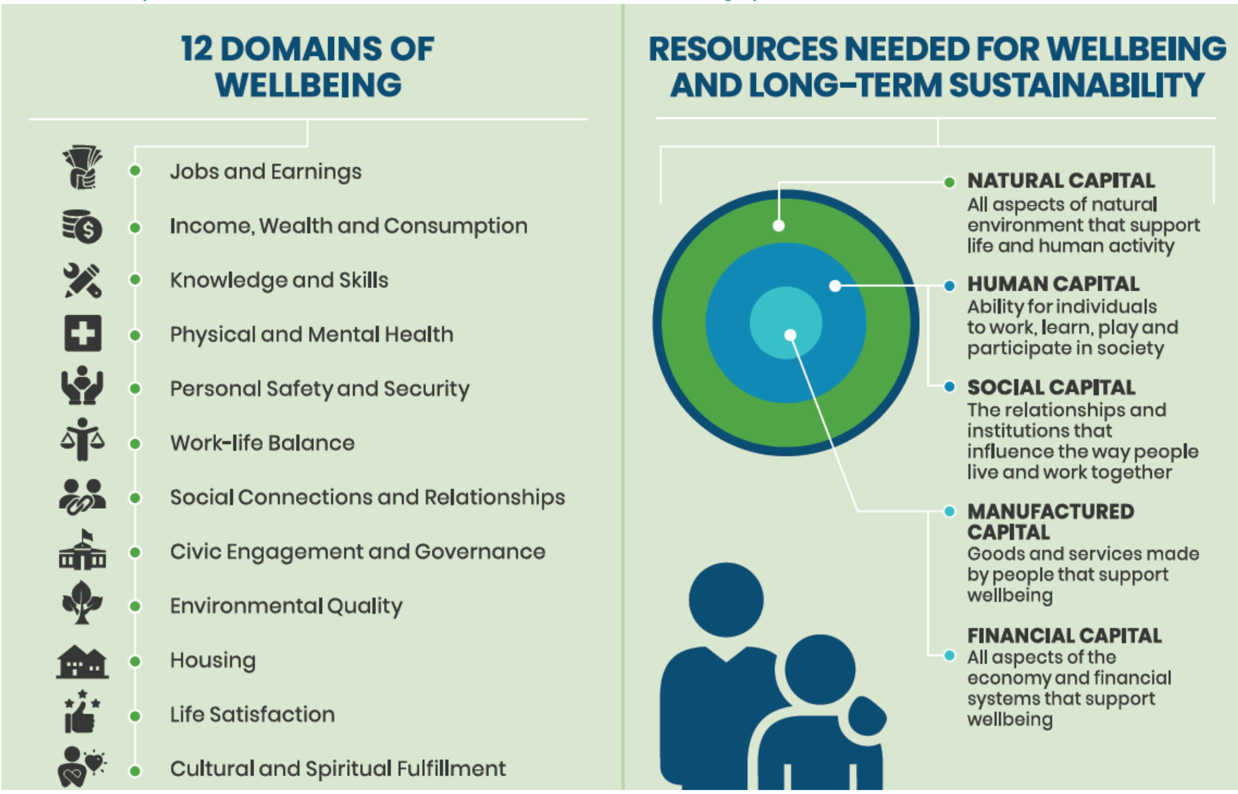
The 12 domains of wellbeing and resources that contribute to them are illustrated in Figure 3-1.

[1] This working definition was adapted from "What Works Wellbeing Definition" (https://whatworkswellbeing.org/about-wellbeing/what-is-wellbeing/) by Nova Scotia Environment and Climate Change.

[2] See: https://www.oecd.org/statistics/better-life-initiative.htm.

[3] See: https://www.treasury.govt.nz/information-and-services/nz-economy/higher-living-standards/our-living-standards-framework.

Figure 3-1. Domains of wellbeing and the resources needed to attain fulfilling and sustainable outcomes (Nova Scotia Environment and Climate Change)



Resources that contribute to wellbeing can be thought of in terms of the **stocks** and **flows** of five types of capital. For example, a wetland (stock) contributes to wellbeing by providing opportunities for recreational bird watching, while also providing flood protection and moderating rates of freshwater pollution (flow) by filtering contaminated water. The supply of housing (stock) might support a certain standard of living, while the unemployment rate (flow) might decrease that standard of living. Capital is a term commonly used in economics to refer to physical or financial assets that have economic value and that are owned by a company, individual, or the state. Social scientists have extended this concept to the whole of society to refer to the assets held by society that contribute to current and future wellbeing. Table 3-1 lists the five types of capital we consider in this study (see Glossary of Terms), describes their relationship to wellbeing, and provides some illustrative stocks and flows for each capital.

Table 3-1. Types of capital and their relationship to wellbeing with example stocks and flows

Types of capital	Definition	Relationship to wellbeing	Example stocks	Example flows from the stock
Natural capital	The stock of physical assets in the environment and the processes from which humans obtain benefits (Jones et al. 2015) and that sustain life on the planet.	Access to nature's benefits, such as environmental quality	Area of wetlands Forested land base	Moderated rates of freshwater pollution Rates of production (e.g., forestry, mining)
Social capital	The stock of contacts, trust, reciprocity, and mutual understanding associated with social networks (Jones et al. 2016). Social capital can be eroded by inequitable distribution of other capitals	Safe communities with trusted institutions and relationships	Trust in institutions Social networks Civic engagement	Crime rates
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 (Jones et al. 2016).	Healthy, fulfilling lives with opportunities to learn, contribute and play	Working population Skills/expertise	Rates of volunteerism Rates of chronic disease and premature mortality
Financial capital	Money that facilitates the interaction of other forms of capital by funding the activities that might be required for the services to be acquired, realised, managed, or improved (Jones et al. 2015).	Economic security and living standards	Net financial assets (e.g., stocks, bonds, cash)	Trade with other regions Investment (e.g., in infrastructure or research)

Types of capital	Definition	Relationship to wellbeing	Example stocks	Example flows from the stock
Manufactured capital	Manufactured assets, such as roads, vehicles, houses, machinery (Jones et al. 2015) that are built from inputs of materials (natural capital) using energy, labour, and production technologies that rely on human and financial capital (Maack & Davidsdottir 2015).	Good homes, the provision of goods and services, and supportive infrastructure	Supply of housing Road network Power stations Public transit fleet	Rates of transit use Electricity use Potable water consumption

It is important to understand these capitals as a nested, interdependent hierarchy with each level of the hierarchy supporting elements of the next level (Figure 3-1). Since humans depend on **natural capital** for basic survival needs, none of the other forms of capital would exist without it. Likewise, financial and manufactured capital are derived from social and human capital. Without skills and expertise (**human capital**), people would not be able to build houses or transit routes (**manufactured capital**). Without trust in financial institutions (**social capital**), people would be less likely to contribute to borrow or save (**financial capital**), which is made possible, in part, by those institutions. It is also important to recognize that resources that contribute to wellbeing are unevenly distributed across people, places and in time. Certain individuals and communities have less access to the types of capital highlighted here, shaping all aspects of climate change risk. Section 4 introduces these inequities.

The following sections provide a broad overview of these five types of capital that support wellbeing in Nova Scotia, **and review some of the ways key capital stocks and flows are expected to be affected by climate change.** These sections are not a comprehensive inventory of all stocks and flows of the five capitals.

3.1 Natural Capital

Nova Scotia's land mass comprises forests (75.8%), coastal and inland wetlands (2.9%), inland water (4.2%), agricultural lands (4.9%), urban areas (2.8%), and naturally non-forested areas (7.8%) (Government of Nova Scotia 2017b). The wellbeing experienced by humans is supported by the natural environment and the benefits it provides that permit us to meet our basic physiological and safety needs, as well as more intangible needs like spiritual fulfillment, artistic expression, and opportunities for recreation and leisure (MEA 2003). Human access to nature's benefits is realized through the supply and availability of natural capital, or the physical, living, and non-living, resources humans derive from an environment, as well as any natural processes that benefit humans. These benefits from nature are often referred to as **ecosystem services**[4].

The Millennium Ecosystem Assessment (MEA) identifies **provisioning**[5], **regulating**[6], and **cultural services**[7] as well as **foundational/supporting services**[8] like habitat and biodiversity (MEA 2003). The ecosystem services framing is inherently anthropocentric – it is about how nature's benefits contribute to the wellbeing of people. There are other ways of thinking about nature's benefits that encompass non-human values, but since this study is focused on human wellbeing, the anthropocentric framing is germane.

The MEA ecosystem service categories are commonly used in welfare economics to assess costs and benefits to society of different policy options. An important distinction to be aware of is the difference between "use" and "non-use" ecosystem services, where the latter are non-consumptive benefits from nature such as the "existence value" of a particular species – the wellbeing people experience knowing a species exists somewhere, regardless of whether they ever encounter, harvest, or consume it. Both "use" and "non-use" values are captured in the MEA categories. In the following sub-sections, for each MEA category, we provide a snapshot that summarizes key ecosystem components in Nova Scotia, the services they provide, and a brief overview of unique provincial characteristics.

Provisioning Services Snapshot

Provisioning services provide humans with physical, living, and non-living resources (MEA 2003). Examples include timber supply, non-timber forest products, food, minerals, energy sources (hydro, solar, wind, tidal, biomass, geothermal, fossil fuels), water supply, medicinal supply, materials supply, shipping/navigation opportunities, and genetic materials. Nova Scotia is situated in the Acadian Forest Region where softwood trees comprise the greatest coverage of the land base (compared to mixed wood and hardwood). Dominant species include Red Spruce, Balsam Fir, Sugar Maple, and Yellow Birch (NSE 2005). Non-timber forest products commonly derived from the province's forests include maple and birch syrup, mushrooms, berries, bark for basket weaving, and herbal medicines (Sutherland 2008).

The Mi'kmaq historically settled along the coasts and estuarine areas, with water serving as the primary medium for transportation and providing important food resources (NSE 2005).

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[4] According to the MEA, Ecosystem Services are defined as the benefits people obtain from ecosystems (MEA 2005). Various kinds of ecosystem services have been defined but the original high-level typology from the Millennium Ecosystem Assessment included **provisioning** services such as food, water, timber, and fiber; **regulating** services that affect climate, floods, disease, wastes, and water quality; **cultural** services that provide recreational, aesthetic, and spiritual benefits; and **supporting** services such as soil formation, photosynthesis, and nutrient cycling.

[5] Provisioning Services are 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 (MEA 2003).

[6] Regulating Services are ecosystem services that benefit humans through regulating natural processes. Examples include climate regulation, disease control, water quality regulation, and air/water purification (MEA 2003).

[7] Cultural Services are 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 (MEA 2003).

[8] Supporting Services are ecosystem services that generate the habitat and biodiversity needed to support plant and animal species. Examples include soil formation, nutrient cycling, and primary productivity (MEA 2003, Bohnke-Henrichs et al. 2013).

Prior to the establishment of reserves, these communities could adjust to changing climatic conditions through seasonal movements to take advantage of opportunities in resource abundance. The maritime waters surrounding the province have also fostered a rich history of larger-scale commercial fishing as well as international marine shipping and navigation dating back to the 1700's (Port of Halifax n.d.). Important marine species that are commonly fished or farmed include haddock, redfish, herring, clams, scallops, lobsters, and crabs, among others (DFO 2018c).

Natural resources that provide energy are also part of Nova Scotia's natural capital. As of 2018, 63% of the province's electricity generation came from coal and coke, 12% came from wind power, and 9% came from both hydro and natural gas (Canada Energy Regulator, n.d.). Nova Scotia operates several hydroelectric plants throughout the province that collectively produce 400 MW of electricity, a biomass power plant that produces 60 MW, and many commercial wind turbines (Nova Scotia Power, n.d.).

Arable land in Nova Scotia is a form of natural capital that permits food production. Approximately 4.3% (435,000 ha) of the provincial land base is currently being used for agriculture (Devanney 2010). Sod production makes up a small proportion (1.2% in 2011) of the province's arable croplands (Sangster, n.d.). All regions in the province engage in some level of farming, but Kings County and Cumberland have the highest proportion of farms (NSFA 2013).

In terms of water supplies, 46% of the province's **potable** water is provided by Nova Scotia's naturally occurring groundwater supply (NSE 2005).

Regulating Services Snapshot

Regulating services benefit humans through regulation of natural processes. Examples include climate regulation, disease control, water quality regulation, flood and erosion protection, and air quality regulation (MEA 2003). Smog levels in the province have declined by about 19% between 1999 and 2009, but air pollutants of concern include ground-level ozone, particulate matter, carbon monoxide, nitrogen oxides, sulphur dioxide, volatile organic compounds, and hydrogen sulphide (Canadian Wellbeing Index 2018). Nova Scotia's forests store approximately 107 million tonnes of carbon and provide important air quality regulation (NSE 2005).

The province's wetlands, most of which are peatlands, filter and store water, and naturally regulate flooding through the absorption of surface water during precipitation events, and the release of water during dry periods. (Sherren et al. resubmitted, in review). The province has an extensive array of dykelands for coastal protection (e.g., 243 km of dykes protecting 17,500 hectares of land in the Bay of Fundy) that also provide important habitat for many animals (NSMA 2015).

The greatest extent of salt marshes occurs along the Bay of Fundy and Minas Basin (Chmura and van Ardenne 2019). Salt marshes in the Bay of Fundy perform several regulating services, including pollination, nutrient cycling, wave attenuation, and sediment transport, as well as climate regulation through the storage of about 8 million tonnes of carbon (Chmura and van Ardenne 2019).

Winter sea ice formation in the Gulf of St. Lawrence is an important regulator of primary productivity by phytoplankton, and thus the productivity of upper trophic levels (Lemmen et al. 2016).

Cultural Services Snapshot

Cultural services are the intangible benefits humans derive from ecosystems through spiritual, cognitive, and experiential enrichment. Examples include opportunities for spiritual and religious inspiration/expression, tourism/recreation opportunities, aesthetic appeal, artistic inspiration, opportunities for intergenerational transfer of knowledge, research and education, mental health, and a sense of identity and cultural meaning (MEA 2003).

Of these services, tourism and recreation opportunities are usually the easiest to quantify. Many such activities in the province are ocean-related, including sailing, boating, kayaking, windsurfing, surfing, fishing, whale watching, and scuba diving. Non-ocean activities include fossil hunting, hiking, bird watching, and hunting (NSE 2005). In 2019, approximately 2,301,000 tourists visited Nova Scotia generating revenues of $2.64 billion (Tourism Nova Scotia, n.d. [online]). In 2018, the province's tourism industry employed 47,000 individuals, with 61% of jobs in food and beverage services, 13% in accommodation, and 11% in recreation and entertainment (Government of Nova Scotia 2020c). Education and research opportunities are also provided by Nova Scotia's landscapes, especially its forests. For example, the province's Natural Resources Education Centre (NREC) provides opportunities for youth to learn nature and encourages future stewardship of Nova Scotia's forests (Government of Nova Scotia 2019).

Natural capital is of intrinsic value to Indigenous peoples in Nova Scotia while simultaneously contributing cultural services to non-Indigenous people. For example, salt marshes in the Bay of Fundy support the cultural identity, practices, and belief systems of the Mi'kmaq, while also creating opportunities for birdwatching and other recreational and educational activities, opportunities for social relationship building, and foster a sense of place among Indigenous and non-Indigenous people alike (Lemmen et al. 2008). The Mi'kmaq have historically relied on access to raw natural materials to make clothing, tools, and dwellings (e.g., wooden poles wrapped with birch bark and sewn with spruce roots). The ability to carry forward knowledge of these traditional practices in perpetuity is important to the survival and evolution of Mi'kmaq culture (Heritage Newfoundland and Labrador 2009). Sea level rise has been highlighted as having the potential to damage the heritage site of Africville, a former African Nova Scotian community that was established in the 1840's, and that was demolished in the late 1960s (The ENRICH Project n.d.[9]).

Foundational/Supporting Services Snapshot

Foundational/supporting services are needed to create habitat and support plant and animal species valued by humans. Examples include soil formation, nutrient cycling, and primary

[9] The ENRICH Project, nd. Welcome to the Africville Story Map. Available at: https://dalspatial.maps.arcgis.com/apps/Cascade/index.html?appid=e7847621b45148b3b21e0800a4e73419&embedd

productivity (MEA 2003, Bohnke-Henrichs et al. 2013). The status of species-at-risk in a region is one way of understanding the condition of these services. Nova Scotia is home to 33 endangered species, 13 threatened species, and 17 vulnerable species. (Government of Nova Scotia [online] n.d.). The listed Atlantic whitefish, for example, is only found in the province and breeds in the Petite Riviere watershed (Biodiversity Panel of Expertise 2010). Some threatened species, like the bobolink, depend on farmland habitat and are at risk by agricultural clearing practices. (Nocera 2005). Over one third of the Atlantic Coastal Plain Flora (ACPF) are only found in Nova Scotia, with 12 species listed as at-risk, and two provincially and federally listed as endangered (Nova Scotia's Atlantic Coastal Plain Flora: Recovery and Stewardship [online] n.d., Environment Canada and Parks Canada Agency 2010).

Forest ecosystems in the province also sustain critical habitats for several charismatic species including the Great Blue Heron and the Bald Eagle (NSE 2005). The parent material for soils throughout the province varies from location to location; in the Halifax regional district, most soils are formed from glacial drift (MacDougall et al., 1963). Nova Scotia does not have any Class 1 soils, which are the best for growing crops. Most soils are acidic podzolic class (Sangster, n.d.) comprised of an acidic layer (Ae Horizon) and a layer rich in iron and aluminum (the B Horizon) (Perennia 2018) and are low in organic matter and not highly fertile. Nutrient cycling is largely moderated by Nova Scotia's forests which take up nutrients from the atmosphere and soils, and deposit them back through litter fall (Porter et al. 2010). Primary productivity in Nova Scotia's oceans is largely driven by phytoplankton occurrence; carbon consumed by these organisms is deposited to deeper levels of the ocean as they die, where they are consumed by zooplankton and other benthic organisms, forming the foundation of the marine food chain (Fuentes-Yaco et al., 2015).

Climate Impacts to Natural Capital

Climate change will decrease access to natural capital through shifts in the seasonal availability and quality of fresh water, more frequent forest disturbances, changes to species ranges, composition, and primary productivity affecting harvest opportunities, more frequent air quality issues from smog and fire smoke affecting health, and increased risk of flood waters breaching of existing natural and built infrastructure that protects coastal communities.

The climate change impacts described in Section 2 affect Nova Scotians' access to stocks and flows of nature's benefits. With rising temperature, increased snowmelt will result in higher streamflow in spring, but lower streamflow in summer. In conjunction with increased summertime surface water evaporation, these trends will result in a disruption to the seasonal availability of freshwater in some locations, limiting the ability of ecosystems to withstand droughts, and impacting human communities that depend on naturally occurring stocks of freshwater for drinking (Bush and Lemmen 2019).

Saltwater intrusion into surface water and groundwater from sea level rise will similarly impact terrestrial environments and water quality, which is of particular concern for the Upper Lawrencetown and Pictou areas that depend on groundwater as their main source of potable drinking water (NSMA 2015, Lemmen et al. 2016). Although a significant number of dykes have been constructed to reduce inundation of lands by ocean water, during periods of heavy rain these dykes may lead to inland freshwater flooding by impeding drainage from overflowing streams and rivers (Lemmen et al. 2016). Heavy rainfall and snowmelt in the spring can lead rivers and tributaries to overflow, flooding the adjacent land, and amplifying the amount of runoff entering the fluvial system (Dietz and Arnold 2021). During increasingly frequent and heavy rain events with high runoff, sources of freshwater are also at greater risk of contamination from nutrients, pollution, garbage, animal waste, and sediment inputs (Lemmen et al. 2016).

Forest disturbance regimes and species composition are expected to be one of the most impacted natural processes (Taylor et al. 2019). More severe storms will result in increased tree blowdown (NSE 2005). Higher air temperature and lower than typical springtime precipitation has already resulted in increased risk of summer droughts and forest fires (NSE 2005, Lemmen et al. 2008). Forest fires have the potential to significantly change forest composition (Lemmen et al. 2008), by increasing the amount of early successional forests and decreasing in the amount of late successional forests. For example, forests in Aspy Bay are expected to entirely shift from boreal to mixed forests, altering the ecology of the land and the species it is able to support (NSE 2005, ClimAction Services 2017). Such changes to tree species composition can facilitate insect infestations. Historically, Gypsy Moths were not particularly destructive in Atlantic Canada because their populations were regulated by prolonged winter temperatures below 9^{o}C. As temperatures rise, Gypsy Moths are more likely to survive through winter and cause more extensive defoliation. The Gypsy Moth prefers foliage from hardwood trees, so any potential shift in forest composition to more hardwood species places those ecosystems at greater risk (NSE 2005, ClimAction Services 2017). Also relevant to forests, altered temperature, precipitation, and wind regimes may increase soil erosion and run-off, which will impact habitat availability, wildlife, and sedimentation.

Climate change alteration of meteorological conditions and atmospheric chemistry will affect the levels of pollutants present in the air (Lemmen et al. 2008). As wildfires become more frequent, emissions of particulate matter from fire smoke will increase, significantly impacting air quality (Lemmen et al. 2008). Higher temperatures lead to greater rates of ozone formation (Lemmen et al. 2008). Ozone that forms at ground-level contributes to the creation of smog, and can inhibit biochemical and physiological processes in vegetation, and damage human lungs (NSE 2009; CICC 2021). Individuals who already suffer from cardiovascular and respiratory illnesses are particularly vulnerable to further damages to their health (Lemmen et al. 2008).

Coastal ecosystems like salt marshes and beaches are at risk from an increased rate of sea level rise, which will increase the frequency and duration of flood events and land loss, interrupting or diminishing the quality and quantity of services these **natural assets** normally provide (NSE 2005). Beaches are particularly susceptible to erosion in coastal areas that are composed of loose sand and gravel, with one site in eastern Nova Scotia retreating at a rate of up to 10 metres per year, with stabilized barrier beaches migrating less than 0.6 metres per year (Taylor 2007). Beach erosion rates are also exacerbated by sea ice melt (Manuel et al. 2014, Lemmen et al. 2016). The existence of hard/grey infrastructure like seawalls undermines the capacity of the land to naturally adapt to the coastal changes brought about by rising sea levels, and under certain wave and storm conditions can exacerbate flood and erosion risk (e.g., by interrupting dynamic sediment transport processes) (Conger 2018). Flood extent depends largely on the natural characteristics and topography of shorelines, such as higher versus low-lying coastal rocky areas versus sandy/muddy areas, and these characteristics will be altered by increased erosion (ClimAction Services 2017). In some cases, climate change will increase the area of available marshland, but at the cost of other natural capital. For example, flood projections for Aspy Bay suggest it will convert to marshland, with more frequent storm activity inhibiting long-term recovery to a more naturally resilient state (ClimAction Services 2017).

Climate change is altering the ranges and distributions of terrestrial and aquatic species, which will subsequently change the quality and availability of food sources (Lemmen et al. 2016). More frequent droughts will impact the productivity of the agricultural land base and water quality (Government of Canada 2017). Severe weather, animal health, and changes to migration patterns also influence the ability of people to engage in food harvesting activities like hunting and fishing (NSE 2005, Lemmen et al. 2016). Marine species distributions will change in response to changing ocean salinity, which is decreasing in coastal waters of Nova Scotia possibly due to freshwater inputs from melting Arctic ice (Lemmen et al. 2016). The reduction or potential loss of winter sea ice in the Gulf of St. Lawrence will adversely affect phytoplankton abundance and distributions, changing primary productivity in the basin with ripple effects on upper trophic levels (Lemmen et al. 2016).

As marine ecosystems change, the resources needed to sustain certain species may become scarce, resulting in a shift in species distributions (Murison 2017). Marine species are also impacted by changes to wetland ecosystems. Several marine species of fish and shellfish that are important to Nova Scotians depend on coastal salt marshes as nursery habitat at one or more of their life stages, as these areas provide refugia and an abundance of food. Loss and inundation of salt marshes will negatively impact the productivity of commercial fishery industries that benefit from harvesting these marine species (Endresz 2020), but other fish-dependent ecosystem services will also be affected like recreational fishing, subsistence use, and cultural heritage values.

As sea surface temperatures and deeper ocean temperatures warm, ocean hydrodynamics and currents will be impacted, leading to habitat loss, disruptions to life cycles, and further changes in the distribution of fish species critical to fisheries (NSE 2005). Increasingly acidic ocean conditions in the region will alter ocean chemistry, dissolve and inhibit the growth of shells and skeletons of marine organisms, increase mortality rates of young organisms, alter species behaviour, alter food webs, and reduce the availability of suitable habitat (Greenan et al. 2019a). Marine species such as lobsters, clams, oysters, and other molluscs, crustaceans, and fish may be particularly at risk from acidification (Gledhill et al. 2015).

Moreover, climate change will continue to increase the frequency and intensity of storms and hurricanes throughout the province, amplifying the impacts of wave action and flooding caused by storm surges. Subsequent flooding and wave action will lead to coastal erosion, modifying coastal sedimentation processes, and degrading critical habitat for fish and other marine organisms (Lemmen et al. 2016). Some of the impacts of a changing climate have already been observed in groundfish landings, which represented 68% of total landings in 1984 but have since declined to 16% of total landings as of 2018 (NSE 2005, DFO 2018b).

The livelihoods of those employed in resource-based jobs throughout Nova Scotia are potentially at-risk following climate-related changes to the province’s natural capital. For example, shifts in tree species distributions and forest composition may have implications for timber production, altered pest occurrences will present challenges for agricultural production, and increasingly acidic ocean conditions and warmer water temperatures will drive a further significant decrease in lobster and shellfish production (Cochran et al. 2012, Greenan et al. 2019b). A more in-depth overview of the impacts of climate change on many of Nova Scotia's industries and livelihoods is provided in the Financial Capital section of this report (Section 3.4).

3.2 Social Capital

A key contributor to the wellbeing of Nova Scotians is the extent to which they can maintain or expand their networks of relationships, which support their values, goals, and interests, feel a sense of trust toward existing institutions, and live safely in their communities. These benefits are realized through stocks and flows of **social capital,** or the contacts, trust, reciprocity, and mutual understanding associated with social networks and institutions (Jones et al. 2016). Examples of factors that contribute to social capital include civic engagement, volunteerism, political engagement, club affiliations, family stability, and trust for government institutions (Maack & Davidsdottir 2015). Table 3-2 provides a snapshot of unique Nova Scotia characteristics for three domains of wellbeing linked to social capital: relationships, civic engagement and governance, and personal safety and security.

Table 3-2. Key elements of **social capital** in Nova Scotia, with a snapshot of unique provincial characteristics

Elements of Social Capital	Snapshot of Nova Scotia Characteristics
Relationships	• "Community vitality", which represents the richness and diversity of relationships as well the adaptive capacity and resilience among its people, has increased by nearly 6% since 1994 (measured using eight indicators including percent of population expressing feelings of belonging, safety, eagerness to help others, and the crime severity index, among others). • About 75% of Nova Scotians feel a strong sense of belonging in their communities (as of 2014). • The willingness of most citizens (80%) to provide unpaid help to those in need is an indicator of strong social cohesion and trust (based on 2014 data). • Between 1996 and 2014 the number of Nova Scotians who have five or more close friends fell from 70.9% to 52.3%. • The average time spent with friends in the province has dropped from about 160 minutes per day to 87 minutes per day, between 1994 and 2014.
Civic Engagement & Governance	• Democratic engagement, or being involved in political institutions, organizations and/or activities that advance democracy, has increased slightly since 2012. • Voter turnout during federal elections increased to 70.5% in 2015 (from 62% in 2011), higher than the national average, and with more younger adults between the ages of 18 to 34 voting compared to previous years. • Confidence in federal parliament has declined significantly since 2004, with only one in four people expressing a great deal of confidence as of 2014.

Elements of Social Capital	Snapshot of Nova Scotia Characteristics
	• The number of hours spent volunteering for cultural and recreational activities has declined by nearly 30% since 1994 (current provincial average is about 34 hrs/yr and used to be at about 47 hrs/yr in 1994).
Safety & Security	• Crime severity in Nova Scotia has declined by 58.4% since 1998, with 75% of Nova Scotians reporting that they feel safe (there is a disparity between men and women in this figure, with 92% of men reporting feelings of safety, while only 66% of women reporting the same). • The percent of Nova Scotia's population that experiences discrimination based on ethnicity sits at around 5% and is more prevalent among people aged 25 and younger, and among racialized groups. • The known (reported) domestic violence rate against women in Nova Scotia increased by 14.3% between 2016 and 2019. This value is 10.4% higher than the Canada-wide increase for the same period.

Sources: Canadian Wellbeing Index 2018, NSACSW 2020

Climate Impacts to Social Capital

> *Climate change impacts to social capital may include reduced feelings of personal safety, increased difficulty providing aid to those in need following climate-related disasters and unequal distribution of community risk based on disparities in access to resources and political influence. Social capital also shapes approaches to climate change adaptation, including motivation to take collective action and information-seeking behaviour to inform action.*

A population's capacity to prepare for, endure, and recover from impacts associated with climate change is linked to social capital (Manuel et al. 2014). Social, cultural, and political conditions influence individuals' "social vulnerability" or their ability to access the resources they need to withstand challenging situations (Manuel et al. 2014). Characteristics such as relationships, civic engagement and governance, and personal safety and security can foster a sense of belonging and attachment within a community that contributes to cohesive and socially responsible responses to climate-related hazards (Stantec 2012). For example, the ability to rely on friends and neighbours for assistance following a severe storm can speed up the rebuilding process. In the aftermath of Hurricane Dorian in 2019, Nova Scotia communities showcased the important role of social cohesion, with many community members voluntarily checking in on neighbours to ensure they were managing amid widespread and prolonged power outages, paying special attention to senior residents (Richler 2019). Despite a lack of resources, store owners reopened their shops to help residents in need, and many community members supported frontline workers by bringing them food and coffee (Richler 2019, Nova Scotia Power 2020). These acts helped maintain positivity and facilitated more efficient cleanup and rebuilding efforts.

A sense of belonging also benefits physical and mental health, encourages active participation in other community endeavours, and makes communities more stable by reducing turnover rates (BCCDC 2018, Stantec 2012). Climate change can reduce feelings of belonging by altering the environment people live in and enjoy such that a sense of *loss of place* is evoked (Clayton et al. 2017); the loss of places that are important to people can have profound impacts on their sense of stability, security, and identity (Clayton et al. 2017). Community involvement in civic and government activities can reveal how much a community feels included and engaged and fosters a sense of responsibility and trustworthiness among individuals (Government of Canada 2001, Canadian Wellbeing Index 2018). Certain neighbourhoods or municipalities may be at greater risk to climate-change based on their level of political influence. For example, Pinkney's Point in Yarmouth County is seriously at risk of flooding from storm surges but lacks the political (and economic) influence needed to secure funding for climate change adaptation measures (Cochran et al. 2012).

Climate change-related events can increase the risks to personal safety for many individuals. Outdoor workers will be the first to contend with the effects of extreme heat events, disaster responders will be at increased risk from exposure to an increased number of disasters (e.g., wildfires, flooding), and agricultural workers will have to endure increased pesticide exposure from altered weather patterns and disease from insect vectors (Clayton et al. 2017). Further, reduced feelings of personal safety and security, for example due to higher crime rates, can hamper a community's ability to reach those in greatest need of assistance during climate-related disasters (BCCDC 2018). Climate change can exacerbate crime rates by triggering increased hostility, violence, and aggression because of warmer temperatures and reduced access to stress-relieving areas like green spaces (Clayton et al. 2017).

Although conventionally thought of as a positive influence on community resilience, social capital can both enable and pose barriers to climate change adaptation. Some research external to Nova Scotia suggests that communities with high social capital present good opportunities for climate change adaptation, due to individuals' willingness to invest time and resources in measures requiring collective action (Richler 2019a), particularly among groups with collectivist identities (Heard 2019). The impacts of climate change, and related changes in local environmental conditions, may motivate individuals with strong place-based identities to learn about and plan for these impacts (Smith et al. 2012). However, strong ties among people with similar background (so-called bonding ties) can discourage information-seeking behaviour (Smith et al. 2012), create disincentives to adopt behaviours incompliant with social norms (e.g., engineered structures as symbols of effective protection versus untested nature-based solutions) and can foster inflexibility to switch to new adaptation strategies when initially successful ones become sub-optimal (Cherng et al. 2019).

3.3 Human Capital

The wellbeing of Nova Scotians is also dependent on the extent to which they can lead healthy, fulfilling lives with opportunities to learn and contribute to broader society. Human access to these benefits is realized through stocks and flows of **human capital**, or the supply 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 (Jones et al. 2016). The foundation of these forms of human capital is the general population and its demographic characteristics. The socioeconomic status and demographic composition of a community can make it exposed and vulnerable to climate change, as factors such as age, race, education level, and living arrangements, and location choices (or lack thereof) can shape the extent to which people experience climate-related impacts (Cutter et al. 2008, Manuel et al. 2014, Waldron 2021). Table 3-3 provides a snapshot of unique Nova

Scotia characteristics for four key elements of human capital: population and demographics, health, knowledge and skills, and work-life balance. Section 4 of this report more fully explores inequities in the distribution of capitals that contribute to wellbeing, with human capital prominently profiled.

Table 3-3. Key elements of **human capital** in Nova Scotia, with a snapshot of unique provincial characteristics

Elements of Human Capital	Snapshot of Nova Scotia Characteristics
Population & Demographics	• The population has risen since the 1970's (˜800,000), with the July 2020 population estimate at 979,351 (136,790 are children) (Statistics Canada 2021 – Table 14-10-0037-01). • Immigration to the province has increased significantly over the last ~50 years, with the strongest recorded annual immigration occurring between July 2018 and July 2019. (Government of Nova Scotia 2020b). • The province is home to over 180,000 people age 65 years or older (with the third highest proportion of individuals age 65 or older of all the provinces as of 2020), over 50,000 individuals who identify as Aboriginal, and has a sizeable population of ethnic minorities, with the largest racially visible population being African Nova Scotians (Waldron 2016, Statistics Canada 2017, Statistics Canada 2020a – Chart 2.4). • Throughout Canada, Indigenous People are disproportionately affected by climate change, especially those living in remote locations (Government of Canada 2017, ECCC 2020). • The percent of working-aged Nova Scotians as of 2014 is approximately 57.2%, about 5% below that of the national average (Canadian Wellbeing Index 2018). • Nearly 75% of the province's forestry workers live in rural areas (NSE 2005).
Health	• Since 1994, the overall health of the population has increased by about 12%, with life expectancy at about 80.5 years, as of 2014. (Canadian Wellbeing Index 2018) • About 25% of Nova Scotians are afflicted by mobility limitations, with structural deficiencies (such accessible transport) reducing their ability to fully participate as active community members (Canadian Wellbeing Index 2018, Smale et al. 2020). • Most of the population (70%) experiences very good or excellent mental health, but a slightly decreasing trend has been observed since 2001. (Canadian Wellbeing Index 2018). • The proportion of the population (15.3%) that has difficulty accessing and affording quality food is 2.6% higher than the national average, with incidence of food insecurity highest among those who rely on government subsidies and single parents. The province has the fourth highest level of food insecurity (behind Nunavut, the Northwest Territories, and the Yukon) in Canada. (Statistics Canada 2020b).
Knowledge & Skills	• Education is one of the province's highest-performing categories of human capital, with 9 in 10 young adults completing high school, and 1 in 4 adults attaining a university degree (according to 2014 statistics). (Canadian Wellbeing Index 2018). • The province is unofficially known to be the "education destination", with ten universities and many colleges. (Canadian Wellbeing Index 2018). • The perspectives of Indigenous communities in Nova Scotia are inadequately captured in population data, and thus are generally omitted from discussions

Elements of Human Capital	Snapshot of Nova Scotia Characteristics
	about wellbeing in the province. (Canadian Wellbeing Index 2018, Health Canada 2015). • Nearly half of the Indigenous youth who responded in a Canadian First Nations Regional Health Survey reported a loss of culture in their communities. (Canadian Wellbeing Index 2018).
Work-life Balance	• Only about 4% of people's time is spent on arts and cultural activities in Nova Scotia. (Canadian Wellbeing Index 2018). • In terms of rest, only about 35% of Nova Scotians are getting 7 to 9 hours of sleep per night, placing the other 65% at greater risk of mental and physical health issues. (Canadian Wellbeing Index 2018). • Most Nova Scotians engage in physical activity on a daily basis, which supports good health and mental wellbeing (Canadian Wellbeing Index 2018). • About 24% of Nova Scotians are dissatisfied with the balance of activities in their daily life (Canadian Wellbeing Index 2018). • Nearly 9% of employed Nova Scotians worked 50 hours or more per week in 2020 (Canadian Wellbeing Index 2018).

Sources: Health Canada 2015, Waldron 2016, Smale et al. 2020, Government of Canada 2017, Statistics Canada 2017, Canadian Wellbeing Index 2018, ECCC 2020, Government of Nova Scotia 2020a, Government of Nova Scotia 2020b, Statistics Canada 2020a – Chart 2.4, Statistics Canada 2020c – Table 17-10-0005-01, Statistics Canada 2021 – Table 14-10-0037-01

Climate Impacts to Human Capital

> *Human capital will be affected by reductions in mental physical and wellbeing because of enhanced exposure to extreme conditions such as heatwaves, floods, and storms. These events coupled with gradual changes in climate may alter food and water security, reduce air quality, increase exposure to contaminants and diseases, limit engagement in cultural, spiritual, ceremonial and subsistence practices, and reduce access to health resources via damage to critical infrastructure. The impacts of climate change will be worse for those with underlying health conditions and those who already face barriers to affordable housing, food and water security, healthcare, and emergency response services.*

While Nova Scotia's population and its characteristics are the province's greatest source of human capital, this advantage is moderated by the fact that climate-related risk is not only unevenly distributed across space, but also across different demographic groups. Groups that are more vulnerable include Indigenous peoples, elderly populations, children, people with disabilities, people who are unemployed or have lower income, people living alone, people without secondary education, visible minorities, people with language barriers, and immigrants (Manuel et al. 2014, Government of Canada 2017). For example, many of the province's coastal communities have a significant population of individuals aged 65 and older, especially in rural areas. These populations can have greater mobility limitations and can be more isolated, requiring more effort to provide care in the event of an emergency (Rapaport et al. 2013, Smale et al. 2020, Stantec 2012). This extra demand on younger populations and emergency services can reduce their capacity to dedicate efforts elsewhere in response to climate-related impacts. Gender also plays a role – women are at greater risk because they are more likely than men to experience wage discrimination and may be less eligible for unemployment insurance benefits during climate-related disasters (Cochran et al. 2012, Manuel et al. 2014). We turn to distributional and equity issues in more detail in Section 4.

Potentially significant physical and mental health impacts from climate change are expected in Nova Scotia. The number of days where temperatures exceed 30°C are projected to increase in some areas, including large population centres like Halifax. Such heat extremes will increase the risk of heat-stroke and other heat-related health impacts, especially to those who work outdoors, older people, people with pre-existing health conditions, and individuals experiencing homelessness (Lemmen et al. 2008, Richards and Daigle 2011, Dietz and Arnold 2021). The same conditions may decrease food and water security, which affect physical and mental health, by reducing agricultural productivity and water supply (Government of Canada 2017). Hotter weather may also result in more forest fires, decreasing air quality and increasing the number of hospitalizations from respiratory illness like asthma and bronchitis (Lemmen et al. 2008, Whitman et al. 2015). Rising levels of particulate matter due to smoke and smog may decrease the ability to pursue health-enhancing outdoor physical activities (Government of Canada 2017; Boyd et al. 2020). More frequent and intense storms will endanger outdoor workers like fishermen, increasing the incidence of work-related injury and death (Rezaee et al. 2016). More flooding of homes will expose people to mouldy, wet, cold conditions, and water-borne disease. Flood-related runoff from overflowing sewage systems will also expose residents to contaminated water, potentially leading to illness (Lemmen et al. 2008). The rate of infectious diseases, such as those transmitted by insects (e.g., Lyme disease), is expected to change as species ranges shift in response to altered precipitation and temperature patterns. Ancient dormant bacteria and viruses may also re-emerge as polar ice melts, raising the global risk of disease contraction (Government of Canada 2017).

Climate change can contribute to acute and/or chronic impacts on mental health in both the short and long term (American Psychological Association, Climate for Health & EcoAmerica 2017). Physical damage from climate-related impacts like floods can cause significant mental stress as people deal with the loss of or damage to their homes and possessions, or the need to relocate temporarily or permanently (Lemmen et al. 2008, Carroll et al. 2009, Lamond et al. 2015, Clayton et al. 2017, Government of Canada 2017, Woodhall-Melnik and Grogan 2019). Winter and summer storms can disrupt power, heating, transportation corridors, and access to water, putting a strain on the daily activities and life quality of affected people (Dietz and Arnold 2021).

Those who live in isolated locations have more limited access to emergency response, resources, and information at times of mental and emotional crises, a risk that is exacerbated for older or disadvantaged demographics (Government of Canada 2001, Stantec 2012, Rapaport et al. 2013, Waldron 2016, NSMA 2015). Regions of the province, such as Cape Breton, where the incidence of mental health issues and addiction are high, may experience reduced access to health services due to longer wait times (Canadian Wellbeing Index 2018 citing Government of Nova Scotia 2017a). Climate change-induced extreme weather events, pollution, and poor resource availability can cause increased levels of stress which can lead to substance abuse, depression, and anxiety (Clayton et al. 2017). There is evidence that higher temperatures and reduced access to stress-relieving green spaces may increase aggressive behaviour such as domestic violence and rape (Clayton et al. 2017). Other evidence from outside Nova Scotia indicates that some disasters, including wildfires, increase the risk of assault and intimate partner violence (Gearhart et al., 2018; Rao, 2020). Many Nova Scotians are already getting inadequate rest, which increases vulnerability to mental and physical health issues that could be amplified by severe weather events and other stress-inducing climate impacts, as illustrated in the above examples (Canadian Wellbeing Index 2018).

Indigenous communities regard connectivity to the land as critical to mental and cultural welfare, which means climate-related disturbances could pose unique mental health challenges in these communities (Government of Canada 2017). Several of Nova Scotia's Indigenous communities identify mental health as one of the largest health issues they currently face (Canadian Wellbeing Index 2018). Climate impacts that alter the land may worsen this challenge by reducing access to traditional cultural and health practices and medicines integral to wellbeing (First Nations Health Authority 2014), and by reducing the ability to show respect to the land, plants, and animals through spiritual and cultural practices like offering tobacco, prayer, or ceremony (Lefort and Dennis 2014). Coastal erosion and inundation have damaged or destroyed culturally and spiritually important archaeological sites, sacred burial grounds, and lands bearing traditional foods and medicines (Lefort and Dennis 2014, Kassam 2017). Contamination from sewage and chemical runoff following flooding events has also impacted areas that provide traditional food sources for Indigenous communities (CBC News 2018 [online]). The Mi'kmaq have traditionally relied on coastal salt marshes for food and medicine, but inundation of these marsh lands has reduced access to many of the culturally significant natural resources on which they depend (e.g., sweetgrass) (Lemmen et al. 2008). Conversion of culturally significant tidal wetlands into agricultural dykelands has also impacted the ability of Mi'kmaw communities to engage in many of their practices. It is worth noting, however, that extensive work has been done to revert some of these agricultural dykelands back to wetlands (Sherren et al. 2019a).

Information on the impacts of a changing climate on Nova Scotians' knowledge and skills and work-life balance is unavailable in the documents reviewed. Intense storms and flooding may reduce the ability of people to engage in the outdoor activities that currently foster a healthy work-life balance. Being the nation's "education destination", Nova Scotia potentially has a lot at stake if impacts from climate change negatively affect educational infrastructure, the educational workforce, or educational opportunities.

3.4 Financial Capital

Sustainable economic stability – or a dependable way to provide for one's basic needs now and into the future – is a key contributor to the wellbeing of Nova Scotians because, in mixed economies like Canada's, the state of the economy and households' access to liquid assets influences the ownership and exchange of the other four capitals between communities and individuals. The ability of Nova Scotians to own or access these capitals depends on available stocks and flows of **financial capital**, or financial resources that facilitate the interaction of other forms of capital by funding the activities required for goods and services to be realised, managed, or improved (Jones et al. 2016). Table 3-4 provides a snapshot of unique Nova Scotia characteristics for two key elements of financial capital: the economy and household income. The former category is associated with employment (or unemployment), characteristics of the labour force, community or regional economic output, trade, expected business opportunities, and entrepreneurship, all of which provide the goods and services from which people derive wellbeing. The latter category refers to the earnings, wages, and income levels experienced by individuals, which all contribute to household wealth. Both elements of financial capital support material living standards and provide economic security against unforeseen shocks.

Table 3-4. Key elements of **financial capital** in Nova Scotia, with a snapshot of unique provincial characteristics

Elements of Financial Capital	Snapshot of Nova Scotia Characteristics
Economy	**Economic activity** • As of 2019, the most productive economic sectors, as measured by gross domestic product, are: mining and oil and gas extraction; utilities; real estate, rental and leasing; and information and cultural industries (NSE 2005, Statista 2021). Real estate, rental and leasing accounted for 15.8% of provincial GDP (2015-2019), followed by public administration at 12.9% and health care and social services at 10.8%, and manufacturing at 7.4%; natural resource sectors accounted for under 3% of provincial GDP. • Fishing, hunting and trapping alone accounted for 1.9% of provincial GDP (2015-2019). • The province's commercial fishery is the most valuable and diverse in Canada. It exported over $2.3 billion worth of fish and seafood products in 2019. • The 2011 Census of Agriculture reported the operation of 3,905 farms, with 2010 gross farm receipts amounting to $594.9 million (Statistics Canada 2012). • Within the agricultural industry, fruit, greenhouse vegetables, beef, forages, dairy, and poultry comprise some of the top commodities produced (NSE 2005). • Tourism expenditures in 2017 amounted to 2.4% of Nova Scotia's GDP, with most expenditures corresponding to transportation (32%), restaurants (18%) and accommodations (16%) (Nova Scotia Department of Finance 2021 [online]). • The transportation industry in Nova Scotia contributes 2.1% of the province's GDP (2015-2019). • According to 2020 data, Nova Scotia has 32,329 small and mid-sized enterprises (SMEs), which represents 2.4% of the number of SMEs in all of Canada, and a total of 190,060 employed individuals in 2020 (Statistics Canada 2020e, Statistics Canada 2021a). • The average annual growth rate for Nova Scotian small businesses between 2014-2019 was 1%, and the average annual growth rate for medium size businesses for the same period was 0.8%. The Net employment change from 2014–2019 for small businesses was 10,200 employees, and 12,600 employees for medium size businesses (Government of Canada 2020). **Employment** • The number of people aged 15 or over in the labour force, according to the 2016 census, is over 470,000. (Statistics Canada 2017).

Elements of Financial Capital	Snapshot of Nova Scotia Characteristics
	• Underemployment most notably affects street youths, children, people with disabilities, marginalized groups, and immigrants (Government of Canada 2001) • Underemployment also notably affects Mi'kmaq people, with an unemployment rate of 24.6% (according to the 2006 census) compared to 9.1% unemployment rate of all of Nova Scotia (for the same 2006 census year) (Waldron 2021). • Employment in the natural resources sectors (forestry, energy, mining, and hunting/fishing/water) accounted for 2.3% of all jobs in the province in 2020 (Statistics Canada 2021c). • In 2020, the unemployment rate across all industries in Nova Scotia was 9.8%, with nearly 48,000 people 15 years and older unemployed; fishing, hunting and trapping had the highest unemployment rate at 25.3%. The unemployment rate among men was 4.4 percentage points higher than among women. **Vulnerabilities** • Climate change-related damage from severe weather and storms (e.g., coastal flooding) is difficult to account for in damage estimates, which rely on historical weather patterns, thus insurance coverage has become less affordable for affected individuals. • Insurance premiums that do not adequately reflect the risk associated with building structures and homes near flood and erosion-vulnerable coasts incentivises investments in construction in dangerous areas (Sherren et al. 2019b).
Household income	• The 2015 median total (pre-tax) income of "economic families"[10] was approximately $77,530, and prevalence of poverty was about 8% (Low Income Cut Off after taxes or LICOAT) and 17% (Low Income Measure after taxes or LIM-AT) (Statistics Canada 2017). • In 2019, the combined median net worth of Nova Scotian economic families and persons not living in economic families was about $485,000 (Government of Nova Scotia 2021), total debt amounted to $30,706, non-pension and financial savings amounted to $24,852, and the net worth for the lowest after-tax income quintile was $12,792 compared with $113,549 for the higher after-tax income quintile (Statistics Canada 2021d). • As of 2020, 15.7% of Nova Scotians reported annual household income between $40,000 and $59,000, with 5.2% reporting annual household income below $10,000 and 12% reporting over $150,000. The Canadian LICO for rural areas in 2019 was $14,325 for a single-person household, $17,436 for a two-person household, and $21,711 for a three-person household. For areas with populations between 100,000 and 499,999 people (such as Halifax) these values are $18,520, $22,540, and $28,068, respectively (Statistics Canada 2021b). • Indigenous peoples throughout Canada typically have an average income that is 30-40% lower than non-Indigenous Canadians (Cochran et al. 2012).

[10] Statistics Canada defines an economic family as a group of two or more persons who live in the same dwelling and are related to each other by blood, marriage, common-law union, adoption or a foster relationship (Statistics Canada 2017)

Elements of Financial Capital	Snapshot of Nova Scotia Characteristics
	• With a Gini coefficient of 0.29 compared to Canada's 0.31 (higher is worse, 1 represents perfect income inequality), the province has one of the lowest income gaps in Canada between the rich and the poor (Canadian Wellbeing Index 2018). • The province's increase in living standards (compared to 1994 levels) reached 13% in 2014, above the national increase of 11.9%. (Canadian Wellbeing Index 2018) • Nearly one in four children live in poverty, the third-highest child poverty rate in Canada (Frank et al. 2020).

Sources: Alexander et al. 2018, Government of Canada 2001, Government of Nova Scotia 2017b, Government of Nova Scotia 2020e, NSE 2005, Cochran et al. 2012, NSFA 2013, Frank et al. 2020, Canadian Wellbeing Index 2018, Sherren et al. 2019b, Smale et al. 2020, Tourism Nova Scotia n.d. [online], Tourism Nova Scotia 2018, Sherren and Greenland-Smith 2019, Statistics Canada 2017, Canadian Water Network 2020, NSBI n.d., NRCAN 2019, Statistics Canada 2016, Statistics Canada 2021a, Table 14-10-0023-01, Statistics Canada 2021c, Table 36-10-0480-01, Government of Nova Scotia 2021, Statistics Canada 2021d

Climate Impacts to Financial Capital

Financial capital will be reduced through disturbances to resource-based industries. The fishing industry will face reduced quality and quantity of valuable marine species from disruptions to ocean environments. Forestry will be impacted by droughts, fires, insect outbreaks, and shifts in species distributions. The agricultural industry will experience altered growing regimes and crop damage from flash floods and pest outbreaks. Changing precipitation and storm activity may alter or reduce energy production and natural resource extraction. The impacts of climate change exacerbate the risk of business interruption for local retail outlets and services (e.g., tourism-related services).

Nova Scotia's economy has historically included many resource-based industries, such as fisheries, forestry, agriculture, and aquaculture (NSE 2005, DFO 2009). With 14% of all provincial jobs related to the ocean, changes to marine environments like ocean acidification, hypoxia, increased water temperatures, and sedimentation can significantly impact fish stocks and result in economic losses for the fishery sector (Bush and Lemmen 2019, Ndlovu and Charlebois 2020, Howarth et al. 2021).

Warmer, drier summers have already impacted the productivity of Atlantic salmon stocks, contributing to the economic decline of the province's commercial and recreational fishing industries (Dietz and Arnold 2021). The province's most valuable fisheries are American lobster, snow crab, sea scallop, and northern shrimp (Howarth et al. 2021). Nova Scotia is known globally for its shellfish industry, which supports local food supply and is a source of revenue from gastronomic tourism (Ndlovu and Charlebois 2020), but lobster, for example, depends on cold water environments. As water temperatures increase, disease prevalence among lobsters will increase and their survival and growth will diminish, negatively impacting the economic prosperity of towns like Yarmouth where lobster is the main fishery (Cochran et al. 2012, Greenan et al. 2019b).

Aquaculture has also been affected by climate change through the increased occurrence of pests and invasive species as well as shifting predator ranges (Dietz and Arnold 2021 – citing Best et al. 2014, 2017, and Lowen et al. 2016). The productivity of mussels and oysters, which comprise a significant portion of farmed seafood in Atlantic Canada, has changed over the last thirty years alongside changing marine environments and ocean acidification, to which climate change has contributed (Reid et al. 2019).

Three quarters of the province's forestry workers live in rural areas and will face new challenges from climate change (NSE 2005). The forestry sector will be impacted by warmer temperatures, which will increase the frequency of forest fires and pest outbreaks and will alter stand composition via long-term species range shifts (NSE 2005, Warren and Lemmen 2014). Shifts in species composition is projected to result in a significant decrease in balsam fir which may have implications for the Christmas tree growing sub-sector (Steenberg et al. 2013, Taylor et al. 2020). Reductions of up to 35% in red spruce are projected by 2300 and these will likely be exacerbated by timber harvest, resulting in significant reductions in the presence of this species (Steenberg et al. 2013).

Warmer temperatures will permit a longer growing season but will not necessarily guarantee that forests will be more productive (Government of Nova Scotia n.d. a [online]). More severe and frequent storms will also increase blowdown of trees, potentially destroying entire tree stands (NSE 2005, Warren and Lemmen 2014, Government of Nova Scotia n.d. a). Any decreases in available timber may create challenges for the economic sustainability of the forestry sector and will directly impact people through reductions in employment and recreation opportunities, and other ecosystem services (Ochuodho et al. 2012). Aside from direct changes to forest composition and productivity, challenges such as access to forest lands following extreme weather-induced blowdown, and damage to logging roads from severe weather will disrupt the productivity of forest workers and increase expenditures on road maintenance (Kirilenko et al. 2007).

Agriculture is highly dependent on climate and the availability of suitable soils, as well as the demographics of farmers, the health of farming communities, and the ability to implement new techniques and technologies (Lemmen et al. 2008, Tourangeau et al. 2021). Climate change will cause more frequent and longer lasting hot, cold, and dry days during the growing season, as well as early fall "hard frosts" and extreme precipitation events that cause flash-flooding (NSE 2005, NSMA 2015, Lemmen et al. 2008). Any increases in productivity resulting from warmer and wetter growing seasons may be offset by increased damage and kill from warmer winters (Lemmen et al. 2008). Transitions to new types of crops that can survive more extreme weather may require significant upfront financial investment and subsidies (Zhang et al. 2019).

Nova Scotia's farms tend to be situated near rivers where soils are more fertile, as much of the inland areas are not conducive to productive farming (NSE 2005, NSFA 2013). Often, these areas are protected by dykes that also provide habitat for several mammals, reptiles, and migratory bird species. When heavy rains, snowmelt, or rising sea levels cause flooding of these riverine systems, farms are at greater risk of becoming inundated, reducing crop yield and threatening farm buildings and equipment. Climate change will also affect crop pest populations and their predators. The time and resources needed to develop, register, and switch to new pest control technologies may not be economically viable for some farmers

(Lemmen et al. 2008). Exacerbating this risk is the reluctance of some farmers to adopt climate-related policies and practices because they are distrustful of government-promoted solutions (Soubry et al. 2020), illustrating the importance of understanding the interplay among climate change impacts and several capitals together—in this case financial and social –when assessing the efficacy of adaptation strategies.

Documentation about the effects of climate change on the mining sector is scarce. There are 12 active mining operations in Nova Scotia, mostly mineral mines (salt, gypsum and gold) and one coal mine (Nova Scotia Department of Energy and Mines 2018). The province's mining industry employs approximately 3,000 workers, accounts for 80% of Canada's gypsum production, and produces about 940,000 tonnes of rock salt annually (NSBI 2018). The presence of coal along shoreline areas has historically encouraged the establishment of mining industries and settlements in coastal areas (NSMA 2015). Erosion and wave exposure therefore increases risks of economic consequences to mining industries and infrastructure situated on these coastal areas.

Climate change will have several implications for Nova Scotia's energy sector. Warmer temperatures that reduce groundwater availability at certain times of the year may reduce the province's hydro-electricity production capacity (Government of Nova Scotia n.d. a). Milder winter temperatures may reduce wintertime energy demand, potentially allowing consumers to save money. However, cost savings may be offset during hotter summers, where increased use of air conditioning may occur (Government of Nova Scotia n.d. a). Increased frequency and severity of extreme weather events such as storms and hurricanes may make working conditions on offshore oil and gas platforms dangerous, with potential evacuations representing a significant impact to production and economic wellbeing (Government of Nova Scotia n.d. a).

Despite these projected impacts, the fact that natural resource-based sectors account for only a small fraction of the province's total employment and GDP does confer an element of resilience to climate change. Compared to other more extraction-oriented provinces, Nova Scotia's broader economy will not be as vulnerable to climate impacts that reduce the stocks or disrupt the flows of services related to these sectors. It is important to note, however, that the benefits Nova Scotian's experience from these sectors goes beyond economic stability (e.g., subsistence fishing, recreation, etc.).

Climate-related hazards will impact other segments of the economy that are not directly resource-based, like local retail outlets and services (Government of Canada 2017). Following flood and storm events, the need to repair or restore buildings, roads, and water systems that support these businesses places an added financial burden on communities and households.

For many small towns, service-based and tourism-related businesses are a significant source of employment (NSMA 2015). Many of these businesses are located in areas close to the ocean, placing them at greater economic risk due to coastal flooding and severe weather. Increased storm frequency and intensity may reduce tourism in Nova Scotia, as evidenced by the 3.3% decline in visitation in 2019 (compared to 2018) primarily due to Hurricane Dorian (Tourism Nova Scotia n.d. [online]). Wind and water damage to businesses is the most commonly cited economic consequence, due to the costs of repair and costs associated with damage-induced closures (NSMA 2015). Flood damage to tourist destinations can impact access to these areas and diminish the quality of tourist experiences, with potential consequences to revenues (NSMA 2015). Examples of some tourist sites that may be at risk from storm damage and sea level rise include the Old Town Lunenburg (UNESCO site), Grand Pré (UNESCO site) and the Fortress of Louisbourg (Markham et al. 2016, Dunham et al. 2017). Warmer winter temperatures may also negatively impact winter recreation and tourism opportunities like snowmobiling and resort stays, by potentially reducing the length of the recreation season by up to 60% over the next fifteen years (since 2014) (Warren and Lemmen 2014).

Household income is at risk from climate change impacts that adversely affect the economic sectors in which people are employed. For example, changes to ocean ecosystems such as warming temperatures, ocean acidification, and ice coverage may make commercially caught fish more susceptible to predation and parasitism, reducing their numbers and subsequently the productivity of the fishing industry. Sediment deposits from increased precipitation runoff due to more intense rainfall events may additionally impact the productivity of shellfish and fin fish harvest (Government of Nova Scotia n.d. a). These reductions in productivity may diminish the economic viability of these sectors, and result in fewer job opportunities. Extreme weather events may present challenges if ocean conditions make fishing or operating offshore oil platforms dangerous, for example (Government of Nova Scotia n.d. a).

3.5 Manufactured Capital

Nova Scotians' access to housing, supportive infrastructure services and the provision of market goods and services is critical to their wellbeing. The ability of Nova Scotians to access these benefits is realized through stocks and flows of **manufactured capital**, or human-built assets, such as roads, vehicles, houses, other commercial or institutional buildings/facilities, and machinery (Jones et al. 2016) that are made from inputs of materials (natural capital) using energy, labour and production technologies that rely on human and financial capital (Maack & Davidsdottir 2015). Table 3-5 provides a snapshot of unique Nova Scotia characteristics for two key elements of manufactured capital: buildings and housing, and public infrastructure.

Table 3-5. Key elements of **manufactured capital** in Nova Scotia, with a snapshot of unique provincial characteristics

Elements of Manufactured Capital	Snapshot of Nova Scotia Characteristics
Buildings & housing	• Of the province's 920,000 inhabitants, 40% live within the Halifax Regional Municipality, and over 60% live near (within 20 km of) the coast. In 2016, a total of 1,609 people (less than 1%) required the use of public shelters in Halifax (Halifax Regional Municipality 2018). • Nova Scotia has 43 hospitals distributed around its counties and regions, 10 universities, and over 400,000 households (occupied private dwellings) (Statistics Canada 2017). • Improvements to the housing stock occur continuously. 45% of Nova Scotia's households have installed more efficient heating and cooling systems, improved

Elements of Manufactured Capital	Snapshot of Nova Scotia Characteristics
	insulation, and upgraded windows and doors between 2008 and 2011 (2018 statistics) (Canadian Wellbeing Index 2018). • Overcrowding in housing is observed. Based on the 2016 census, 11,540 private dwellings are considered unsuitable housing (2.9% of the 390,445 suitable dwellings in the province) (Statistics Canada 2017). Household suitability is measured according to the National Occupancy Standard (NOS) and considers whether a dwelling has enough bedrooms for the composition of the household (Statistics Canada 2017). • Nova Scotia's 2020-2021 budget (where revenues are anticipated to amount to $11.6 billion) includes the allocation of $54.3 million for construction, repair and renewal of hospitals and medical facilities. (Government of Nova Scotia 2020a). • Over 40% of Canada's military assets are situated in Nova Scotia, with the country's largest military base located in Halifax. Several other major military facilities exist throughout the province. (Government of Nova Scotia 2014). Expenditure on Nova Scotia's military defense was $449 per capita in 2014 (Government of Nova Scotia 2016). • Approximately 5% of the province's healthcare facilities are currently located in flood prone areas (CICC 2021). • Buildings and homes and supportive infrastructure constructed along rivers in the Bay of Fundy, the river valleys of the Cape Breton Highlands, and southeastern shallow streams and lakes will be particularly at-risk from flash-flooding as the climate changes (NSMA 2015).
Public infrastructure	• Nova Scotia has some of the oldest public infrastructure in Canada, especially in small, remote coastal communities (Gagnon et al. 2008, Rapaport 2015). • Along with Newfoundland and Labrador, the province has the third oldest road networks in Canada (Gagnon et al. 2008). • Nova Scotia has 23,000 km of roads and highways, as well as 4,100 bridges. 1.1% of Nova Scotia's landbase is comprised of transportation networks (roads, rail, and pipeline corridors). This transportation network serves about 331,000 cars, 26,000 light passenger trucks and 2,000 buses .in Nova Scotia, which collectively consume about in 40 Petajoules (PJ) of fuel per year (Government of Nova Scotia (2018b). • Nova Scotia Power operates 33 hydroelectric plants on 17 rivers throughout the province (NS Power n.d.). • The Bay of Fundy has dykes spanning 243 km, protecting approximately 17,500 hectares of land. Many stretches of dykes are in disrepair from storms and sea level rise breaching. Efforts are underway to either rebuild dykes using modernized specifications, or to decommission them and restore the land to salt marshes. (NSMA 2015).

Sources: Gagnon et al. 2008, NSMA 2015, Rapaport 2015, Canadian Wellbeing Index 2018, Canada Energy Regulator [online], Halifax Regional Municipality 2018, Karim 2019, Government of Nova Scotia 2014, Government of Nova Scotia 2017b, Government of Nova Scotia 2018b, Government of Nova Scotia 2020a, Government of Nova Scotia 2020f, Nova Scotia Power (n.d.), Statistics Canada 2017, Sherren et al. 2019, Statistics Canada, 2021, Table 36-10-0402-02, NRCAN, 2021, Comprehensive Energy Use Database

Climate Impacts to Manufactured Capital

Manufactured capital may be impaired by damage to homes, workplaces, critical infrastructure, and equipment due to sea-level rise, flooding, and intense storms. Opportunities to limit exposure to these climate-related hazards include land use planning, zoning restrictions and the provision of updated, publicly-available hazard maps. Disaster recovery offers a window to build with climate resilience in mind. Physical relocation of structures and entire communities may also be necessary in cases of repeated events causing loss and damage. Infrastructure hardening and ongoing maintenance lessen structures' sensitivity to climate damages.

Climate change effects like sea level rise and more severe storms will negatively impact buildings, homes, and infrastructure in Nova Scotia via direct physical damages and disruptions to critical infrastructure services. Prior to current land-use regulations, development patterns and economic drivers resulted in the placement of many structures near coasts and in river floodplains, putting them at risk from floods and erosion caused by sea level rise and storms (NSMA 2015, Manuel et al. 2014, Lemmen et al. 2016). A lack of flood mapping throughout the province has meant continued development of buildings and infrastructure on high flood risk lands (NSMA 2015). Some residents have rejected flood mapping because of its impacts on real estate values, but given the increasing risk of climate change-related flooding, the province has recently expressed interest in undertaking provincewide flood mapping (KarisAllen et al. 2019, CBC News 2021 [online]). In a similar example, residents along a coastal lagoon called Big Lake expressed resistance to the government's recommendation of fortifying their properties, preferring instead that the government rebuild the natural cobble barrier that failed after a storm hit the area (Sherren et al. 2019).

In some cases, impacts from climate change that continually place communities at high risk of damage to homes, buildings and other infrastructure will require retreat-based adaptation strategies like physical relocation and rezoning. However, retreat-based approaches are often met with strong opposition. The need to relocate or become more mobile can lead to economic insecurity and negatively impact residents' access to the network of supporting neighbours, family, and friends which may have previously fostered enhanced capacity to respond to climate hazards (Government of Canada 2001). In Advocate Harbour, for example, residents were presented with the option to relocate because of the area's high exposure to flooding via storm surges (Sherren et al. 2019). Community members participated in a 2018 meeting to discuss the future of the dyke protecting the agricultural lands in Advocate Harbour, and the majority of people voiced their desire to address rising water levels by strengthening the dyke while continuing to maintain their livelihoods in the area. Sherren et al. (2019) notes that public sentiments like these can encourage ongoing development in high-risk areas and represents a barrier to coastal adaptation.

Nova Scotia has a growing number of coastal short-term rentals (CSTRs), which are dwellings that provide short-term living spaces for visitors and tourists (e.g., Airbnb, VRBO). A recent survey of planners indicated a lack of knowledge regarding where these CSTRs exist, making emergency planning for these dwellings and their occupants challenging (Karim 2019). Exacerbating this issue is the fact that many of these dwellings are vulnerable to sea level rise either directly, or by being isolated from emergency services (Karim 2019).

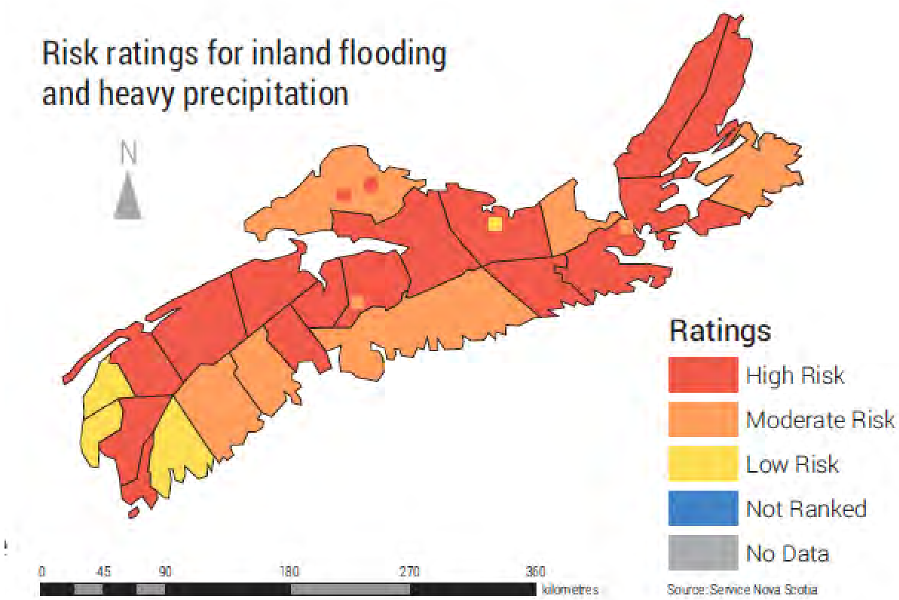
Physical damages to small and medium-sized businesses are costly to repair and can result in the loss of employment, leaving affected staff without the financial capital to respond to other impacts (Cochran et al. 2012, Government of Canada 2017). Communities upstream of dams, such as in Wreck Cove on Cape Breton Island, can be particularly vulnerable when increased river flows and ice jams result in reservoir flooding, increasing the need for expensive flood remediation and repairs to damaged dam infrastructure (Dietz and Arnold 2021). Wharves, boats, and fishing equipment are also increasingly at risk of being damaged, imposing an additional financial burden on public and private owners for maintenance and replacement (Cochran et al. 2012).

Further inland, structures built along rivers in the Bay of Fundy, the deep river valleys of the Cape Breton Highlands, and near shallow streams and lakes in the southeast part of the province are particularly susceptible to flash-flooding (NSMA 2015). Human-caused changes to land cover like road construction or drainage and development of wetlands all exacerbate flood risk by increasing impermeable surfaces (Cutter et al. 2018).

Nova Scotia’s roads, power generating facilities, and waste and stormwater facilities have consistently demonstrated their vulnerability to storms and flooding (see Figure 3-2) (NSMA 2015, Rapaport et al. 2013). In 2004, for example, extreme weather events caused $12.6 million in damage to electricity lines (Lemmen et al. 2008). Sewage systems and water treatment facilities can also become overwhelmed by high volumes of water following heavy precipitation events, resulting in water contamination and risks to public health (NSMA 2015, Lemmen et al. 2016). Figure 3-3 shows how the risk of flooding and heavy precipitation varies throughout the province.

Source: Bush and Lemmen (2019)

Figure 3-2. Impacts of flooding from storm surges to coastal transportation infrastructure.



Source: NSE (2015)

Figure 3-3. Risks of flooding and heavy precipitation throughout Nova Scotia.

The need to repair damaged roadways following storm events is critical, as certain roads may be the only or most convenient route between areas (McGillis et al. 2010). Similarly, roads built too close to the ocean may be frequently subjected to flooding and coast erosion, resulting in the need for road realignment or elevation projects, representing a significant economic consequence of climate change (McGillis et al. 2010). While preparing in advance may be more cost effective compared to continuing to accept recovery costs (CICC 2020), it can still be costly, for example, when major infrastructure upgrades are needed, like improved road drainage systems to mitigate flooding (Zhang et al. 2019).

Easily cut-off transportation infrastructure like bridges, ferries and docks, or key routes like those along the Chignecto Isthmus connecting Nova Scotia to New Brunswick will create additional vulnerabilities by reducing connectivity to emergency services if they are damaged by climate hazards (Palko et al. 2017, Rapaport et al. 2017). In the county of Yarmouth, a study found that floodwaters from storm surge events could breach Milton Dam and damage the main access route between the town and the adjacent areas, potentially cutting off access to the regional hospital (Cochran et al. 2012). The Yarmouth study also found that residents were concerned with the age of electricity infrastructure and whether or not it can maintain its integrity when challenged by increased storm frequency, especially during cold seasons when people depend on electricity for home heating (Cochran et al. 2012).

To protect farm infrastructure and homes from flooding, dykes have been extensively constructed throughout coastal regions of Nova Scotia in areas where farmland was developed in historic floodplains (NSMA 2015). By 2050, the majority of the province's dykes will be at risk of breaching from storms at high tide (van Proosdij et al. 2018). Rising sea levels will not only impact the infrastructure the dykes are designed to protect, but will also make maintenance and repair of the dykes themselves more challenging (NSMA 2015). Further complicating the challenge, dykes and other barrier structures can have counterproductive impacts by disrupting coastal processes and impeding overland drainage from overflowing rivers, worsening erosion and sedimentation, and degrading or removing entire coastal ecosystems and the services they provide (Lemmen et al. 2016).

4 Equity, Wellbeing and Climate Change

Section Summary

How Nova Scotians experience and react to a changing climate depends on their social context. Colonialism, neocolonialism, racism, sexism, ageism, poverty, ableism, and intergenerational trauma are among the forces shaping the lives of African Nova Scotians, Mi'kmaq, racialized peoples, immigrants, individuals living on low incomes, individuals living with disabilities, older adults, youth, and women, with particularly impactful influences on those living at the intersection of these different experiences. These forces will influence how impacts from climate change are felt from person to person, and community to community; they will also shape people's ability to successfully adapt to a changing climate. By influencing the geographic location of people and physical assets as well as access to wellbeing capitals, social and economic contexts affect exposure to climate hazards, sensitivity, and coping / adaptive capacity. This can help determine and understand exposure, climate change vulnerability and risk in space and time as a basis for adaptation planning and implementation.

As is the case in other jurisdictions, inequitable access to wealth, resources and power, among other social characteristics shape how Nova Scotians experience and respond to climate change impacts. Those living in poverty, persons with disabilities or chronic illness, lesbian, gay, bisexual, transgender, and queer (LGBTQ+) populations, people who are from Mi'kmaw or African Nova Scotia communities, and those lacking formal education, are at greater risk of experiencing social exclusion than other social groups, hampering their ability or motivation to access resources or services when confronted with climate hazards (Government of Canada 2001, Colpitts and Gahagan 2016, Waldron 2021). Climate hazards may also exacerbate the challenges many of these marginalized groups already face due to these challenges contributing to their increased exposure and sensitivity to climate change impacts (Waldron 2021). Systemic discrimination and barriers can impede people from reaching their full potential and having a voice, contributing to social vulnerability through, for example, the erosion of coping capacity (Eriksen et al. 2020).

This section complements Section 3's overview of climate change impacts to the wellbeing of Nova Scotians by discussing baseline inequities in access to capitals by different social groups and why they exist. Illuminating such patterns and their causes informs climate risk assessment and the development and implementation of adaptation policies and programs, with policy research increasingly pointing to addressing the root causes of vulnerability to climate change as a robust approach to sustainable adaptation (CICC 2021).

Having introduced the relationship between wellbeing domains and wellbeing capitals in Section 3 (Figure 3-1), this section layers on additional concepts. One set of concepts comes from human health research but is broadly applicable to diagnose social inequities in experiences of and responses to environmental hazards. Social determinants refer to how an individual's physiological and material conditions (e.g., occupation) shape health (Davidson 2015). In turn, structural determinants shape material conditions of individuals through phenomena outside of their control, such as historic and ongoing discrimination against racialized and marginalized people (Waldron 2021a). Colonialism, neocolonialism, racism, sexism, ageism, poverty, ableism, and intergenerational trauma are among the forces shaping the lives of African Nova Scotians, Mi'kmaq, racialized peoples, immigrants, individuals living on low incomes, individuals living with disabilities, older adults, youth, and women, with particularly impactful influences on those living at the intersection of these different experiences.

The other set of concepts are specific to climate change assessment: exposure, sensitivity, coping capacity, and adaptive capacity (Section 5 provides a detailed overview of these concepts and our application of them in our primary analysis). Figure 4-1 represents examples of how inequities interact with exposure, sensitivity, and coping or adaptive capacity and illustrates the complexities involved in effectively understanding current conditions let alone projecting how climate change impacts may co-evolve with social contexts. It is important to remember that systemic inequities and structural and social factors also intersect to increase exposure and vulnerability to climate hazards; these are not independent or sequential (i.e., climate exposure leading to greater sensitivity, leading to less coping or adaptive capacity).

A final concept to introduce is intersectionality, which is a lens that moves beyond looking at individual social categories (e.g., sex, race, class, immigration status, Indigeneity) and encourages reflection on how the combinations of identities shapes lived experiences and the distribution of climate change vulnerability (Hankivsky 2012, Osborne 2015, Versey 2021; Djoudi et al. 2015, Kaijser and Kronsell 2014). Aside from exploring the dynamics of intersecting social categories, intersectionality analysis is: i) multi-scale (i.e., examines dynamics from the individual to community to institutional level), ii) explicitly looks at power structures, and iii) describes how relations can be reinforced and also renegotiated / transformed (Kaijser and Kronsell 2014). Canadian scholarship acknowledges the importance of adopting intersectional approaches in climate change vulnerability and adaptation assessment but remains largely conceptual in its application (Walker et al. 2019) although GIS-based social vulnerability analyses certainly contribute to this goal (e.g., Chakraborty et al. 2021). The application of feminist approaches, gender-based analysis and social justice lenses to the study of climate change vulnerability, disaster management and adaptation policy is increasing (e.g., Byrnes 2013, Gaard 2015; MacGregor 2009, Malloy and Ashcraft 2020, Rochette 2016), although published literature focused on Nova Scotia is scant.

What follows is *not* an intersectionality analysis but a brief overview of how characteristics of selected social groups in Nova Scotia influence wellbeing outcomes now and will continue do so in a changing climate, if left unaddressed. We recognize that in trying to paint a single picture of highly-diverse groups, we run the risk of causing further harm, further stereotyping and eliminating important differences of opinion and experience. We also recognize that, in breaking down impacts for specific groups and into categories of wellbeing, positive attributes can also be missed, and the interrelationships between these domains can elude us. As a result, the following overview is admittedly incomplete and simply a point of departure to further exploration, learning and consideration in the policy process.

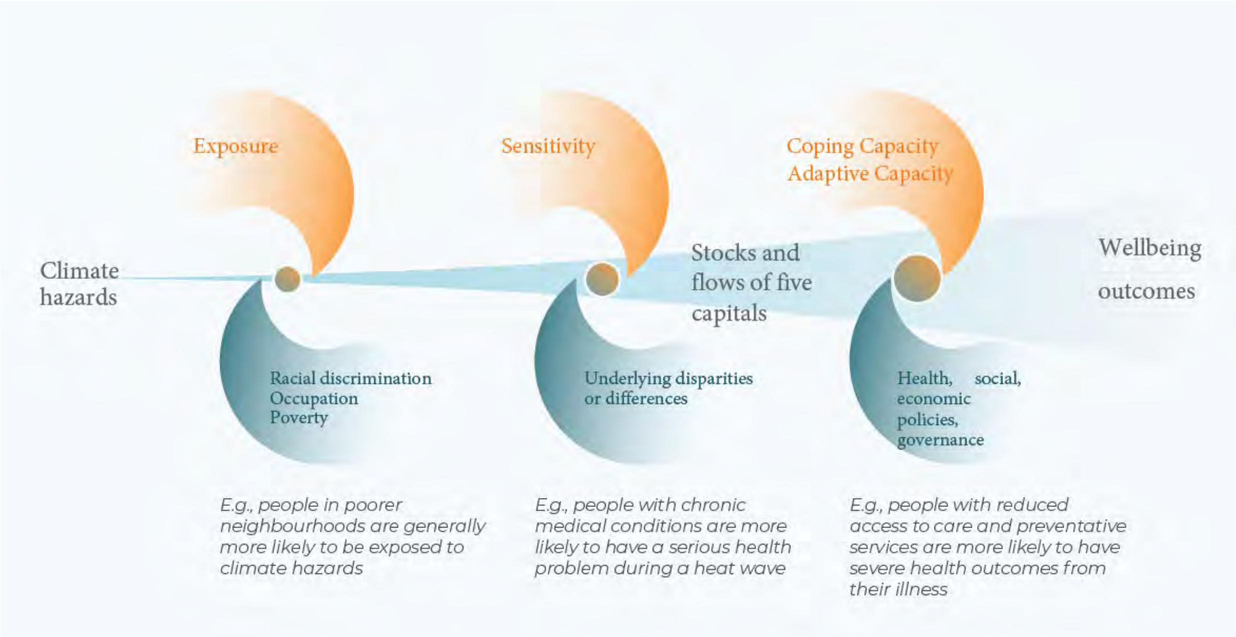


Figure 4-1. Diagram showing the intersection of social and structural determinants of health and climate change vulnerability factors, showing how they combine to generate wellbeing outcomes. Each of these factors has social, economic, and geographic dimensions (reproduced and adapted from CICC 2021).

Youth

The story of youth in Nova Scotia has many facets, intersecting with racism, poverty, ableism, gender, and colonialism. Three highly interconnected aspects having a significant influence on youth quality of life and wellbeing in Nova Scotia are: rural experience and its interconnections with socioeconomic circumstances (i.e., access to opportunities and access to critical infrastructure (e.g., health care) (Karabanow et al. 2014, Manos et al. 2014); experiences of low-income (Frank 2021); and broader changes relating to socioeconomic and political forces that impact local communities and experiences (Didkowsky 2016, Mackinnon 2016).

Compared to urban-dwelling counterparts, rural youth in Canada have higher levels of poverty, stress and health-related problems and are less likely to have access to services (Manos et al. 2014), recreational facilities, transportation options, and employment and educational opportunities, all of which can contribute to health-related issues (e.g., depression, anxiety, suicide) and social exclusion and isolation (Didkowsky 2016).

High tuition fees (Frank 2018), combined with rising costs of living, can saddle students with high levels of debt for decades. Food bank usage is on the rise across campuses and 38.1% of students surveyed at one rural Nova Scotian university experienced moderate or severe food insecurity in the previous 12 months (Frank 2018).

Although forces that shape rural restructuring also impact urban youth, evidence shows that rural youth are both responding to the forces shaping their communities and acting to shape the “social dynamics occurring within their communities” (Dikowsky 2016, p. 55). In other words, youth are agents of change (Ho et al. 2015) and are “interpreting and constructing their own experiences” (Didowsky 2016, p. 67). Sometimes youth act to change these circumstances through activism and collective organizing (Ho 2015 et al., Dlamini et al. 2019), but for rural youth these issues are often navigated through difficult, personal decisions about whether to stay or leave families and communities for opportunities elsewhere. Either option takes courage. Leaving requires resources, but also means leaving behind important connections to place and people. Staying means wrestling with job instability and fewer economic options and / or challenging societal norms and expectations to look for new or different options to achieve and re-imagine quality of life in rural communities (Mackinnon 2016).

Older Adults

In Canada, older persons are the fastest-growing age group with an estimated 4.8 million people aged 65 or older (Mistry et al. 2021). The older population is anticipated to make up to one quarter of Canada’s population by 2036 (Wang et al. 2019).

Research is demonstrating the significant negative toll that ageism and the associated oversimplified and negative age stereotypes takes on older adults in Canada, impacting the interconnected issues of income (Berger and Hodgins 2012), health care access and bias and associated physical and mental health outcomes (Wang et al. 2019, Shippee et al. 2019, Vervaecke and Meisner 2021, Mistry 2021), housing adequacy and quality and long-term care (Weeks and Leblanc 2010, Wyndham-West et al. 2021), meaningful and free choice and opportunities for social participation (Rozanova et al. 2012, Gilmour 2012), elder abuse and neglect (Harbison et al. 2012, Edwards 2012), and even access to information and social contact in the digital age (Lagacé et al. 2015).

As cited in Vervaecke and Meisner (2021), “Most older people are merely living their ordinary lives (p. 162),” but are facing ageist and ableist assumptions that shape beliefs in the capabilities of older adults. Ageism results in characterizing the aging population as frail, vulnerable and in need of protection (Harbison et al. 2012) in ways that can undermine confidence, dignity, self-determination, and independence. Nevertheless, many seniors in Nova Scotia do tend to fall into the low-income category and this implies that their access to financial resources to prepare for or recover from natural hazards may be limited (Rapaport et al. 2013). It should also be noted, however, that there exist “service-rich” communities in which seniors tend to have good health, higher social status, better financial status, and greater access to resource networks and services, reducing their vulnerability compared to “service-poor” elderly communities, like those in rural areas (Davenport et al. 2009).

Poverty and Income Inequality

Poverty is a reality for many in Nova Scotia and, as with all issues, intersects with gender, geography, racism, ableism, and colonialism. Unlike much of the rest of Canada, rural areas have higher rates of poverty than urbanized areas in Nova Scotia, pointing to differences in education levels and housing quality as two characteristics that differentiate urban from rural counterparts (Karabanow et al. 2014).

Poverty is linked with higher crime rates (MacEwan and Saulnier 2010) and can affect personal safety and security. Poverty constrains access to essentials and choices (not just outcomes), including nutritious and healthy food (Newell et al. 2014), transportation access and options (Marr 2015), civic and social participation (Ravensbergen and VanderPlaat 2010), adequate and quality housing (Kothari 2009), physical activity and recreation (Spinney and Millward 2010), and social and health care access.

One in four children in Nova Scotia experience living in poverty, with higher rates among African Nova Scotian children (Frank et al. 2021). The negative effects of poverty and income inequality on children and youth are extensive and far-reaching, affecting childhood development, school readiness, educational outcomes (Ferguson et al. 2007), housing (Waterston et al. 2015), and physical and mental health (Gupta et al. 2007). Child poverty in the province, as in other places, reflects the dynamics of women's poverty, which include shouldering a disproportionate amount of unpaid caregiving and gender discrimination in the workplace (Frank et al. 2021).

Research based in Vancouver sheds light on barriers to citizen participation among people living on low income and characterized the effects of poverty in four ways (Ravensbergen and VanderPlaat 2010).

- Poverty as trauma, capturing the all-encompassing experience of poverty and how it affects all aspects of physical, mental, emotional, and spiritual health, quality of life and wellbeing, including contributing to intergenerational trauma and poverty.
- The stigma and prejudice associated with poverty that contributes to physical and social marginalization.
- Poverty as created and upheld by government policies and practices, for example through inadequate incomes from social assistance (e.g., disability assistance, income assistance).
- Disenfranchisement and experiences of powerlessness to change circumstances or have voices heard by decision makers.

This research also highlights the feedback loops among wellbeing capitals, with economic instability undermining social and personal stability with resulting trauma that generates physical and mental health issues that play out day to day further eroding dignity and limiting opportunities to escape from poverty (Ravensbergen and VanderPlaat 2010).

Disabilities

Approximately 1 in 5 Canadians aged 15 or older (approximately 6.2 million) have one or more disabilities. About half a million youth and young adults in Canada live with disabilities and mental health is the largest disability (Tompa et al. 2020). Those living with disabilities are a diverse group including physical and intellectual disabilities, visible and invisible disabilities, and ranging from mild to severe. Only 29% of Canadians with disabilities have only one disability (Tompa et al. 2020).

The rights of individuals living with disabilities are enshrined through the UN Convention on the Rights of Persons with Disabilities and Canadian Charter of Rights and Freedoms

(Government of Canada), yet persons with disability face significant inequities in access to resources needed for quality of life and wellbeing. For example, those living with disabilities are two to three times as likely to have unmet health care needs compared to those without disabilities, and those needs increase over time (Casey 2015). Women living with disabilities experience poorer quality health care and less preventative health care, compared with men and nondisabled women from structural and attitudinal barriers, which lead to increased risk of mental health and chronic diseases (Gibson and Mykitiuk 2012). More than half of women (55%) with disabilities in Canada experience some form of intimate partner violence in their lifetime, compared with 37% of women without disabilities (Savage 2021).

Ableism helps to shape university experiences for students with disabilities, including the ways in which assumptions of the potential and future productivity of students are used to justify their exclusion (Easterbrook et al. 2019). Individuals living with disabilities face systemic social and institutional barriers to quality education, including increased risk of bullying and exclusion by peers (Canadian Human Rights Commission 2017), leaving students more likely to stop their education and limit their career choices or courses of study (Canadian Human Rights Commission 2017).

Canadians with disabilities have worse employment and work-related outcomes than those without disabilities and are more likely to be employed in low skilled (Tompa et al. 2020) and precarious work. In addition, persons with disabilities face higher costs of living to meet needs (Levesque 2016). Working age individuals living with disabilities are approximately twice as likely as other Canadians to live below the poverty line (Crawford 2013). The rate of poverty is 40% higher for persons with mild disabilities and nearly 200% higher for those with more severe disabilities, compared to Canadians without disabilities (Tompa et al. 2020).

Immigrants

Migrants to Canada arrive under very different circumstances, such as refugees, economic or family class migrants, and those who become permanent residents after arriving on student or temporary work visas. These differences can be significant (e.g., pre-migration experiences of trauma) and intersect with race, gender, age, and ability to speak English or French to shape inequities experienced by many immigrants.

University degrees (including professional accreditations) and work experiences from other countries are often devalued or sometime unrecognized entirely (Creese and Wiebe 2012). Racial discrimination and bias against accented English can leave many immigrants, particularly immigrant women of colour, channelled towards low-wage “survival jobs” and facing significant wage gaps (Creese and Wiebe 2012, Chai et al. 2018). Unemployment rates for recent immigrants are more than double of those born in Canada, even though immigrants are more likely to hold university degrees (Chai et al. 2018).

Although employment rates improve over time (Chai et al. 2018), individuals may still not be working in the field of their choice and earnings remain incomparable with Canadian-born counterparts (Chai et al. 2018). Chronic low-income is pervasive and long-lasting (Picot and Yugian 2017). Older (Picot and Yugian 2017) and racialized immigrants experience the largest wealth gaps and continue to experience them years after arrival (Maroto and

Aylsworth 2016), and the rate of chronic low income amongst immigrant women is 1.3 times that of men (Picot and Yugian 2017).

The “Healthy Immigrant Effect” is well documented. Most immigrants self-report good physical and mental health on arrival, but health deteriorates within a few years of living in Canada (Subedi and Rosenberg 2014). This may be due to a combination of factors, such as lifestyle changes, low incomes, stress of migration, language barriers, racial discrimination, and knowledge of how to access or navigate health services (Kim et al. 2013, Kalich et al. 2016).

Immigrant youth, particularly racialized youth and those coming from pre-migration experiences of conflict and violence, face several challenges. Immigrant children and youth may face difficult socioeconomic circumstances (Rossiter et al. 2015), challenging education experiences in Canadian schools (Rossiter et al. 2015), racism and discrimination and resultant social exclusion (Rossiter 2015, Oxman-Martinez et al. 2012), and cultural identity issues similar to immigrant adults. The lack of Canadian work experience, discrimination, and lack of networks may drive immigrant youth towards survival jobs (Lauer et al. 2012).

African Nova Scotians

Black communities have lived in Nova Scotia for over 400 years, as enslaved peoples of African descent were brought to Nova Scotia with the first colonists (Beagan et al. 2012). Over several major waves of migration, Blacks were settled in Nova Scotia as slaves, British loyalists, Maroons, and refugees, but not accepted as citizens (Moreau 2019). African Nova Scotians represent 44% of the visible minority population, the largest in Nova Scotia. Anti-black racism is a daily part of the life of African Nova Scotians and has resulted in socioeconomic exclusions and denial of health, social, and educational services (Etowa et al. 2017).

Policy-based school segregation in the first half of the 20th century (until the 1950’s) and subsequent and ongoing geographic segregation continue to impact generations of African Nova Scotians (Moreau 2019). This exclusion and undermining of education for Black children contributed to workforce marginalization (Moreau 2019), although many African Nova Scotian parents fought and continue to fight racism, discrimination, lack of Afrocentric learning, and lack of representation in the education of their children (Moreau 2019, Cox 2021, Hamilton-Hinch et al. 2017, Jean-Pierre 2021).

The racial wage gap for Black Canadians is 19.6% (Conference Board of Canada). Of the children living in poverty in Nova Scotia, nearly 40% are Black children, compared to 20.3% of non-visible minority children (Frank et al. 2021). Black households are 3.56 times more likely to be food insecure than white households in Canada, with the overriding factor determining vulnerability to household food insecurity is whether one is racialized as Black (Dhunna and Tarasuk 2021).

Anti-black racism has shaped where people lived (Jean-Pierre 2021), including locating toxic and polluting industries near Black communities (e.g., waste sites) (Waldron 2020), access to social services (Waldron 2020), and access to public infrastructure (e.g., clean drinking water, transportation) (Waldron 2020), all of which impact physical and mental health both directly and indirectly (Veenstra and Patterson 2016).

The centuries of anti-black racism are a form of collective and intergenerational trauma (Jean-Pierre 2021), with far-reaching consequences. For example, Waldron (2021) notes that, “Intimate partner violence is endemic in any Black community that continues to deal with intergenerational trauma stemming from historical, structural, and institutional inequalities” (p. 23).

However, as with advocates for Black learners, community advocates are working to challenge racial profiling (Wortley 2019, Jean-Pierre 2021, Bundy 2019), the overincarceration of Black people, and the use of excessive force by law enforcement (Jean-Pierre 2021, Wortley 2019, Bundy 2019), challenging anti-black racism in all spheres, including using their voices to seek better representation in governance and government (Bickerton and Graham 2020).

Mi’kmaq

The Mi’kmaq, or L’nu, have a 12,000-year history in Mi’kmaki and some of the earliest encounters with European colonization in Turtle Island or North America (Bowers 2010, Prosper et al. 2011).[11] Overall, Indigenous peoples in Canada have been subject to revisionist histories that eliminated awareness of the atrocities perpetrated as state and colonial violence (Paul 2006). It is only through efforts of Indigenous, ally scholars, and initiatives (e.g., Truth and Reconciliation Commission) that Canadians are beginning to understand the breadth and depth of past and present impacts (Getty 2013, Lewis 2020, Prosper et al. 2011, Cullen et al. 2021, Yeung et al. 2020). In addition to the significant risk of loss of the Mi’kmaw language (Julian and Denny 2016, Smith and Peck 2004), Mi’kmaw children experienced land dispossession and freedom to move around in it, losses of traditional livelihoods, the right to practice traditional ceremonies, and their ability to define community, among other losses (Getty 2013).

Some of the effects on Indigenous peoples, according to Western ways of knowing and in comparison to non-Indigenous counterparts, include: overrepresentation in the justice system (Larmer 2018, Palmater 2016), higher rates of “poverty” as narrowly defined by material deprivation (Frank et al. 2021), living in housing in higher rates of needing repair (Larmer 2018), higher unemployment rates with significant wage gaps (Nguyen et al. 2020), experiencing barriers to educational attainment (Nguyen et al. 2020), facing racism and physical barriers to accessing health care (Nguyen et al. 2020), and disproportionate proximity to environmentally hazardous facilities and exposure to pollutants, placing communities at greater risk of ill health (e.g., higher rates of cancer and mental health issues

[11] In developing this section, we made best efforts to identify sources that did not replicate colonial and extractive practices and honoured Indigenous ways of knowing – both in methods and in representation - prioritizing Indigenous scholars and/or trusted scholars with good relationships using OCAP® Principles in research. We focused on peer-reviewed articles, despite the limitations of these sources and recognize that much knowledge is likely held in communities for communities (e.g., state of infrastructure, income, health, etc.). We acknowledge that much of the peer-reviewed literature is historical in nature. Although this literature is highly relevant it tends to situate Mi’kmaw experiences in the past, as opposed to the present/future and can undermine knowledge and perceptions of the Mi’kmaq as a living people.

associated with "failure" to steward the land) (Waldron 2018; Green 2021). Indigenous women and girls have and continue to experience gendered and sexualized violence (Palmater 2016, Larmer 2018), simply because they are "Indigenous and because they are female" (Palmater 2016, p. 258).

The forces that have shaped these experiences have also contributed to the continued erasure of Indigenous knowledge and world views (Lewis 2020). As a result, even comparisons between Indigenous and non-Indigenous populations using the same measures and methods are not necessarily appropriate (Lewis 2020, Vukic et al. 2011, Cullen et al. 2021). For example:

- Community-involved research within Pictou Landing First Nation in Nova Scotia showed that perceptions of safety, as a component of social capital, is understood as a comprehensive concept that includes physical, mental, and emotional security as opposed to the more typical emphasis on physical safety in other social capital literature (Yeung 2020).
- Mental health and addictions are a concern amongst many Indigenous communities in Canada, but as Vukic (2011) points out, even the conception of mental illness perpetuates a mind-body dichotomy that does not resonate with Indigenous understandings of the important interconnections between mental, physical, emotional, cultural, and spiritual health.
- First Nations-led research has rejected Western concepts and measures surrounding child and family poverty as documents in the *2021 Report Card on Child and Family Poverty in Nova Scotia* report. Instead, "they [First Nations Poverty Action Research Project] approached the task from a much wider, holistic, perspective seeking to achieve the good life, one that included dimensions such as spiritual, mental, emotional and physical health and well-being; that stressed the idea of balance and harmony among the dimensions, and that showed a preference for 'building our community together' rather than focusing on a disadvantaged subset of the community (Frank et al. 2021, pp.22-23)".

Therefore, one cannot consider the inequitable access to resources needed for wellbeing within Mi'kmaw communities and Indigenous populations living off-reserve in Nova Scotia without considering the historical and ongoing effects of colonialism, cultural genocide, and racism with which Indigenous peoples are living (Lewis 2020). In addition, it is important to acknowledge how dominant narratives about Indigenous peoples rarely acknowledge their strengths and abilities (Yeung et al. 2020) and the lack of recognition of the ways in which the Mi'kmaq have and continue to be active agents in working to maintain and reimagine livelihoods (Cullen et al. 2021), language, governance (Julian and Denny 2016), culture, and traditions.

5 Assessing Climate-related Risks to the Wellbeing of Nova Scotians

Section Summary

To illuminate the relationships between climate hazards and human wellbeing, a wellbeing framework was used to perform an index-based assessment of wellbeing at risk from climate change. This will permit a better understanding of how climate change might affect the ability to achieve or make improvements to the individual and collective wellbeing of Nova Scotians, such as progress on social, environmental, and economic goals.

A composite index (the "wellbeing-at-risk" index or WRI) is used to evaluate how census divisions of Nova Scotia differ in terms of relative consequences for wellbeing (and dimensions thereof) from climate change. The WRI adopts a hierarchical structure, with four sub-indices (Climate Impacts, Exposure, Sensitivity and Low Coping Capacity), five pillars (one each for the five capitals), 14 sub-pillars (to capture key dimensions of wellbeing), and numerous indicators.

Climate projections for three future timeframes under RCP4.5 and RCP8.5 were used to develop 51 indicators for use in the Climate Impact Sub-index; uncertainty in the projections is captured using the 5th and 95th percentile values. A total of 175 indicators were researched and constructed for the Exposure, Sensitivity and Low Coping Capacity Sub-indices.

The WRI is specific to individual climate-related impacts. Nineteen individual climate-related impacts were defined (e.g., drought, fluvial flooding, sea-level rise and coastal flooding, vector-borne diseases, wildfire, etc.). Impact statements were developed for each of these 19 climate-related impacts; these govern the specific indicators to include in the WRI across all sub-indices.

Policymakers can use the results to guide the formulation and targeting of adaptations to mitigate potential climate-related risks or seize potential climate-related opportunities.

To achieve the goals of this study we apply an index-based approach, drawing on the Intergovernmental Panel on Climate Change's (IPCC) conceptualization of risk (see Section 5.1). A composite index of "wellbeing-at-risk" (or the WRI) is developed to evaluate how census divisions in Nova Scotia differ in terms of relative consequences for dimensions of wellbeing from climate change. The WRI approach we apply 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 we adapted to reflect the latest climate risk terminology used by the IPCC.

The WRI is an **index-based approach** rather than a **damage function** approach. This distinction is important because it clarifies what the WRI can and cannot reveal about the relationship between potential climate-related impacts and dimensions of human wellbeing. Damage functions (or "damage curves") are quantitative relationships between two or more things (e.g., flood depth and building damages, mortality rates and mean daily temperature) that predict changes in the actual unit values of the variable of interest as other variables change, often established via statistical modelling of contrasting degrees of complexity. In the context of this study, a damage function approach would be most useful at the local scale for identifying and assessing specific adaptation priorities and measures. Index-based approaches like the WRI can provide relative comparisons on a scale from highest to lowest across specific units of space or time that are being evaluated. To illustrate the difference between the two approaches and how they can complement one another, consider the following example. An index-based assessment could be used to rank-order and identify administrative units in Nova Scotia (or neighbourhoods in an urban centre) with the highest potential for premature heat-related mortality and morbidity, as well as identify the main contributing factors—e.g., socioeconomic, demographic and health characteristics of the population, the quality and composition of the building stock, etc. Such an analysis may identify the Halifax Regional Municipality (HRM) area as most "at-risk". Now, a damage function approach could be used to quantify and monetise welfare losses resulting from premature heat-related mortality and morbidity in the HRM. This information in turn could be used to justify—on cost-benefit grounds—specific levels of investment in, say, a local Heat Alert Response System (HARS) to reduce adverse health outcomes. Moreover, the design of the HARS should take into account the main contributing factors of heat-related health risks identified through the index-based analysis.

For this study, the key implication of an index-based approach is that it can reveal **relative risk and potential benefit** to dimensions of wellbeing for Nova Scotians, how that might change under different climate futures, and *why* cross-regional differences exist; however, it cannot predict changes in the *amount* of wellbeing attributable to climate change. For example, the HRM may have the highest WRI value (risk rating) for extreme heat and the Cape Breton Regional Municipality (CBRM) the lowest WRI value, but this **should not be interpreted as implying the absolute risk to wellbeing from extreme heat in CBRM is negligible or minor**. Rather, it just reveals that relative to the other regions, the risk to dimensions of wellbeing in CBRM from extreme heat is lower.

What can be determined from the WRI is whether the difference between the two regions arises due to differences in the projected change in a climate impact-driver, or levels of exposure, vulnerability, sensitivity, and/or coping capacity, or any of the sub-categories (capitals and dimensions of wellbeing) that comprise these elements. We selected an index-based approach because it is useful for a rapid screening of sub-provincial regions to provide early insights and to identify regions with a higher or lower propensity to be impacted, positively or negatively, by climate change. Specifically, the WRI can help address the following questions:

- What climate-related impact is the largest relative source of potential losses of wellbeing in the 2030s? 2050s? 2080s? What capitals (and dimensions of wellbeing of greatest importance to Nova Scotians) are most exposed? What capitals (and dimensions of wellbeing of greatest importance to Nova Scotians) are largely driving sensitivity and coping capacity (and thus vulnerability) and the propensity for losses from the change in climate?
- What climate-related impact is the largest relative source of potential improvements in wellbeing in the 2030s? 2050s? 2080s? What capitals (and dimensions of wellbeing of greatest importance to Nova Scotians) are most exposed? What capitals (and dimensions of wellbeing of greatest importance to Nova Scotians) are largely driving sensitivity and coping capacity (and thus vulnerability) and the propensity to benefit from the change in climate?

- What regions are impacted relatively more by climate change—both positively and negatively? What climate-related impacts are relatively more impactful in each region? And with respect to both questions, why?

Policymakers can use answers to these questions to guide the formulation and targeting of adaptations to mitigate potential climate-related risks or seize potential climate-related opportunities.

Furthermore, as the example above illustrates, damage function approaches could be considered for finer-scale follow-up assessments within priority areas that are identified using the WRI approach.

The Well-being at Risk Index can:

- Support comparisons of relative risk and opportunities across regions
- Clarify why differences exist across regions with respect to climate impact-drivers, exposure, and vulnerability (sensitivity, coping capacity)
- Identify the most impactful capitals and dimensions of wellbeing
- Rapidly screen priorities at a provincial and regional scale

The Well-being at Risk Index cannot:

- Estimate how much wellbeing will change because of climate change
- Determine if the magnitude of *absolute* climate-related impact is negligible, minor, moderate, high, or extreme

5.1 Hazards, Vulnerability and Risk – What do they Mean?

The conceptual framing of hazards, vulnerability and risk has been interpreted differently over time and across scientific disciplines. Understanding this background is important because it clarifies the difference between a climate vulnerability assessment and a climate risk assessment; this report is the latter.

In earlier reports of the IPCC (circa 2007), climate vulnerability was understood to arise from a combination of exposure to external climate-related stressors and the inherent sensitivity and adaptive capacity of a human-ecological system. A key distinction from later interpretations (circa 2012) was this integration of exposure with sensitivity and adaptive capacity as inter-dependent co-determinants of vulnerability. Specifically, the Fourth Assessment Report of the IPCC in 2007 defined vulnerability to climate change as:

> *The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity*.

This framing changed in 2012 when the IPCC issued its Special Report on Managing Risks from Extreme Events and Disasters to Advance Climate Change Adaptation, which promoted a "risk management framework" that was subsequently adopted by the IPCC Fifth Assessment Report (2014) and all subsequent Reports. In this new framing, vulnerability and exposure are separated – vulnerability is treated as independent of exposure but the two are related through their contribution to overall risk and their links with the hazard of concern. Unlike the earlier interpretation, the term exposure is instead used to reference the presence or absence of exposed people, assets, natural systems, etc. in a location where a hazard might occur (linking exposure to the hazard), and the term hazard refers to an external stressor that can potentially cause adverse consequences or outcomes. The evolution of these different concepts is illustrated in Figure 5-1. The diagram clarifies how a climate vulnerability assessment only considers exposure, sensitivity, and adaptive capacity, while a climate risk assessment considers climate hazards, exposure to those hazards, and vulnerability (which comprises sensitivity and adaptive capacity). The WRI is based on this more recent IPCC conceptualization of climate vulnerability and risk (i.e., the right side of Figure 5-1) with some minor modifications introduced for the IPCC Sixth Assessment Report (2020)[12] that are described below.

[12] See IPCC, The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions, Guidance for IPCC Authors, 4 September 2020.

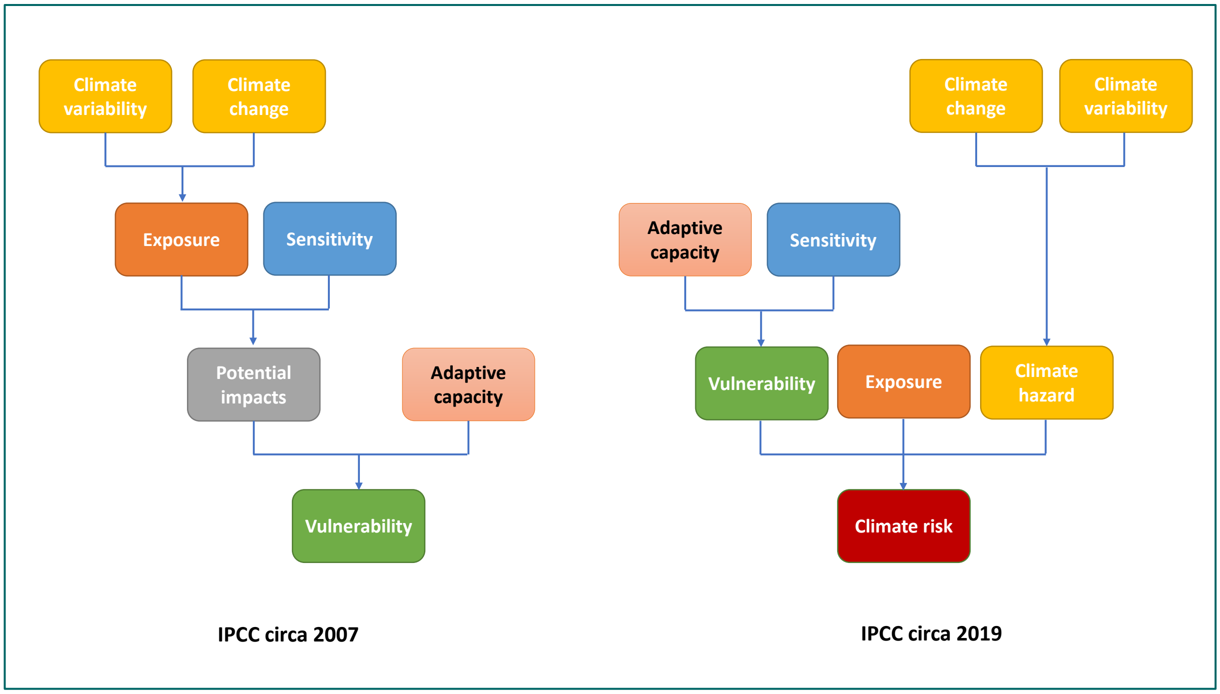


Figure 5-1. Evolution of climate vulnerability (left) and risk (right) assessment concepts used by IPCC.

In the WRI, we use the term **exposure** to refer to the inventory of elements of our five capitals (e.g., people, infrastructure, buildings, habitat, and economic, social, and cultural resources) in specific places that *could be* affected by one or more climate-related impacts, such as sea-level rise, increased temperatures, droughts, and extreme precipitation events.

The term **climate-related impact** is used to describe a climatic event or trend that may have an impact on wellbeing. Impacts may have predominantly adverse (negative) or predominantly beneficial (positive) consequences or outcomes for wellbeing. By "predominantly", we recognize that some climatic events or trends can have both positive and negative consequences, but the overall net effect is one way or the other. If the consequences are predominantly negative, we refer to the climatic event or trend as a **climate hazard**. In contrast, if the consequences are predominantly positive, we refer to the climatic event or trend as a **climate opportunity**. This reflects the main change to the IPCC's conceptualization of risk introduced by the Sixth Assessment Report.[13]

We use the term **vulnerability** to capture the propensity or predisposition of these elements to be affected by the climate-related impact to which they are exposed. Consistent with the IPCC risk framing, we consider vulnerability to be a function of the sensitivity of the capitals

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[13] Note that the IPCC Sixth Assessment Report uses the term "Climate Impact-Driver" (CIDs) to refer to climatic events or trends that may impact human and ecological systems. Moreover, the IPCC identifies 33 specific CIDs. For the purpose of the WRI, we instead use the term "climate-related impact" as some of the impacts assessed for Nova Scotia are not on the IPCC's list of CIDs, such as "winter tourism and recreation". See: IPCC, 2021. Annex VII: Glossary. [Matthews, J., et al. (eds.)]. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et a., (eds.)]. Cambridge University Press. In Press.

to each climate-related impact to which they are exposed. Different capitals are more or less sensitive to a climate-related impact. For example, looking at manufactured capital, a well-built stone house is less susceptible to harm from a tropical storm than a mobile home. This is captured by the concept of **sensitivity** in the WRI—i.e., the degree to which capitals can be affected, adversely or beneficially, by a climate climate-related impact should it occur.

Vulnerability is also a function of the capacity of people, institutions, and systems to adjust and adapt to, and recover from, potential harm, or to take advantage of opportunities. Human and natural systems will have some means of coping with a climate-related impact (e.g., trained emergency response personnel, savings, social networks). These kinds of capacities are captured in the WRI by the concept of **coping capacity**. The concept of coping capacity refers to the ability of people, institutions, and systems, to successfully accommodate, manage and overcome adverse conditions or to take advantage of opportunities in the short-to medium-term, using *available* skills, values, beliefs, and resources. In contrast, the concept of **adaptive capacity** has a medium-to-long-term perspective. It can be viewed as the 'room to move' for adaptation—e.g., our capacity to increase coping capacity, and to reduce sensitivity and exposure to anticipated climate hazards. This is true both with respect to closing adaptation deficits arising from current climate conditions and preparing for future climate change. It is important to consider the adaptive capacity of Nova Scotia when formulating an adaptation strategy. Follow-up research is planned by the Province to more deeply explore adaptive capacity. However, for the purpose of assessing risks in this study, a measure of baseline coping capacity is a better suited concept.[14]

Figure 5-2 shows how the above defined terms fit together within the conceptual framing of the WRI. As we develop indicators for each of the components shown in the figure, it will become evident that both exposure and sensitivity are specific to individual climate-related impacts; whereas, coping capacity is more a general trait of affected systems and only partially impact specific.

[14] Rome, E., et al., 2018. Impact and Vulnerability Analysis of Vital Infrastructure and Built-up Areas. European project RESIN – Climate Resilient Cities and Infrastructures, the Horizon 2020 Framework Programme of the European Union.

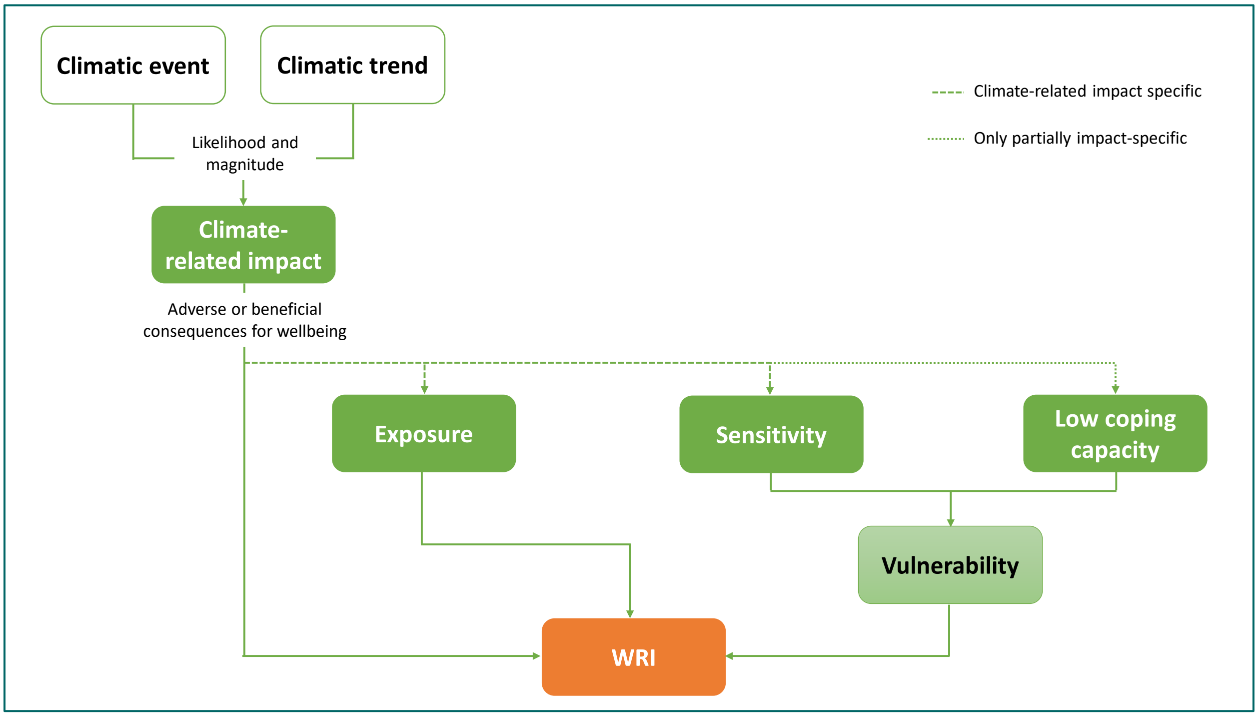


Figure 5-2. Conceptual framing of the WRI.

5.2 The Wellbeing at Risk Index (WRI)

Drawing on the right-hand side of Figure 5-1, the Wellbeing at Risk Index (WRI) that we develop adopts a hierarchical structure, like the generic example shown in Figure 5-3. In this section we specify how the components of this hierarchy interrelate in mathematical terms. At its highest level of aggregation, the WRI (the Index) comprises four **Sub-indices**:

1. Climate Impact Sub-index ($CI_{c,h}^{RCP,t}$);
2. Exposure Sub-index ($E_{c,h}^{RCP,t}$);
3. Sensitivity Sub-index ($S_{c,h}^{RCP,t}$); and
4. Low Coping Capacity Sub-index ($LCC_{c,h}^{RCP,t}$).

The WRI is calculated as an unweighted arithmetic mean[15] of these four Sub-indices with equal weights, as follows:

$$WRI_{c,h}^{RCP,t} = \frac{1}{4} \times \left(CI_{c,h}^{RCP,t} + E_{c,h}^{RCP,t} + S_{c,h}^{RCP,t} + LCC_{c,h}^{RCP,t}\right)$$

[15] See Box 1 for an explanation of the difference between geometric and arithmetic aggregation rules.

Where c is the census division $(c = 1, \dots, C)$, h is the climate-related impact $(h = 1, \dots, H)$, RCP is the Representative Concentration Pathway, and t is the time period. The WRI is calculated for both RCP4.5 and RCP8.5. For each RCP, the WRI is calculated for the following three time periods relative to the baseline period 1981-2010: 2015-2045 (2030); 2035-2065 (2050); and 2065-2095 (2080).

In this study, the time dimension is relevant only to the Climate Impact Sub-index, which incorporates future projections for a range of climate variables. The estimated values for the other Sub-indices are held constant at current levels over time. The WRI as employed in this report effectively overlays projected climate change on Nova Scotia today. Put another way, for these other Sub-indices t = today. However, it is possible to incorporate appropriate future socioeconomic scenarios, when available, to generate projections for the Exposure, Sensitivity and Low Coping Capacity Sub-indices.

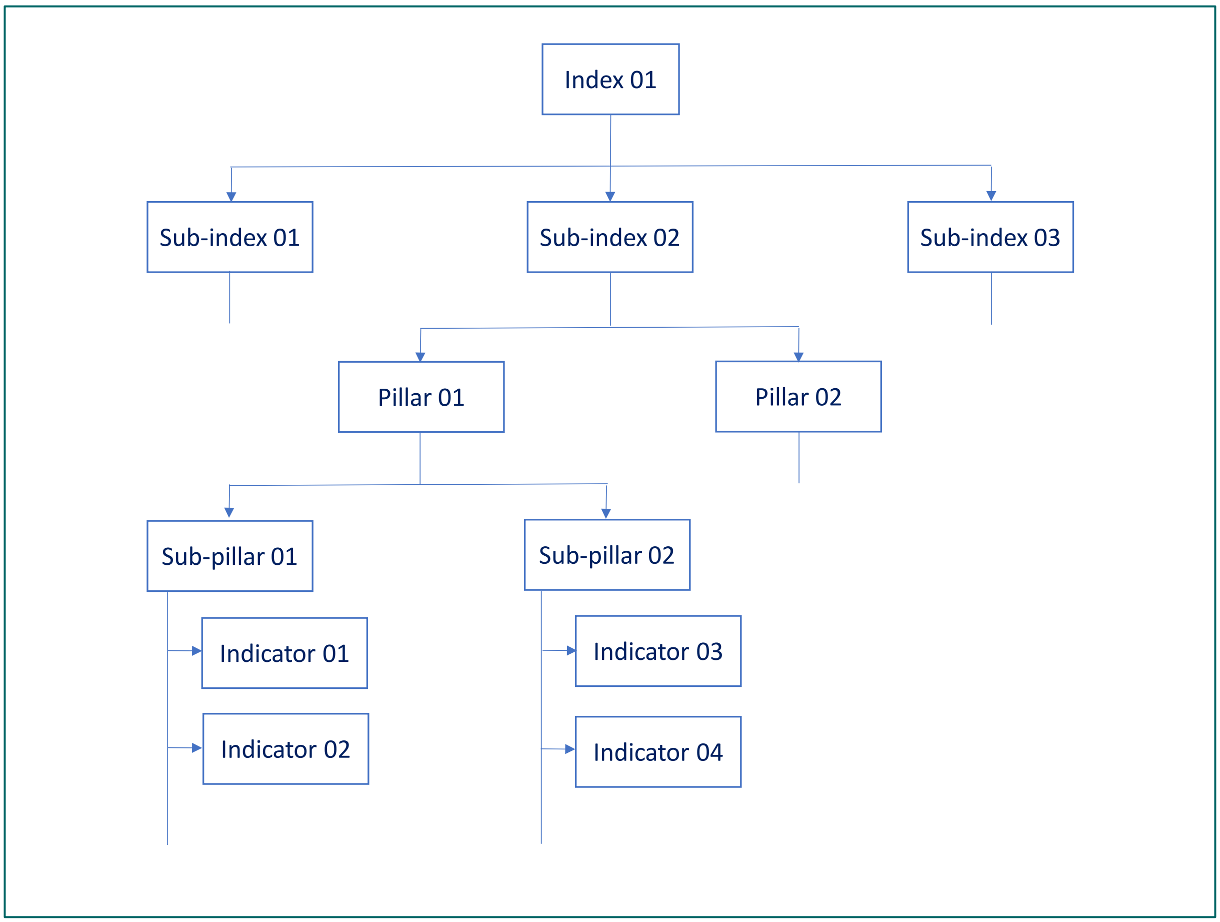


Figure 5-3. Hierarchical structure of the WRI.

The WRI is constructed such that higher normalized values throughout its structure (Sub-indices, Pillars, etc.) indicate:

- Relatively worse outcomes for *climate hazards* projected to increase as a result of climate change—by "worse" we mean larger potential deteriorations in wellbeing.
- Relatively better outcomes for *climate opportunities* projected to increase as a result of climate change—by "better" we mean larger potential improvements in wellbeing.

It is therefore necessary to check all normalized values to ensure they increase in the right direction. Where a higher normalized value would contribute to a lower WRI, the indicator needs to be inverted. This is done by subtracting the normalized value of the indicator from the maximum normalized value on indicator scale.

By way of example, "educational attainment" may be included as an indicator of coping capacity, where higher levels of educational attainment represent a higher coping capacity and subsequently lowers risk and the WRI value. Consequently, the direction of the indicator's value range is negative—i.e., the WRI increases as the indicator value decreases. The normalized indicator value thus increases in the wrong direction, and it is necessary to invert the indicator. A normalized value of 8 out of 10 for educational attainment would be included as 2 out of 10 in the Low Coping Capacity Sub-index (2 is the inverted value; 10 – 8 = 2). In effect, all positively increasing indicators of coping capacity for climate hazards are inverted to generate a sub-index reflecting a *lack* of coping capacity, which is what is included in the WRI.

The only exception to this rule concerns coping capacity and climate opportunity anticipated to increase with climate change. In this case, all selected indicators of coping capacity are not inverted, since we are interested in the capacity of systems to take advantage of anticipated benefits with a higher WRI score indicating larger potential improvements in wellbeing. Higher levels of educational attainment or household incomes, for example, represent higher capacity to seize the opportunities presented by climate change. Hence, for increasing climate opportunities the WRI is computed as:

$$WRI_{c,h}^{RCP,t} = \frac{1}{4} \times \left(CI_{c,h}^{RCP,t} + E_{c,h}^{RCP,t} + S_{c,h}^{RCP,t} + CC_{c,h}^{RCP,t}\right)$$

Where $CC_{c,h}^{RCP,t}$ is the Coping Capacity Sub-index.

Further note that with either of the above two formulations of the WRI, each of the four Sub-indices is given equal weight (1/4). In other words, the WRI is equally sensitive to each Sub-index. An alternative formulation would have been to separately estimate a Vulnerability Sub-index ($V_{c,h}^{RCP,t}$) and include that as opposed to Sensitivity and Low Coping Capacity Sub-indices, as follows:

$$WRI_{c,h}^{RCP,t} = \frac{1}{3} \times \left(CI_{c,h}^{RCP,t} + E_{c,h}^{RCP,t} + V_{c,h}^{RCP,t}\right)$$

However, with this formulation, both the Sensitivity and Low Coping Capacity Sub-indices would be implicitly assigned less weight (1/2 of 1/3) in the overall WRI than the Climate Impact and Exposure Sub-indices. The WRI would be more sensitive to the Exposure Sub-index and thus census divisions with relatively high populations and associated infrastructure and buildings. With our formulation, smaller variations in the Sensitivity and Low Coping Capacity Sub-indices across census divisions with similar exposures will have a stronger influence of outcomes. This is a desirable feature since these two Sub-indices can be influenced most by adaptation activities. Even so, separate from estimation of the WRI, we generate and report a distinct Vulnerability Sub-index, calculated as:

$$V_{c,h}^{RCP,t} = \frac{1}{2} \times \left(S_{c,h}^{RCP,t} + LCC_{c,h}^{RCP,t}\right)$$

The spatial unit of measurement for the WRI is the census division, of which there are 18 in Nova Scotia. The WRI as described above is thus specific to a census division and is calculated for an individual climate-related impact. The results can nonetheless be rolled-up across all climate-related impacts that fall within a specific category (see Section 5.2.1) for an individual census division as follows:

$$WRI_c^t = \sum_{h=1}^{H} WRI_{c,h}^t$$

Where:

WRI_c^t	=	The WRI score across all climate-related impacts h within a specific category for the cth census division at time t

The results can also be rolled-up across all census divisions for an individual climate-related impact as follows:

$$WRI_h^t = \sum_{c=1}^{C} WRI_{c,h}^t$$

Where:

WRI_h^t	=	The WRI score across all census divisions c for the hth climate-related impact in a specific category at time t

Although one objective is to derive overall WRI scores, an equally important objective is to understand the underlying root causes of the scores, as these will be of policy relevance to decision-makers. Consequently, similar aggregations can be performed for all individual building blocks of the WRI (the indicators, Sub-pillars, Pillars and Sub-indices) by census division or by climate-related impacts.

How to interpret the index values is explained in the Section 5.2.1, since the interpretation varies by type of climate-related impact.

Box 1: Arithmetic versus geometric aggregation

There are a variety of aggregation methods in the literature, but the two most common approaches are arithmetic aggregation and geometric aggregation; both of which can incorporate weights. With the former approach, values for indicators in a sub-pillar (or sub-pillars in a pillar, and so on) are simply summed and divided by the number of indicators. This leads to what is known as "full compensability", whereby a high value for one indicator or component of the index can offset a low score for another indicator or component. With this approach, extreme values are removed during aggregation.

Geometric aggregation involves the multiplication of individual indicators (sub-pillars, pillars, and sub-indices) to arrive at the composite index. In contrast to arithmetic aggregation, it only allows for partial compensability between index components. That is, a high value for one indicator or component of the index can only partly offset a low score for another indicator or component. While this is a desirable quality in some situations, the aggregation effects produce a strong bias towards low values. By way of example, aggregating two scores of 0.1 and 0.9 using the arithmetic approach results in an average value of 0.5; whereas it results in an average value of 0.3 using the geometric approach. For the purpose of rank-ordering and establishing priority areas this can be an undesirable and counterintuitive property. Take a census division with high and low scores for components of the index. With geometric aggregation, an improvement in low scores will have a greater effect on the aggregate score than an equal improvement in high scores. This would suggest focusing adaptation effort on improving the lowest scores to achieve the largest gain in the relative ranking of the census division; yet high scores throughout the index indicate worse outcomes. For this reason, we employ arithmetic aggregation throughout the WRI.

5.2.1 The Climate Impact Sub-Index

As described above, the WRI is calculated for an individual climate-related impact. A total of 19 climate-related impacts are assessed in this report, which are grouped into one of four categories defined by the quadrants in Figure 5-4:

Increasing adverse outcomes:

- Drought
- Pluvial flooding
- Fluvial flooding
- Heat extreme (agriculture)
- Heat extreme (ecosystems)
- Heat extreme (human health)
- Heat extreme (transport infrastructure)
- Cooling demand (buildings)
- Pests and diseases (agriculture)
- Shifting ecoregions
- Vector-borne diseases (Lyme disease and West Nile virus)

- SLR and costal flooding
- Wildfire

Decreasing adverse outcomes:

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

Increasing beneficial outcomes:

- Summer tourism & recreation (extended)
- Growing season (longer)

Decreasing beneficial outcomes:

- Winter tourism & recreation

Other climate hazards (climate-related impacts with predominantly negative consequences) identified during the literature review conducted to inform Sections 2 and 3 include freezing precipitation, windstorms, and tropical cyclones. However, appropriate data were unavailable to include these climate hazards in the version of the WRI constructed for this report. Other climate hazards pertinent to Nova Scotia but not included in the WRI are rising sea surface temperatures and ocean acidification. The adverse consequences of these two climate change-related impacts are not differentiable by census divisions and are thus not compatible with the WRI.

The calculated values for the WRI and all sub-components differs slightly by impact category; the meaning of *high* values across the Index is presented in Figure 5-5.

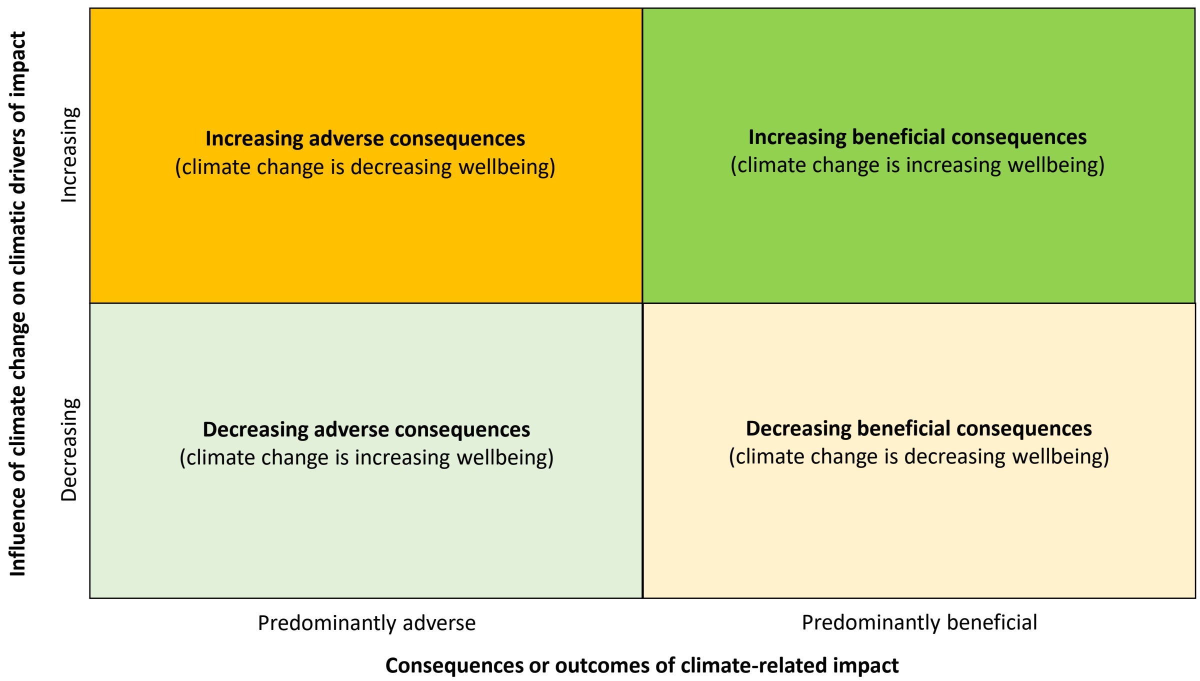


Figure 5-4. Categories of climate-related impacts included in study.

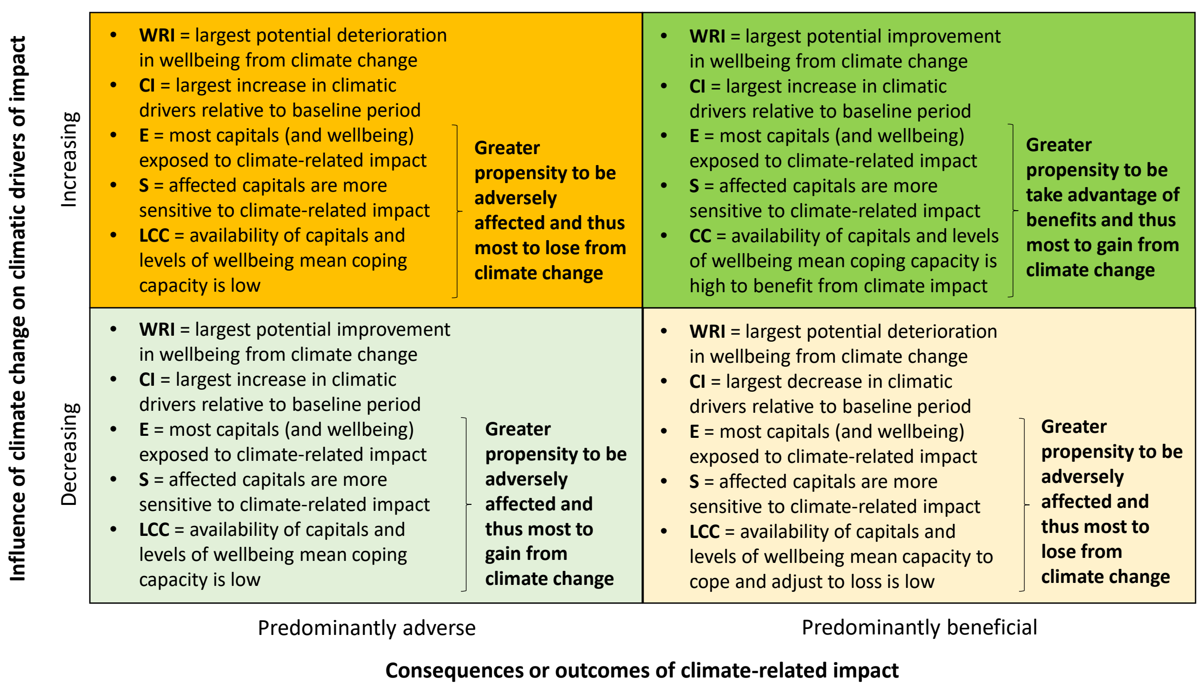


Figure 5-5. Interpretation of *high* Index values for each category of climate-related impacts.

A separate Climate Impact Sub-index is constructed for each of the 19 climate-related impacts. Each index is considered a proxy for the climate-related impact and comprises one or more climate variable indicators. In total, 51 climate variable indicators were generated for the Climate Impact Sub-index; these are listed in Table 5-1. Values were generated for the baseline period (1981-2010) and projected 5th, 50th and 95th percentile values (for the periods 2015-45, 2035-65, and 2065-95) for each indicator by census division where sourced from CRC (2021), as well as for both RCP4.5 and RCP8.5 (see Appendix B for further details). **Within the WRI, the 5th, 50th and 95th percentiles are used as a first approximation of the likelihood of the projected value of an indicator being exceeded in any given year, on average, over each future period**. By way of example, consider the projections for maximum daily temperature (one indicator for human mortality due to heat stress) exceeding 24.7°C for Annapolis across the distribution of projected values, there is a 95% chance, 50% chance, and 5% chance the value will exceed 51 days, 69 days, or 88 days, respectively, by the end of the century (2065-2095). Similarly, looking at Cooling Degree Days for Annapolis, there is a 95% chance, 50% chance, and 5% chance the projected value for the end of the century will exceed 188 degree-days, 285 degree-days, or 398 degree-days, respectively.

As part of defining the "impact statement" for each climate-related impact (see Section 5.4.2), relevant climate variable indicators from Table 5-1 are included to capture the projected impact of climate change on the WRI. The selected indicators will define the Climate Impact Sub-index for that particular climate-related impact.

The Climate Impact Sub-index for climate-related impact h is calculated as follows:

$$CI_{c,h}^{RCP,t} = \frac{1}{\sum v(h)} \times \sum_{v(h)=1}^{v(H)} A_{c,v(h)}^{RCP,t}$$

Where:

$A_{c,v(h)}^{RCP,t}$ = The anomaly for climate variable v included in the Sub-index for climate-related impact h for the cth census division at time t.

The anomaly is the difference between the projected value for the climate variable in t=2015-2045, t=2035-2065 and t=2065-2095, and its value in the baseline period (1981-2010).

In effect, the Climate Impact Sub-index for any particular climate-related impact is an arithmetic average of the anomaly for all climate variables selected for that impact. For each of the 19 climate-related impacts listed above, the Climate Impact Sub-index (and hence, WRI) is calculated for three future periods: 2030 (2015-2045), 2050 (2035-2065), and 2080 (2065-2095).

Table 5-1: Indicators for the Climate Impact Sub-index.

Sub-index: Climate hazard		
Indicator	ID	Units
Accumulated moisture	am	mm
Coldwave magnitude	cwm	degrees C
Coldwave number	cwn	number of events
Consecutive dry days	cdd	days
Consecutive hot days	chd	days
Cooling degree days	cdd18_ann	degree days
Critical heat days duration	chdd	days
Critical heat spells	chdf	days
Freezing precipitation	fp	mm
Freeze-free season length	ff	days
Freeze-thaw cycles	ft_ann	events
Frost days	frostdays	days
Growing degree days (5C)	gddgrow5	degree days
Growing degree days (10C)	gddgrow10	degree days
Growing season length	gsl	days
Heating degree days	hdd18_ann	degree days
Heat wave magnitude	hwm	degrees C
Heat wave number	hwn	number
Maximum daily temperature (hottest day)	txmax_ann	degrees C
Mean of maximum daily temperature (summer)	txmean_sum	degrees C
Maximum daily temperature (mean winter)	txmax_win	degrees C
Maximum daily temperature above 24.7C (heat mortality)	txg_hh	days
Maximum daily temperature above 26.7C (labour productivity)	txg_lp	days
Maximum daily temperature above 29C (heat warning)	txgt29	days
Maximum 1-day precipitation	rx1day	mm
Maximum 5-day precipitation	rx5day	mm

Sub-index: Climate hazard		
Indicator	ID	Units
Mean temperature (annual)	tgmean_ann	degrees C
Mean temperature (summer)	tgmean_sum	degrees C
Minimum daily temperature (coldest day)	tnmin_ann	degrees C
Minimum daily temperature below 5C (days with)	tnlt5_win	days
Minimum daily temperature below 15C (days with)	tnlt15_ann	days
Rain days (winter)	dwr_win	days
Rainfall (short duration, high intensity) (24-hour total; 1-50 years)	sdhi_24hr	mm
Rainfall (short duration, high intensity) (15-minute intensity; 1-10 years)	sdhi_15min	mm / hour
Sea-level rise	slr	Index
Snow days (days with snow) (winter extended)	dws_win_ext	days
Snow days (accumlation >15cm) (annual)	sd15_ann	days
Snow days (accumlation >15cm) (shoulder seasons)	sd15_shoulder	days
Snow water equivalent	swe_ann	mm
Standardized Precipitation Evapotranspiration Index (SPEI)	spei	index
Total precipitation - annual	prcptot_ann	mm
Total precipitation - spring	prcptot_spr	mm
Total precipitation - summer	prcptot_sum	mm
Total precipitation - fall	prcptot_fal	mm
Total precipitation - winter	prcptot_win	mm
Tropical nights (minimum temp > 16C)	tr16	days
Wet days (with precipitation above 20mm)	r20mm_ann	days
Wildfire (amplitude)	fwia	index
Wildfire (duration)	fwid	days
Wildfire (frequency)	fwif	days
Wind (strong)	ws	m per sec

Note: “Freezing precipitation” and “wind (strong)” are built into the WRI model and thus are included in the table; however, it was not possible to generate the necessary data to construct these indicators in this project.

5.2.2 The Exposure, Sensitivity and Low Coping Capacity Sub-Indices

The Exposure, Sensitivity and Low Coping Capacity Sub-indices themselves comprise their own sub-indices, which we will refer to as **pillars** to avoid confusion. Each sub-index contains the same set of five pillars; one pillar for each of the five capitals that provide the resources (stocks and service flows) from which Nova Scotians derive wellbeing now and into the future. This structure is necessary to evaluate the association between each capital—as a foundation for wellbeing—and the WRI via their influence on exposure, sensitivity and lack of coping capacity. While each sub-index contains the same five pillars, the mix of indicators included in each pillar vary across climate-related impacts; hence, the value of each pillar and the WRI will vary from one climate-related impact to another.

Taking the Exposure Sub-Index as an example, it is calculated as the arithmetic average of the following five pillars:

$$E_{c,h}^{t} = \frac{1}{5}\left(FC_{c,h}^{t} + HC_{c,h}^{t} + MC_{c,h}^{t} + NC_{c,h}^{t} + SC_{c,h}^{t}\right)$$

Where:

$FC_{c,h}^{t}$	=	Is the Financial Capital Pillar value for the hth climate-related impact for the cth census division at time t
$HC_{c,h}^{t}$	=	Is the Human Capital Pillar value for the hth climate-related impact for the cth census division at time t
$MC_{c,h}^{t}$	=	Is the Manufactured Capital Pillar value for the hth climate-related impact for the cth census division at time t
$NC_{c,h}^{t}$	=	Is the Natural Capital Pillar value for the hth climate-related impact for the cth census division at time t
$SC_{c,h}^{t}$	=	Is the Social Capital Pillar value for the hth climate-related impact for the cth census division at time t

The Sensitivity and Low Coping Capacity Sub-indices are similarly calculated; each comprising the five 'capital' pillars. As noted above, **for all three of these Sub-indices, t is essentially today** (or more precisely, the most recent year for which the required indicator data is available). To the extent that any of the indicators selected for inclusion in these three Sub-indices changes over time at different rates across census divisions—which is highly likely—the projected WRI results presented in Section 6 and Appendix E will also change. This will have implications for immediate adaptation choices informed by this report. However, this source of uncertainty can be accounted for through judicious adaptation decision-making processes.

Each of the five 'capital' pillars comprises two or more sub-pillars with corresponding indicators; the selection of indicators is discussed in Section 5.3. These sub-pillars seek to capture—as best as possible—dimensions of human wellbeing (see Box 2) associated with particular capitals that will influence exposure, sensitivity and lack of response capacity, and thus aggregate risk attributable to climate hazards (see Figure 5-6).

A set of two “aggregate” sub-pillars have been constructed for the Manufactured Capital Pillar; Infrastructure and Buildings. Each of these comprises of two or more “disaggregate” sub-pillars. For Infrastructure; Transport, Water, Waste, Energy, and Information and Communications Technology (ICT). For Buildings; Residential and Institutional, Commercial and Industrial (ICI). These sub-pillars and their indicators are intended to capture the housing dimension of wellbeing, as well as support wellbeing more generally through the provision of manufactured capital.

Likewise, a set of two “aggregate” sub-pillars have been constructed for the Financial Capital Pillar; Economy and Financial security. Each of these comprises three “disaggregated” pillars. For Economy; Employment, Earnings and Output. For Financial Security; Income, Wealth and Income Sufficiency. These sub-pillars and their indicators are intended to primarily capture the jobs, earnings, income, wealth and consumption dimensions of wellbeing.

Three “aggregate” sub-pillars have been constructed for the Human Capital Pillar; Population and Demographics, Knowledge and Skills, and Health. The first two of these each comprise two “disaggregate” sub-pillars. For Population and Demographics; Residents and Cultural Identity. And for Knowledge and Skills; Education Attainment and Educational Quality. These sub-pillars and their indicators are intended to capture the physical and mental health, knowledge and skills, and cultural identity dimensions of wellbeing, as well as measure the population at risk to climate hazards.

Four “aggregate” sub-pillars have been constructed for the Natural Capital Pillar, reflecting broad groups of ecosystem services; Regulating Services, Provisioning Services, Cultural Services, and Habitat and Biodiversity (referred to as Foundational and Supporting Services in Section 3). The first two of these each comprise four “disaggregate” sub-pillars. For Regulating Services; Air Quality, Water, Solid Waste, and Environmental Quality. For Provisioning Services; Energy, Freshwater Resources, Food, and Timber. These sub-pillars and their indicators are intended to capture the environmental quality dimension of wellbeing, as well as support wellbeing more generally through the provision of natural capital.

Finally, three “aggregate” sub-pillars have been constructed for the Social Capital Pillar; Civic Engagement and Governance, Personal Safety and Security, and Relationships. The former comprises of three “disaggregate” sub-pillars; Democratic Engagement, Trust, and Volunteering. These sub-pillars and their indicators are intended to capture the social connections and relationships, work-life balance, civic engagement and governance, and personal safety and security dimensions of wellbeing.

The hierarchical structure of the Exposure, Sensitivity and Low Coping Capacity Sub-Indices, with nested pillars and sub-pillars is shown in Figure 5-7. The number of indicators included in each “disaggregate” sub-pillar is also shown. This figure shows how the Index components seek to capture the various domains of wellbeing defined in Box 2.[16]

[16] We introduced this information briefly in Section 1 and have included it here, too, to facilitate readability.

Box 2: Working definition of wellbeing

There is no universally accepted definition for human wellbeing. For the purpose of this report wellbeing has been defined by Nova Scotia Environment and Climate Change and the project team to characterize "how we are doing" as individuals, households and communities.[17] Informed by the OECD's Better Life Initiative[18] and the New Zealand Living Standards Framework[19], Nova Scotia Environment and Climate Change and the project team also identified 12 dimensions of wellbeing that capture outcomes for individuals, households and communities 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.

The 12 domains of wellbeing are:

1. Jobs and earnings
2. Social connections and relationships
3. Income, wealth and consumption
4. Civic engagement and governance
5. Knowledge and skills
6. Environmental quality
7. Physical and mental health
8. Housing
9. Personal safety and security
10. Life satisfaction
11. Work-life balance
12. Cultural identity

[17] This working definition was adapted from "What Works Wellbeing Definition" (https://whatworkswellbeing.org/about-wellbeing/what-is-wellbeing/) by Nova Scotia Environment and Climate Change

[18] See OECD 2011b: https://www.oecd.org/statistics/better-life-initiative.htm.

[19] See New Zealand Treasury 2018: https://www.treasury.govt.nz/information-and-services/nz-economy/higher-living-standards/history-lsf

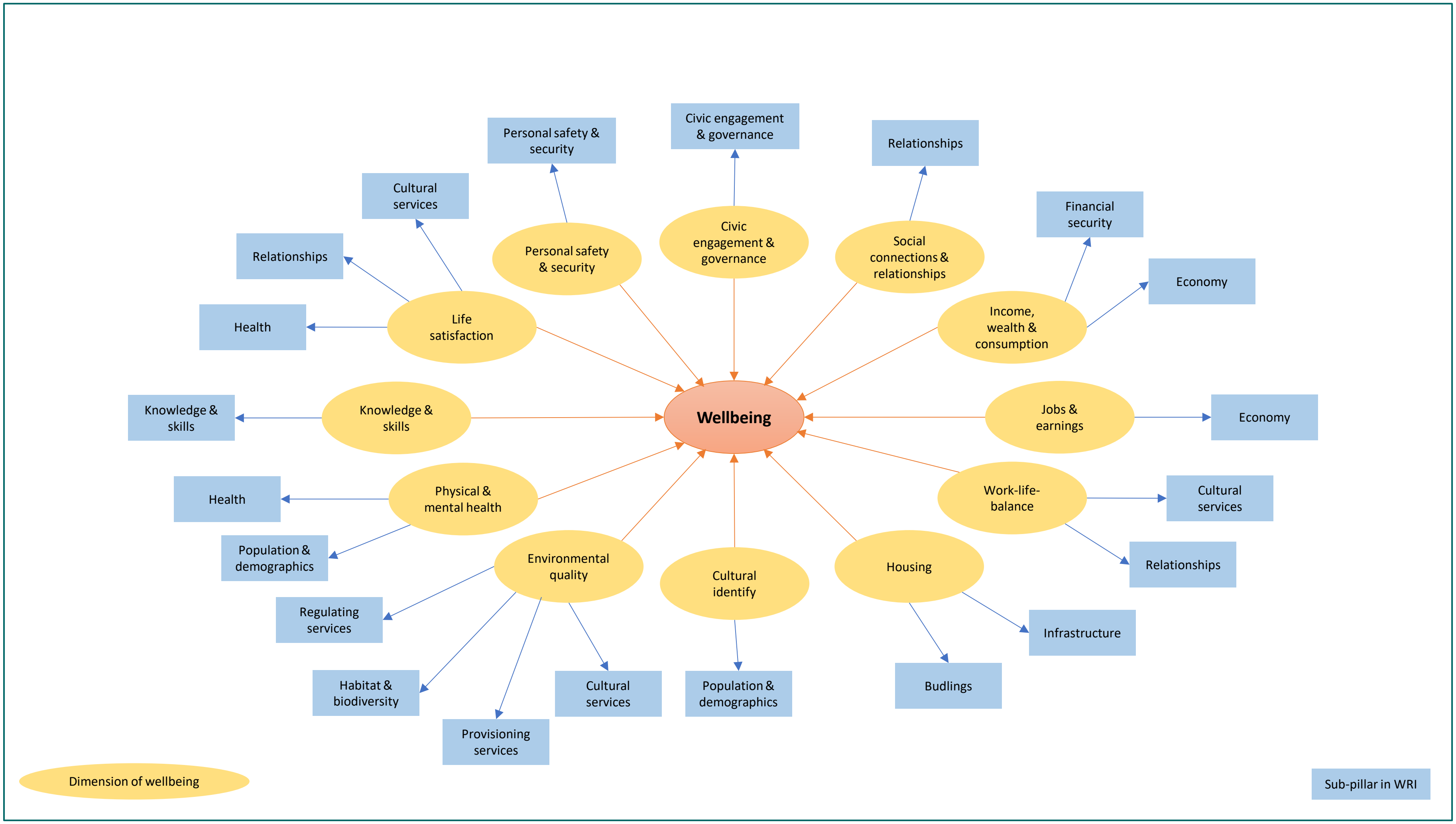


Figure 5-6. Mapping domains (also referred to as dimensions) of wellbeing onto the WRI Sub-pillars.

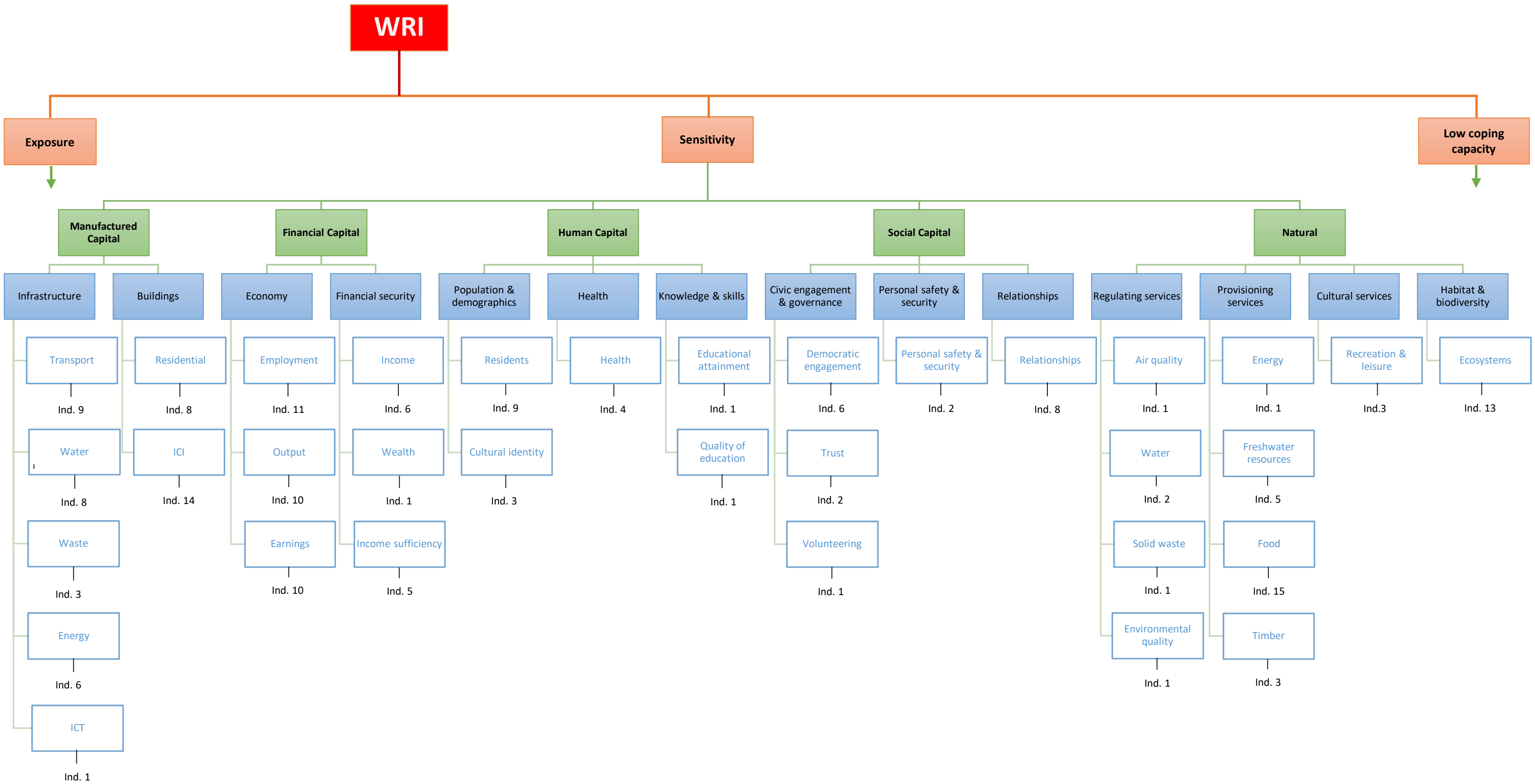


Figure 5-7: Structure of the Exposure, Sensitivity and Low Coping Capacity Sub-indices and their nestedness.

The diagram shows nested pillars (the five capitals in shaded green boxes), aggregate sub-pillars (shaded blue boxes) disaggregate sub-pillars (blue outlined boxes), and the number (#) of indicators available for inclusion within each disaggregated sub-pillar (ind. #). **The nested structure is shown only for the Sensitivity Sub-index, but it is identical for the other two Sub-indices. When constructing the Sub-indices for a climate-related impact, an indicator is included only once across all Sub-indices.**

5.3 Indicator Inventory and Selection

The WRI relies on the availability of input data for a range of indicators and measurement metrics. Since the complete list of indicators relevant to wellbeing in Nova Scotia is too large to include in a single assessment, it is necessary to develop a representative short-list of indicators. In this section we describe the construction of the indicator inventory, the criteria-based selection process used to identify a list of top candidate indicators for use in the WRI, and the results of that selection procedure.

5.3.1 Development of a Comprehensive Indicator Database

As a starting point, the Adaptation Team with the Climate Change Unit of Nova Scotia Environment and Climate Change (NS ECC) provided a database of potential indicators organized by the five capitals [“Indicator Inventory Critical Stocks Identified 2020.08.27.xls”] and a folder of relevant documents. To supplement these materials, we reviewed a number of publications relating to (a) existing disaster, climate change, social vulnerability, risk, resilience, and adaptation indices, and (b) existing human wellbeing and capitals-based indices. Examples of these references are listed in Appendix B, some of which were included in the materials provided by the NS ECC Adaptation Team. The purpose of the literature review was threefold: 1) to develop a better understanding of pertinent indicators and how they should be organized across sub-indices, pillars, and sub-pillars, 2) to better understand the nuanced relationships (associations and causality) between the five capitals and wellbeing, and 3) to support the identification of additional indicators to be included in the inventory.

The completed indicator inventory contains roughly 539 candidate biophysical and socioeconomic indicators. These indicators are used to create the Exposure, Sensitivity and Low Coping Capacity (and Vulnerability) Sub-indices. A screenshot from the database is shown in Figure 5-8 for illustration purposes.

As shown in Figure 5-8, the database is organized in separate tabs for the five capitals (manufactured, financial, human, social and natural), with nested domains (to estimate pillars in the WRI) and sub-categories (to estimate sub-pillars in the WRI) reflecting typologies typical of composite wellbeing indices. All candidate indicators in the database are linked to a specific sub-category and in turn to a higher-level domain.

In addition, each candidate indicator is identified as being provisionally an indicator of one of Exposure, Sensitivity or Coping Capacity; though which sub-index an indicator is ultimately placed in the WRI will largely be hazard-specific—especially for Exposure and Sensitivity, and to a much lesser extent, for Low Coping Capacity where indicators are more generally applicable.

capitalSheet	domain	subCategory	indicator	metric
Financial	Financial security	Income	Prevalence of low-income 3	% of households in "low income" (LIM-AT)
Financial	Financial security	Income	Prevalence of low-income 4	% of 1-person households in "low income" (LIM-AT)
Financial	Financial security	Income	Prevalence of low-income 5	% of population in "low income" (LICO-AT or LIM-AT)
Financial	Financial security	Income	Prevalence of child poverty	% of population aged 0-17 years in "low income" (LICO-AT or LIM-AT)
Financial	Financial security	Income	Prevalence of elderly poverty	% of population aged 65 years and over in "low income" (LICO-AT or LIM-AT)
Financial	Financial security	Income	Prevalence of poverty among visible minoities	% of population identifying as visible minority in "low income" (LICO-AT or LIM-AT)
Financial	Financial security	Earnings	Wage NAICS 11 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 21 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 22 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 23 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 31-33 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 41 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 44-45 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 48-49 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 51 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 52-55 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 56 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 61 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 62 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 71 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 72 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 81 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage NAICS 91 ++	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage all industries, NAICS 11-91 (can be by priority sectors, like "tourism")	(average or median) weekly wage - FT & PT employed, 15 years and over (can split by gender, by age interval)
Financial	Financial security	Earnings	Wage all industries - dispartities 1	median wage as a % of average wage
Financial	Financial security	Earnings	Wage all industries - dispartities 1	P90/P10 gross earnings ratio
Financial	Financial security	Earnings	Wages - gender equality	Gender Pay Gap or Ratio (annual wages)
Financial	Financial security	Earnings	Wages - visible minority equality	Pay Gap or Ratio (annual wages) vs non visible minorities
Financial	Financial security	Earnings	Wages - aboriginal equality	Gender Pay Gap or Ratio (annual wages) vs non-aboriginal identity
Financial	Financial security	Wealth	Ownership of dwelling	% of private dwellings owned by household
Financial	Financial security	Wealth	Value of dwelling	median or average ($) value of dwelling (self reported) (can be split by age, including +65)*
Financial	Financial security	Wealth	Savings	median or average savings (deposits at financial institions + financial assets, non-pension) (economic families)
Financial	Financial security	Wealth	Savings disparity	ratio of (median or average) savings of lowest (AT) income quintile to highest (AT) income quintile
Financial	Financial security	Wealth	Net worth (assets less debt)	median or average net worth ($) of economic families, persons not in economic families, or both
Financial	Financial security	Wealth	Net worth disparity 1	ratio of (median or average) net worth of lowest (AT) income quintile to highest (AT) income quintile
Financial	Financial security	Wealth	Net worth disparity 2	Share of household neet wealth held by top 20% of households
Financial	Financial security	Wealth	Disposable income	median or average disposable income of household
Financial	Financial security	Wealth	Disposable income - disparities 1	median disposable income as % of average disposable income
Financial	Financial security	Wealth	Disposable income - disparities 2	S80/S20 household disposable income ratio
Financial	Financial security	Wealth	Household debt	interest paid per households
Financial	Financial security	Wealth	Debt service ratio	debt service ratio, interest only
Financial	Financial security	Wealth	Savings rate	household savings rate
Financial	Financial security	Income sufficiency	Affordable energy	weighted average price of home energy / mean equivalized net household income
Financial	Financial security	Income sufficiency	Affordable utilities	weighted average cost of home utilities / mean equivalized net household income
Financial	Financial security	Income sufficiency	Affordable bills	% of Nova Scotians who could not pay their bills (utilities, credit card) on time at least once every 6 months in the last year
Financial	Financial security	Income sufficiency	Affordable food 1	% of Nova Scotians who could not purchase "nutritious" foods at least once in 6 months in the last year
Financial	Financial security	Income sufficiency	Affordable food 2	% of Nova Scotians who used a local food bank at least once in 6 months in the last year

Manufactured | **Financial** | Human | Social | Natural

Figure 5-8. Screenshot of the financial capital tab of the indicator database.

5.3.2 Criteria-based Selection of Indicators

The process of selecting indicators for provisional inclusion in the WRI involved assessing their performance with respect to defined criteria. Table 5-2 describes the three criteria we applied. Note that a fourth criterion relating to "materiality" (i.e., there is a clear relationship between the indicator and the WRI based on theory, and changes in the indicator capture important impacts to the WRI) was initially proposed. However, following scoring it was dropped from the screening calculus due to its highly subjective nature.

Table 5-2. Indicator selection criteria.

Criterion	Description	Scoring Rubric
Feasibility	The indicator or data to construct the indicator is accessible without delay with reasonable effort and cost and can provide information on changes in the WRI over time, including in the necessary aggregation/disaggregation units.	3 = minimal collection and processing effort 2 = modest collection effort and minor calculations involved 1 = more significant effort securing data, downloading and processing GIS information, and more complex transformations
Data quality	The data associated with the indicator are reliable, valid (i.e., not prone to a high degree of error), unambiguous with respect to direction of change, have sufficient spatial and temporal coverage with coverage that is likely to persist in future, and are appropriate to combine as composite indicators where relevant.	Geometric average of the following two scores: Geographic scale: 3 = available at census division level 2 = available at other sub-provincial level 1 = available at provincial level only 0 = available at national level only Frequency of data collection: 3 = annual frequency 2 = occasional frequency (even if regular, like the Census) 1 = one-off (survey or study)

Criterion	Description	Scoring Rubric
Evidence-based	The association between changes in the indicator and changes in the capitals/WRI are clearly understood and supported by evidence and/or the indicator is recommended/used by leading experts.	Geometric average of the following two scores: Climate-related evidence: 3 = associations clearly understood, documented in peer-reviewed or grey literature, and used by other practitioners 2 = used by other practitioners and indices 1 = suggested by ESSA project team Wellbeing-related evidence: 3 = associations clearly understood and documented in peer-reviewed or grey literature 2 = used by other practitioners and indices 1 = suggested by ESSA project team

Sources: c.f. OECD 2005 (Nardo et al. 2005); OECD 2011a, this study

The overall score for each indicator is calculated using the geometric average of the data quality, feasibility and evidence-based scores, and ranges from 1 (relatively poor) to 3 (relatively good). The individual criteria scores assigned to each candidate indicator, along with the overall score for that indicator, are recorded in the indicator database. We then used these scores in conjunction with the following decision rules to identify the short list of 245 candidate indicators, some of which are not intended for the WRI, but are used instead to support analysis of the distributional effects of the WRI results:

- Across the five capitals, every "disaggregated" sub-pillar is represented.
- Scores <1.96 are discarded (based on natural breaks in the data, meaning that there were small gaps in scores slightly below that value and a marked drop off between groups of values above 1.96, determined via visual inspection).
- For each capital, there must be at least one indicator in each "disaggregated" sub-pillar.

Working from the screened list of top candidate indicators intended for the WRI, we set about collecting the necessary data to compute the indicators. During this process, we discovered more detailed data for some indicators than originally anticipated was available; for example, with respect to types of buildings and facilities, and types of habitat (e.g., dunes and beaches). At the same time, data for some indicators that we believed to be available, turned out to be unavailable at the appropriate spatial scale or not at all (e.g., for linear drainage and water supply infrastructure). So, we lost some indicators and gained others. Overall, following data collection and processing, a total of 175 indicators intended for the Exposure, Sensitivity and Low Coping Capacity Sub-indices were included in the WRI. These indicators are listed in Table 5-3. Note that several of the listed indicators are themselves composites of two or more indicators; the description of these composite indicators in the last column identifies the underlying individual indicators.

Table 5-3. Indicators included in the WRI for characterizing the Exposure, Sensitivity and Low Coping Capacity Sub-indices.

ID	Indicator, and sub-pillars in brackets	Units	Notes on indicators, if needed, and data sources in brackets
ind.1	Aquaculture (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for North American Industrial Classification System Codes (NAICS) 1125 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.2	Earnings diversity (Economy | Earnings)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for payroll compensation payments across all sectors of the economy divided by total for NAICS 11-91 (NAICS 11-91) (Statistics Canada, 2021)
ind.3	Farms (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 1110 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.4	Fishing (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 1141 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.5	Forestry (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 113 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.6	Insurance and real estate services (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 524 + 521 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.7	Outdoor workers (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 11 + 21 + 22 + 23 + 481 + 482 + 483 + 484 + 485 + 487 + 491 + 492 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.8	Outdoor & manufacturing workers (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 11 + 21 + 22 + 23 + 31-33 + 481 + 482 + 483 + 484 + 485 + 487 + 491 + 492 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.9	Construction and repairs (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 23 divided by total for NAICS 11-91 (Statistics Canada, 2021)

ind.10	Tourism (earnings dependence) (Economy | Earnings)	(% of total employed)	Employed persons 15 years and older times total payroll compensation per hour times average annual hours worked per employed person for NAICS 4821 + 4831 + 4832 + 487 + 4881 + 4882 + 4883 + 4884 + 4889 + 5615 + 71 + 72 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.11	Aquaculture (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 1125 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.12	Employment diversity (Economy | Employment)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for employed persons across all sectors of the economy (NAICS 11-91) (Statistics Canada, 2021)
ind.13	Farms (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 1110 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.14	Fishing (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 1141 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.15	Forestry (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 113 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.16	Insurance and real estate services (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 524 + 521 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.17	Outdoor workers (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 11 + 21 + 22 + 23 + 481 + 482 + 483 + 484 + 485 + 487 + 491 + 492 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.18	Outdoor & manufacturing workers (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 11 + 21 + 22 + 23 + 31-33 + 481 + 482 + 483 + 484 + 485 + 487 + 491 + 492 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.19	Construction and repairs (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 23 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.20	Tourism (employment dependence) (Economy | Employment)	(% of total employed)	Employed persons 15 years and older for NAICS 4821 + 4831 + 4832 + 487 + 4881 + 4882 + 4883 + 4884 + 4889 + 5615 + 71 + 72 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.21	Unemployment rate (Economy | Employment)	(%)	(Statistics Canada, 2021)
ind.22	Aquaculture (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for North American Industrial Classification System Codes (NAICS) 1125 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.23	Economic output diversity (Economy | Output)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for GDP across all sectors of the economy (NAICS 11-91) (Statistics Canada, 2021)

ind.24	Farms (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 1110 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.25	Fishing (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 1141 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.26	Forestry (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 113 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.27	Insurance and real estate services (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 524 + 521 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.28	Outdoor workers (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 11 + 21 + 22 + 23 + 481 + 482 + 483 + 484 + 485 + 487 + 491 + 492 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.29	Outdoor & manufacturing workers (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 11 + 21 + 22 + 23 + 31-33 + 481 + 482 + 483 + 484 + 485 + 487 + 491 + 492 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.30	Construction and repairs (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 23 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.31	Tourism (economic output dependence) (Economy | Output)	(% of total output)	Employed persons 15 years and older times GDP per hour times average annual hours worked per employed person for NAICS 4821 + 4831 + 4832 + 487 + 4881 + 4882 + 4883 + 4884 + 4889 + 5615 + 71 + 72 divided by total for NAICS 11-91 (Statistics Canada, 2021)
ind.32	Individual income diversity (Financial Security | Income)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for households across all sources of income (market, savings and investment, and government transfers) (Statistics Canada, 2021)
ind.33	Gini coefficient (after-tax (AT) household income) (Financial Security | Income)	(index)	Based on household after-tax income groups in 2015 for private households (Statistics Canada, 2021)
ind.34	Median after-tax income individuals (all sources) (Financial Security | Income)	($ 2015)	(Statistics Canada, 2021)
ind.35	Prevalence low income (Financial Security | Income)	(%)	Arithmetic average of LICO-AT and LIM-AT percentages (Statistics Canada, 2021)
ind.36	Prevalence low income among children (Financial Security | Income)	(%)	Arithmetic average of LICO-AT and LIM-AT percentages (Statistics Canada, 2021)
ind.37	Prevalence low income among elderly (Financial Security | Income)	(%)	Arithmetic average of LICO-AT and LIM-AT percentages (Statistics Canada, 2021)

ind.38	Affordable bills (Financial Security | Income Sufficiency)	(score: 5 = least once per month)	Could not pay my bills on time (e.g., water, power, phone, credit card) in last 12 months (Engage Nova Scotia, 2021)
ind.39	Affordable foods (Financial Security | Income Sufficiency)	(score: 5 = least once per month)	Could not purchase nutritious foods or had to use local food bank in last 12 months (Engage Nova Scotia, 2021)
ind.40	Average monthly shelter costs (Financial Security | Income Sufficiency)	($ 2015)	Weighted average of rental and owner monthly shelter costs (Statistics Canada, 2021)
ind.41	Financial wellbeing (Financial Security | Income Sufficiency)	(score: 12 = good financial health)	Had enough money to buy what I needed in last 12 months and was happy with financial situation (Engage Nova Scotia, 2021)
ind.42	Spending 30% or more of income on shelter costs (Financial Security | Income Sufficiency)	(% of households)	(Statistics Canada, 2021)
ind.43	Average value of dwellings (Financial Security | Wealth)	($ 2015)	(Statistics Canada, 2021)
ind.44	Accessibility of health care (Health)	(score: 5 = excellent]	Overall accessibility of the health care services in this community (Engage Nova Scotia, 2021)
ind.45	Perceived mental health (Health)	(score: 12 = high health)	Arithmetic (weighted) average of two indicators: self-assessed mental health (scored out of 5); and satisfaction with mental wellbeing (scored out of 7) (Engage Nova Scotia, 2021)
ind.46	Perceived physical health (Health	(score: 12 = high health)	Arithmetic (weighted) average of two indicators: self-assessed physical health (scored out of 5); and satisfaction with physical wellbeing (scored out of 7) (Engage Nova Scotia, 2021)
ind.47	Quality of health care (Health)	(score: 5 = excellent]	Overall quality of the health care services in this community (Engage Nova Scotia, 2021)
ind.48	Ethnic diversity (Population & Demographics | Cultural Identity)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for ethnic identify of residents (Statistics Canada, 2021)
ind.49	Neither English nor French (Population & Demographics | Cultural Identity)	(% of total pop)	(Statistics Canada, 2021)
ind.50	New immigrants (Population & Demographics | Cultural Identity)	(% of total population)	Immigrants arriving between 2011-2016 (Statistics Canada, 2021)
ind.51	Demographic dependency ratio (Population & Demographics | Residents)	(ratio)	Total persons aged 19 years and younger plus total persons aged 65 years and older, divided by total persons aged 20-64 years (Statistics Canada, 2021)
ind.52	Elderly adults living alone (Population & Demographics | Residents)	(% of 65+ pop)	(Statistics Canada, 2021)
ind.53	Elderly population	(% of total pop)	(Statistics Canada, 2021)

	(Population & Demographics | Residents)		
ind.54	Infants & children population (Population & Demographics | Residents)	(% of total pop)	(Statistics Canada, 2021)
ind.55	Lone-parent households (Population & Demographics | Residents)	(% of all households)	(Statistics Canada, 2021)
ind.56	Population (Population & Demographics | Residents)	(count)	(Statistics Canada, 2021)
ind.57	Population density (Population & Demographics | Residents)	(people / km2)	(Statistics Canada, 2021)
ind.58	Recent migrant movers (Population & Demographics | Residents)	(% of total population)	(Statistics Canada, 2021)
ind.59	1-person households (Population & Demographics | Residents)	(% of all households)	(Statistics Canada, 2021)
ind.60	Adults (25-64) with no certificate; diploma or degree (Knowledge & Skills | Educational Attainment)	(% of total pop)	(Statistics Canada, 2021)
ind.61	Education opportunities (Knowledge & Skills | Educational Quality)	(score: 7 = extremely satisfied)	Arithmetic average of three indicators: there are plenty of opportunities to take formal education courses; there are plenty of opportunities to take courses of interest; satisfaction with access to educational opportunities in the community (ENGAGE, 2021)
ind.62	Buildings (Buildings | ICI)	(m2)	All buildings, including residential and ICI; note that a residential building may have multiple dwellings (see Appendix D)
ind.63	Buildings (Buildings | ICI)	(count)	All buildings, including residential and ICI; note that a residential building may have multiple dwellings (see Appendix D)
ind.64	EMS 1 (Buildings | ICI)	(count)	(see Appendix D)
ind.65	EMS 2 (Buildings | ICI)	(persons per facility)	Calculated from ind. 64
ind.66	Heritage sites (Buildings | ICI)	(m2)	(see Appendix D)
ind.67	Hospitals 1 (Buildings | ICI)	(m2)	(see Appendix D)
ind.68	Hospitals 2 (Buildings | ICI)	(persons per m2)	Calculated from ind. 67
ind.69	Industrial sites (Buildings | ICI)	(m2)	(see Appendix D)
ind.70	Lighthouse	(count)	(see Appendix D)

	(Buildings | ICI)		
ind.71	Pulp and lumber mills (Buildings | ICI)	(m2)	(see Appendix D)
ind.72	Outdoor rinks (Buildings | ICI)	(m2)	(see Appendix D)
ind.73	Places to gather 1 (Buildings | ICI)	(count)	Churches, community centres, schools, and town halls (see Appendix D)
ind.74	Places to gather 2 (Buildings | ICI)	(persons per facility)	Calculated from ind. 73
ind.75	Senior care facilities (Buildings | ICI)	(count)	(see Appendix D)
ind.76	Apartment in a building that has five or more storeys (Buildings | Residential)	(% of total dwellings)	(Statistics Canada, 2021)
ind.77	Band housing (Buildings | Residential)	(% of total dwellings)	(Statistics Canada, 2021)
ind.78	Dwellings built before 1990 (Buildings | Residential)	(% of total dwellings)	(Statistics Canada, 2021)
ind.79	Dwelling density (Buildings | Residential)	(dwellings / km2)	(Statistics Canada, 2021)
ind.80	Dwellings in major need of repairs (Buildings | Residential)	(% of total dwellings)	(Statistics Canada, 2021)
ind.81	Movable dwellings (Buildings | Residential)	(% of total dwellings)	(Statistics Canada, 2021)
ind.82	Private dwellings (Buildings | Residential)	(count)	(Statistics Canada, 2021)
ind.83	Rental housing (Buildings | Residential)	(% of total dwellings)	(Statistics Canada, 2021)
ind.84	Electricity generating plant (Infrastructure | Energy1)	(m2)	(see Appendix D)
ind.85	Fuel storage (Infrastructure | Energy1)	(count)	(see Appendix D)
ind.86	Substation (Infrastructure | Energy1)	(count)	(see Appendix D)

ind.87	Tower (Infrastructure | Energy1)	(count)	(see Appendix D)
ind.88	Transmission lines (Infrastructure | Energy1)	(km)	(see Appendix D)
ind.89	Windmill (Infrastructure | Energy1)	(count)	(see Appendix D)
ind.90	Reliability of internet service (Infrastructure | ICT)	(score: 5 = excellent]	How would you rate the quality of internet service in your home (Engage Nova Scotia, 2021)
ind.91	Air transport infrastructure (Infrastructure | Transport)	(m2)	Includes airstrips and heliports (paved and unpaved) (see Appendix D)
ind.92	Coastal transport infrastructure (Infrastructure | Transport)	(m2)	Includes ferry terminals, wharfs, drydocks, dockyards, and slipways (see Appendix D)
ind.93	Commuting option diversity (Infrastructure | Transport)	(index)	(Statistics Canada, 2021)
ind.94	Duration of commute (Infrastructure | Transport)	(mins per day)	Number of minutes to commute to work from residence for main job (Engage Nova Scotia, 2021)
ind.95	Employed labour force with commute < 15 mins (Infrastructure | Transport)	(% of labour force)	(Statistics Canada, 2021)
ind.96	Rail lines (Infrastructure | Transport)	(km rails)	(see Appendix D)
ind.97	Road transport 1 (Infrastructure | Transport)	(km lanes)	Includes all types of roads, ramps, bridges, tunnels, etc. (see Appendix D)
ind.98	Road transport 2 (Infrastructure | Transport)	(km lanes per km2)	Calculated from ind. 97
ind.99	Road transport 3 (Infrastructure | Transport)	(persons per km lanes)	Calculated from ind. 97
ind.100	Dumps (Infrastructure | Waste)	(m2)	(see Appendix D)
ind.101	Landfill sites (Infrastructure | Waste)	(m2)	(see Appendix D)
ind.102	Solid waste (non-linear) (Infrastructure | Waste)	(persons per m2)	Calculated from ind. 101
ind.103	Culverts (Infrastructure | Water1)	(m per km lanes)	Covers both rail and road transport networks (see Appendix D)
ind.104	Dams	(km)	(see Appendix D)

	(Infrastructure | Water1)		
ind.105	Ditches and dikes 1 (Infrastructure | Water1)	(km)	(see Appendix D)
ind.106	Ditches and dikes 2 (Infrastructure | Water1)	(m per km2)	Calculated from ind. 105
ind.107	Pumping station (Infrastructure | Water1)	(count)	(see Appendix D)
ind.108	Reservoir (Infrastructure | Water1)	(m2)	(see Appendix D)
ind.109	Wastewater (non-linear) 1 (Infrastructure | Water1)	(m2)	Includes wastewater treatment plants and settling ponds (see Appendix D)
ind.110	Wastewater (non-linear) 2 (Infrastructure | Water1)	(persons per m2)	Calculated from ind. 109
ind.111	Campgrounds (Cultural services | Recreation & Leisure)	(m2)	(see Appendix D)
ind.112	Nature-based opportunities (Cultural services | Recreation & Leisure)	(score: 27 = participate all the time)	% of maximum score, which is 27, 27 = engage in outdoor leisure activities all of the time (Engage Nova Scotia, 2021)
ind.113	Ski area (Cultural services | Recreation & Leisure)	(m2)	(see Appendix D)
ind.114	Critical / sensitive terrestrial habitat (Habitat & Biodiversity | Ecosystems)	(km2)	(see Appendix D)
ind.115	Critical / sensitive freshwater habitat (Habitat & Biodiversity | Ecosystems)	(km2)	(see Appendix D)
ind.116	Critical / sensitive marine habitat (Habitat & Biodiversity | Ecosystems)	(km2)	(see Appendix D)
ind.117	Nature reserve (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)
ind.118	Land trust (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)
ind.119	National park (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)
ind.120	Protected areas (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)

ind.121	Provincial park (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)
ind.122	Saltmarshes 1 (Habitat & Biodiversity | Ecosystems)	(km2)	(see Appendix D)
ind.123	Dunes and beaches (Habitat & Biodiversity | Ecosystems)	(km2)	(see Appendix D)
ind.124	Tree area (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)
ind.125	Wetlands 1 (Habitat & Biodiversity | Ecosystems)	(km2)	(see Appendix D)
ind.126	Wilderness area (Habitat & Biodiversity | Ecosystems)	(m2)	(see Appendix D)
ind.127	Energy conservation (Provisioning Services | Energy2)	(score: 5 = all the time)	How often did you conserve energy in the last 12 months (Engage Nova Scotia, 2021)
ind.128	Perceived water quality (Provisioning Services | Freshwater Resources)	(score: 7 = very strongly agree is very good)	The water quality in my community is very good (Engage Nova Scotia, 2021)
ind.129	Inputs to agricultural lands (Provisioning Services | Freshwater Resources)	(acres)	(Statistics Canada, 2021)
ind.130	River (Provisioning Services | Freshwater Resources)	(m2)	(see Appendix D)
ind.131	Lakes and riverlakes (Provisioning Services | Freshwater Resources)	(m2)	(see Appendix D)
ind.132	Water conservation (Provisioning Services | Freshwater Resources)	(score: 5 = all the time)	How often did you conserve water in the last 12 months (Engage Nova Scotia, 2021)
ind.133	Animal production: farms (Provisioning Services | Food)	(count)	Includes the following types of farms: beef & cattle ranching, dairy cattle, hog and pig, poultry and egg, and other (Statistics Canada, 2021)
ind.134	Animal production: farm diversity (Provisioning Services | Food)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for mix of animal farms (e.g., cattle, dairy, poultry, etc.) (Statistics Canada, 2021)
ind.135	Animal production: net income (Provisioning Services | Food)	($ million)	(Statistics Canada, 2021)
ind.136	Animal production: net income diversity (Provisioning Services | Food)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for the net income sourced from the mix of animal farms (Statistics Canada, 2021)
ind.137	Aquaculture	(count)	(see Appendix D)

	(Provisioning Services | Food)		
ind.138	Bee colonies (Provisioning Services | Food)	(count)	(Statistics Canada, 2021)
ind.139	Consumption of local foods (Provisioning Services | Food)	(score: 5 = all the time)	How often in the last year did you purchase foods produced locally (Engage Nova Scotia, 2021)
ind.140	Crop production: farms (Provisioning Services | Food)	(count)	Includes the following types of farm: oilseed & grain, vegetable & melon, fruit & nut tree, greenhouse, nursery or floriculture, and other (Statistics Canada, 2021)
ind.141	Crop production: farm diversity (Provisioning Services | Food)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for mix of crop farms (e.g., grain and oilseed, vegetable and melon, fruit and tree nut, etc.) (Statistics Canada, 2021)
ind.142	Crop production: net income (Provisioning Services | Food)	($ million)	(Statistics Canada, 2021)
ind.143	Crop production: net income diversity (Provisioning Services | Food)	(index)	Arithmetic average of Shannon equitability index and inverse Simpson evenness index calculated for the net income sourced from the mix of crop farms (Statistics Canada, 2021)
ind.144	Agricultural land (Provisioning Services | Food)	(acres)	Includes land in crops, summer fallow land, tame pasture, seeded pasture, natural pasture and other farmland (Statistics Canada, 2021)
ind.145	Greenhouses (Provisioning Services | Food)	(m2)	(see Appendix D)
ind.146	Irrigate crop production (Provisioning Services | Food)	(acres)	(Statistics Canada, 2021)
ind.147	Orchards (Provisioning Services | Food)	(m2)	(see Appendix D)
ind.148	Crown land harvest plans (Provisioning Services | Timber)	(m2)	(see Appendix D)
ind.149	Forest land 1 (Provisioning Services | Timber)	(km2)	(see Appendix D)
ind.150	Forest land 2 (Provisioning Services | Timber)	(m3)	(see Appendix D)
ind.151	Perceived air quality (Regulating Services | Air Quality)	(score: 7 = very strongly agree is very good)	The air quality in my community is very good (ENGAGE, 2021)
ind.152	Perceived environ. Quality (Regulating Services | Environmental Quality)	(score: 7 =very strongly agree is very good)	The environmental quality in my community is good very (ENGAGE, 2021)

ind.153	Waste minimization (Regulating Services | Solid Waste)	(score: 5 = all the time)	How often did you reduce, avoid, recycle or reuse waste in last 12 months (Engage Nova Scotia, 2021)
ind.154	Saltmarshes 2 (Regulating Services | Water2)	(km2)	(see Appendix D)
ind.155	Wetlands 2 (Regulating Services | Water2)	(km2)	(see Appendix D)
ind.156	Interest in politics (Civic Engagement & Governance | Democratic Engagement)	(score: 10 =a lot of interest)	Arithmetic average of three indicators: Level of interest in: Federal politics; Provincial politics; and Municipal/Band politics (ENGAGE, 2021)
ind.157	Participate in democracy 1 (Civic Engagement & Governance | Democratic Engagement)	(score: 1 = yes; 2 = no)	Participate in democratic event in community in last 12 months (Engage Nova Scotia, 2021)
ind.158	Participate in democracy 2 (Civic Engagement & Governance | Democratic Engagement)	(score: 10 = always have time)	Adequate time to be active in the community (Engage Nova Scotia, 2021)
ind.159	Participate in democracy 3 (Civic Engagement & Governance | Democratic Engagement)	(score: 7 = extremely satisfied)	Satisfaction with how well democracy is working (Engage Nova Scotia, 2021)
ind.160	Political efficacy 1 (Civic Engagement & Governance | Democratic Engagement)	Score out of 7, 7 = very strongly agree	Arithmetic average of two indicators: people like me do not have any say about what government does; and I do not think public officials care much what people like me think (Engage Nova Scotia, 2021)
ind.161	Political efficacy 2 (Civic Engagement & Governance | Democratic Engagement)	(score: 7 = extreme satisfied)	Satisfaction with the way my local government responds to community needs (Engage Nova Scotia, 2021)
ind.162	Trust in institutions (Civic Engagement & Governance | Trust)	(score: 7 = trusted a lot)	Arithmetic average of six indicators: how much do you trust: local/municipal/band government; provincial government; federal government; the media; the police; and the justice system and courts (Engage Nova Scotia, 2021)
ind.163	Trust in others (Civic Engagement & Governance | Trust)	(score: 7 = trusted a lot)	Arithmetic average of two three indicators: how much do you trust: people in your neighbourhood; people you work/go to school with; and strangers (Engage Nova Scotia, 2021)
ind.164	Volunteered in last year (Civic Engagement & Governance | Volunteering)	(score: 1 = yes; 2 = no)	Volunteered in last year (Engage Nova Scotia, 2021)
ind.165	Discriminated against (Personal Safety & Security)	(score: 7 = all the time)	Arithmetic average of six indicators: How often do you feel discriminated against in our community because of: your ethnicity, culture, race, or skin colour; your religious affiliation; your sexual orientation; your age; your gender; and a disability you have? (Engage Nova Scotia, 2021)
ind.166	Perceived safety (Personal Safety & Security)	(score: 7 = very safe)	How safe from crime are you walking alone after dark in your neighbourhood (Engage Nova Scotia, 2021)
ind.167	Sense of belonging (Relationships)	(score: 7 = extreme satisfied)	Arithmetic average of three indicators: sense of belonging to community, satisfaction with sense of belonging to this community,

			and satisfaction with neighbourhood as place to live (Engage Nova Scotia, 2021)
ind.168	Social contacts 1 (Relationships)	(count)	Arithmetic average of number of social contacts (close relative, close friends, and neighbours you know well enough to ask a favour) (Engage Nova Scotia, 2021)
ind.169	Social contacts 2 (Relationships)	(score: 10 = always enough time)	Adequate time to form and sustain serious relationships (Engage Nova Scotia, 2021)
ind.170	Social contacts 3 (Relationships)	(score: 7 = extremely satisfied)	Satisfaction with personal relationships (Engage Nova Scotia, 2021)
ind.171	Social isolation (Relationships)	(score: 7 = strongly agree)	Arithmetic average of two indicators: I often feel that I lack companionship, and I often feel isolated from others in the community (Engage Nova Scotia, 2021)
ind.172	Social support (Relationships)	(score: 7 = strongly agree)	Arithmetic average of four indicators: people in this community are available to give help if somebody needs it, if I need help, this community has many excellent services to meet my needs, if I had an emergency, people I do not know would be willing to help me, and (inverted) in this community, people are not willing to help those in need (Engage Nova Scotia, 2021)
ind.173	Socialize 1 (Relationships)	(days per month)	Socialize with friends in last month (Engage Nova Scotia, 2021)
ind.174	Socialize 2 (Relationships)	(score: 10 = always enough)	Adequate time to socialize (Engage Nova Scotia, 2021)
ind.175	SLR exposures (Independent of pillars and sub-pillars; only applied to Exposure Sub-index for SLR & Coastal Flooding	(ratio)	Ratio of area of all buildings with 10m of shoreline to the total area of all buildings (see Appendix D)

5.4 Constructing the Wellbeing at Risk Index (WRI) with Selected Indicators

5.4.1 Technical steps

Constructing the Wellbeing at Risk Index (WRI) involved several steps, all of which are associated with their own sets of assumptions. We list and describe these steps briefly in Table 5-4. See Appendix A for more detail on some of the steps. The WRI was built in Microsoft Excel.

Table 5-4. Technical steps in the construction of the WRI.

Technical Step	Description
1. Data inspection and treatment	The processing of the raw indicator data collected involved, first, identifying missing data, and second, computing a range of descriptive statistics (including mean, median, standard deviation, minimum and maximum values, interquartile range, skewness, and kurtosis) to help identify outliers. With the exception of data made available 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, all other indicator data sets were complete for all 18 census divisions. The Engage Nova Scotia data set, however, did not include values for the following three census divisions; Lunenburg, Queens, and Yarmouth. The missing data for these census divisions was imputed using multivariate regression analysis. Outliers in the indicator data were identified using two methods; a box plot based on the interquartile range (IQR) and the absolute skewness and kurtosis. If either approach identified outliers in the indicator data, it was treated using a sequence of methods; first, a log transformation was applied to the data; and if outliers were still present, Winsorisation was used confining low outliers to the 2.5th percentile value and high outliers to the 97.5th percentile value. The WRI can be estimated using either treated or untreated indicator data.
2. Normalization	Most indicators are initially measured in different units from one another. The next step is to transform the indicator data, so all indicators are expressed on a common scale free from units, which renders them comparable. Indicators are transformed to a common scale to avoid problems of trying to aggregate different units of measurement (such as population, vegetation cover, trees, roads, disposable income, educational attainment, etc.). The process of rendering indicators comparable is frequently called “normalization” (Nardo et al., 2005). Linear min-max normalization is used in the WRI, with the minimum value and maximum value confined to, respectively, 1 and 10.

Technical Step	Description
3. Weighting	When indicators are aggregated to sub-pillars, sub-pillars to pillars, pillars to sub-indices, and sub-indices to the WRI, they are weighted in some way. Weights are essentially value judgements about the relative importance of different indicators and components of the index. Even the adoption of equal weighting does not imply no weighting; but rather that the weights are equal. Most composite indicators, for practical reasons and in the absence of appropriate knowledge or statistical or empirical evidence, are based on equal weighting (OCED and JCR, 2008). The WRI model has not been set up to accommodate explicit weighting of sub-pillars when aggregating to pillars, pillars when aggregating to Sub-indices, and sub-indices when aggregating to the WRI; hence, it implicitly adopts equal weighting of these components during the aggregation step.[20]
4. Aggregation	To derive a summary measure of WRI for each census division, the normalized scores must be aggregated across all relevant indicators for each climate hazard, and then across all climate hazards. The two most common approaches are the arithmetic (additive) approach and the geometric (multiplicative) approach (OECD and JCR, 2008; de Groeve et al., 2014; Greco et al., 2019; and Rome et al., 2017). The difference between these two approaches was explained in Box 1. For the reasons provided in Box 1, the WRI employs the arithmetic approach for aggregation; though it is set up to also use the geometric approach as a sensitivity test.
5. Assessment of statistical coherence	Statistical coherence is assessed by estimating correlation between indicators, sub-pillars, pillars, sub-indices and the WRI. Calculated correlations between indicators and aggregation levels are then checked to see if some components are over- or under-represented in the overall WRI score, or whether a bias has been introduced by including indicators that dominate the index. Decisions can then be made about taking steps to improve the statistical properties of the WRI; for example, by removing or moving indicators to other sub-pillars.
6. Uncertainty and sensitivity analysis	Uncertainty about the robustness of the conclusions drawn from the WRI and the steps and assumptions underpinning its construction (OECD and JCR, 2008) are assessed using sensitivity analysis. Sensitivity analysis is achieved by running the WRI for both RCP4.5 and RCP8.5, as well as p05, p50, and p95 modelled climate data as inputs. These analyses permit side-by-side comparison of changes in overall WRI scores. Uncertainties also arise from key methodological choices, for example, the use of treated vs untreated data, as well as individual indicator choices and sensitivity analyses were performed *in situ* to evaluate the effects of these choices on results.
7. Data visualization & interpretation	The final step is to present the results using a range of visual aids, such as heat maps, spider diagrams, and bar charts.

5.4.2 Formulating hazard-specific impact statements

A crucial input to the WRI, that drives the results, is a so-called “impact statement” that is specific to each climate hazard. These impact statements define what indicators are to be included within each sub-index for each climate-related impact. An example of the impact statement for the

[20] It’s worth noting that the MQO results on wellbeing priorities are applied as a *sensitivity test* at the ‘aggregate’ pillar level only, so we can see how the (unweighted) significance of these wellbeing dimensions as determinants of Exposure and Vulnerability change if weighted by their importance to Nova Scotians. But these changes are not traced through the model and do not alter the WRI.

climate hazard "extreme heat (humans)" is shown in Figure 5-9. Based on the experience and professional judgement of the project team with climate vulnerability and risk assessments, similar impact statements have been prepared for all 19 climate-related impacts listed in Section 5.2.1.

Note that the last column in the impact statement specifies the directional impact of the indicator on the sub-index and the overall WRI score. A "+" signifies that a high value of the indicator will increase risk; in contrast, "-" signifies that a high value of the indicator will decrease risk. This will dictate whether the inverted normalized value of the indicator is used in the calculations of the WRI.

A final point to note regarding the impact statements; most indicators for the Low Coping Capacity Sub-index are generally applicable across all climate-related impact statements; that is, they reflect the general coping capacity (or lack thereof) of Nova Scotians to shocks and stresses. Some indicators of Low Coping Capacity are nonetheless specific to climate-related impacts.

Figure 5-9. Illustration of impact statement for "extreme heat (humans)" climate hazard.

Sub-index: Climate impact

Indicator	ID	Units	IN = 1; OUT = 0	Direction of impact on Sub-index
Consecutive hot days	chd	days	1	+
Heat wave magnitude	hwm	degrees C	1	+
Heat wave number	hwn	number	1	+
Maximum daily temperature (hottest day)	txmax_ann	degrees C	1	+
Maximum daily temperature above 24.7C (heat mortality)	txg_hh	days	1	+
Maximum daily temperature above 26.7C (labour productivity)	txg_lp	days	1	+
Maximum daily temperature above 29C (heat warning)	txgt29	days	1	+
Tropical nights (minimum temp > 16C)	tr16	days	1	+

Sub-index: Exposure

Indicator	ID	Units	IN = 1; OUT = 0	Direction of impact on Sub-index
Population	ind.56	(count)	1	+

Sub-index: Sensitivity				
Indicator	ID	Units	IN = 1; OUT = 0	Direction of impact on Sub-index
Earnings diversity	ind.2	(index)	1	-
Outdoor & manufacturing workers (earnings dependence)	ind.8	(% of total employed)	1	+
Employment diversity	ind.12	(index)	1	-
Outdoor & manufacturing workers (employment dependence)	ind.18	(% of total employed)	1	+
Economic output diversity	ind.23	(index)	1	-
Outdoor & manufacturing workers (economic output dependence)	ind.29	(% of total output)	1	+
Individual income diversity	ind.32	(index)	1	-
Affordable bills	ind.38	(score: 5=least_once_per_month)	1	+
Perceived mental health	ind.45	(score: 12=high_health)	1	-
Perceived physical health	ind.46	(score: 12=high_health)	1	-
Elderly population	ind.53	(% of total pop)	1	+
Infants & children population	ind.54	(% of total pop)	1	+
Population density	ind.57	(people / km2)	1	+
Apartment in a building that has five or more storeys	ind.76	(% of total dwellings)	1	+
Band housing	ind.77	(% of total dwellings)	1	+
Dwellings built before 1990	ind.78	(% of total dwellings)	1	+
Dwelling density	ind.79	(dwellings / km2)	1	+
Dwellings in major need of repairs	ind.80	(% of total dwellings)	1	+
Perceived air quality	ind.151	(score: 7=very_strongly_agree_good)	1	-

Sub-index: Low response capacity (LRC)				
Indicator	ID	Units	IN = 1; OUT = 0	Direction of impact on Sub-index
Unemployment rate	ind.21	(%)	1	+
Gini coefficient (AT household income)	ind.33	(index)	1	+
Median after-tax income individuals (all sources)	ind.34	($ 2015)	1	-
Prevalence low income	ind.35	(%)	1	+
Prevalence low income among children	ind.36	(%)	1	+
Prevalence low income among elderly	ind.37	(%)	1	+
Average monthly shelter costs	ind.40	($ 2015)	1	+
Financial wellbeing	ind.41	(score: 12=good_fin_health)	1	-
Spending 30% or more of income on shelter costs	ind.42	(% of housholds)	1	+
Assessibility of health care	ind.44	(score: 5=excellent]	1	-
Quality of health care	ind.47	(score: 5=excellent]	1	-
Ethnic diversity	ind.48	(index)	1	+
Neither English nor French	ind.49	(% of total pop)	1	+
New immigrants	ind.50	(% of total population)	1	+
Elderly adults living alone	ind.52	(% of 65+ pop)	1	+
Recent migrant movers	ind.58	(% of total population)	1	+
Adults (25-64) with no certificate; diploma or degree	ind.60	(% of total pop)	1	+
Education opportunities	ind.61	(score: 7=extreme_satisfied)	1	-
EMS 1	ind.64	(count)	1	-
EMS 2	ind.65	(persons per facility)	1	+
Hospitals 1	ind.67	(m2)	1	-
Hospitals 2	ind.68	(persons per m2)	1	+
Places to gather 1	ind.73	(count)	1	-
Places to gather 2	ind.74	(persons per facility)	1	+
Rental housing	ind.83	(% of total dwellings)	1	+
Reliability of internet service	ind.90	(score: 5=excellent]	1	-
Energy conservation	ind.127	(score: 5=all_the_time)	1	+
Interest in politics	ind.156	(score: 10=a lot_of_interest)	1	-
Participate in democracy 1	ind.157	(score: 1=yes; 2=no)	1	+
Participate in democracy 2	ind.158	(score: 10=always_time)	1	-
Participate in democracy 3	ind.159	(score: 7=extreme_satisfied)	1	-
Political efficacy 1	ind.160	Score out of 7, 7 = very strongly agree	1	+
Political efficacy 2	ind.161	(score: 7=extreme_satisfied)	1	-
Trust in institutions	ind.162	(score: 7=trusted_alot)	1	-
Trust in others	ind.163	(score: 7=trusted_alot)	1	-
Volunteered in last year	ind.164	(score: 1=yes; 2=no)	1	+
Discriminated against	ind.165	(score: 7=all_the_time)	1	+
Perceived safety	ind.166	(score: 7=very_safe)	1	-
Sense of belonging	ind.167	(score: 7=extreme satisfied)	1	-
Social contacts 1	ind.168	(count)	1	-
Social contacts 2	ind.169	(score: 10=always_enough)	1	-
Social contacts 3	ind.170	(score: 7=extreme_satisfied)	1	-
Social isolation	ind.171	(score: 7=strongly_agree)	1	+
Social support	ind.172	(score: 7=strongly_agree)	1	-
Socialize 1	ind.173	(days per month)	1	-
Socialize 2	ind.174	(score: 10=always_enough)	1	-

6 Results

This section presents the “Wellbeing-at-Risk Index” (WRI) results, placing emphasis on addressing the questions posited at the introduction to Section 5.

6.1 Priority Climate-Related Impacts

The aggregate WRI and Sub-index scores and relative rankings for each climate-related impact considered in this report are presented in Table 6-1 and Table 6-2 for the median projections (50th percentile) under RCP8.5. The same results for RCP4.5 are found in Section 6.5 (in Table 6-18 and Table 6-19). By “aggregate”, we mean the sum of scores across all census divisions. To interpret the results, we split the climate-related impacts into two categories (recall Figure 5-4 and Figure 5-5): (1) impacts that are expected to result in a net deterioration in wellbeing, all else being equal; and (2) impacts that are expected to result in a net improvement in wellbeing, all else being equal.

6.1.1 Wellbeing deteriorating climate-related impacts

Concerning climate-related impacts with predominantly adverse consequences today that are anticipated to worsen as a result of climate change, those of greatest concern vary over the time periods considered.

By 2030 (the centre year of the period 2015-2045), the two climate hazards[21] of greatest concern (highest WRI scores) are **pluvial flooding** and **fluvial flooding[22]**. In each case, there are more regions of NS where the impact of climate change from the hazard presents relatively more risk to wellbeing than the other hazards. Put another way, relative to other climate hazards, these two present more potential adverse consequences for wellbeing because of climate change.

Why do these two climate hazards rise to the top in 2030? In both cases, the vulnerability (the combination of sensitivity and low coping capacity) of exposed capitals and wellbeing in Nova Scotia is among the highest compared to other hazards. There are more regions of the province with relatively higher levels of sensitivity to both forms of flooding, and relatively lower levels of coping capacity, compared to the other hazards. The four most vulnerable census divisions are listed below in rank order (1=highest) (detailed results for individual census divisions is presented in Appendix E):

[21] Recall, a climate hazard is a climate-related impact resulting in predominantly negative consequences for wellbeing because of climate change.
[22] This finding holds true for RCP4.5 as well given that divergence in climate projections across RCPs tends to happen after 2050s.

	Pluvial (overland) flooding			Fluvial (riverine) flooding		
	Vulnerability	Sensitivity	LCC	Vulnerability	Sensitivity	LCC
1	Digby	Kings	Digby	Digby	Halifax	Digby
2	Annapolis	Pictou	Annapolis	Annapolis	Kings	Annapolis
3	Pictou	Hants	Shelburne	Pictou	Hants	Shelburne
4	Colchester	Cumberland	Queens	Halifax	Lunenburg	Queens

As explained in Section 5, low coping capacity (LCC) is only slightly climate impact specific; it is mainly a general characteristic of exposed systems. Hence, the same four census divisions have the lowest coping capacity (and same rank order) with respect to both forms of flooding.

The exposure scores for both forms of flooding are also relatively high across CDs; in particular for pluvial flooding. This means there are more regions of the province with relatively higher levels of capitals exposed to these climate hazards compared to the other hazards. In other words, based on total scores across all CDs more regions are above median values than below.

Finally, the climate impact scores for pluvial flooding and fluvial flooding are 4th and 1st highest, respectively, across all climate hazards. More regions of Nova Scotia are thus projected to experience relatively larger changes in the climatic drivers for these two hazards because of climate change than for the other hazards.

Focusing on pluvial flooding – the highest rated climate hazard by 2030 – details of what capitals and wellbeing dimensions (and indicators) are driving the results are presented below (numbers in square brackets indicate the importance of the Sub-index component, with 1=most influential; only relevant components are identified) (see Table 6-4, Figure 6-1 and Figure 6-2):

Exposure

Human capital [3]
Manufactured capital [2]
Natural capital [1]

Provisioning services

Food ← Ind. ***Agricultural land*** (acres)

Sensitivity

Financial capital [4]
Human capital [3]
Manufactured capital [2]
Natural capital [1]

Provisioning services [2]
Regulatory services [1]

Water ← Ind. ***Wetlands*** (km^2)

Low coping capacity

Financial capital [5]
Human capital [3]
Manufactured capital [4]
Natural capital [2]
Social capital [1]

Civic engagement & governance [3]
Personal safety & security [2]
Relationships [1]

Relationships

Ind. Sense of belonging (index) [2]
Ind. Av. number of social contacts (index) [4]
Ind. Adequate time to form relationships (index) [3]
Ind. Satisfaction with personal relationships (index) [5]
Ind. Social isolation (index) [6]
Ind. ***Social support*** (index) [1]
Ind. Socialize with friends in last month (index) [7]
Ind. Adequate time to socializes (index) [8]

	Impact of climate change by 2015-45		Impact of climate change by 2035-65		Impact of climate change by 2065-95		Today			
	WRI	Climate impact	WRI	Climate impact	WRI	Climate impact	Exposure	Vulnerability	Sensitivity	Low coping capacity *
Increasing adverse outcomes:										
Drought	88.5	99.5	87.7	96.3	90.1	105.7	82.8	85.9	78.7	93.2
Pluvial Flooding	94.3	102.4	90.3	86.1	90.6	87.6	90.5	92.2	90.5	94.0
Fluvial Flooding	92.8	105.4	91.8	101.6	90.6	96.7	83.5	91.1	88.2	94.0
Heat extreme - agriculture	89.5	92.5	90.1	95.1	94.0	110.5	86.8	89.3	84.9	93.8
Heat extreme - ecosystems	87.7	92.5	88.3	95.1	92.2	110.5	85.6	86.3	81.3	91.4
Heat extreme - human health	88.4	98.0	89.6	102.8	90.9	108.1	78.8	88.4	86.1	90.7
Heat extreme - transport infrastructure	85.8	84.8	88.2	94.1	93.0	113.3	78.6	90.0	87.0	92.9
Cooling demand	88.2	93.2	89.2	97.1	92.5	110.1	85.9	86.9	83.9	90.0
Agriculture pests and diseases	88.8	96.6	89.4	98.9	88.0	93.6	90.7	83.9	76.3	91.4
Shifting ecoregions	91.7	104.8	91.0	102.1	90.9	101.7	86.8	87.6	83.7	91.4
Vector-borne diseases	92.2	104.5	90.2	96.8	90.2	96.7	78.8	92.7	95.8	89.5
SLR and coastal flooding	89.7	97.8	89.7	97.8	89.7	97.8	80.6	90.1	85.8	94.4
Wildfire	86.7	84.0	92.1	105.5	91.5	103.0	83.4	89.8	85.1	94.4
Decreasing adverse outcomes										
Heavy snowfall	88.8	95.9	88.7	95.5	90.3	101.9	84.8	87.2	82.1	92.3
Freeze-thaw Cycles	88.4	96.2	89.8	101.5	90.3	103.4	85.2	86.2	80.8	91.5
Heating demand	93.0	106.8	90.7	97.7	91.8	102.1	85.9	89.7	90.6	88.8
Increasing beneficial outcomes										
Summer tourism & recreation	91.8	91.6	90.9	88.0	93.0	96.4	78.8	98.4	90.3	106.6
Growing season	96.6	101.9	96.7	102.3	98.7	110.5	93.7	95.3	84.1	106.6
Decreasing beneficial outcomes										
Winter tourism & recreation	92.1	112.2	92.3	113.0	93.1	115.9	78.8	88.8	86.0	91.6

* for "increasing beneficial outcomes" the value measures coping capacity (to sieze benefits) as opposed to low coping capacity

Table 6-1. Total WRI scores for the median projections (50th percentile) under RCP8.5. *Scores for each index are the sum across CDs.*

	Impact of climate change by 2015-45		Impact of climate change by 2035-65		Impact of climate change by 2065-95		Today			
	WRI	Climate impact	WRI	Climate impact	WRI	Climate impact	Exposure	Vulnerability	Sensitivity	Low coping capacity *
Increasing adverse outcomes:										
Drought	8	5	13	9	11	6	9	12	12	6
Pluvial Flooding	1	4	4	13	8	13	2	2	2	3
Fluvial Flooding	2	1	2	4	9	10	7	3	3	3
Heat extreme - agriculture	6	10	6	10	1	2	4	7	8	5
Heat extreme - ecosystems	11	10	11	10	4	2	6	11	11	8
Heat extreme - human health	9	6	8	2	7	5	11	8	5	11
Heat extreme - transport infrastructure	13	12	12	12	2	1	13	5	4	7
Cooling demand	10	9	10	7	3	4	5	10	9	12
Agriculture pests and diseases	7	8	9	5	13	12	1	13	13	8
Shifting ecoregions	4	2	3	3	6	8	3	9	10	8
Vector-borne diseases	3	3	5	8	10	11	11	1	1	13
SLR and coastal flooding	5	7	7	6	12	9	10	4	6	1
Wildfire	12	13	1	1	5	7	8	6	7	1
Decreasing adverse outcomes										
Heavy snowfall	2	3	3	3	2	3	3	2	2	1
Freeze-thaw Cycles	3	2	2	1	3	1	2	3	3	2
Heating demand	1	1	1	2	1	2	1	1	1	3
Increasing beneficial outcomes										
Summer tourism & recreation	2	2	2	2	2	2	2	1	1	2
Growing season	1	1	1	1	1	1	1	2	2	1
Decreasing beneficial outcomes										
Winter tourism & recreation	1	1	1	1	1	1	1	1	1	1

* for "increasing beneficial outcomes" the value measures coping capacity (to sieze benefits) as opposed to low coping capacity

Table 6-2. Rankings of climate-related impacts for the median projections (50th percentile) under RCP8.5. [1=highest Index score for corresponding impact category]

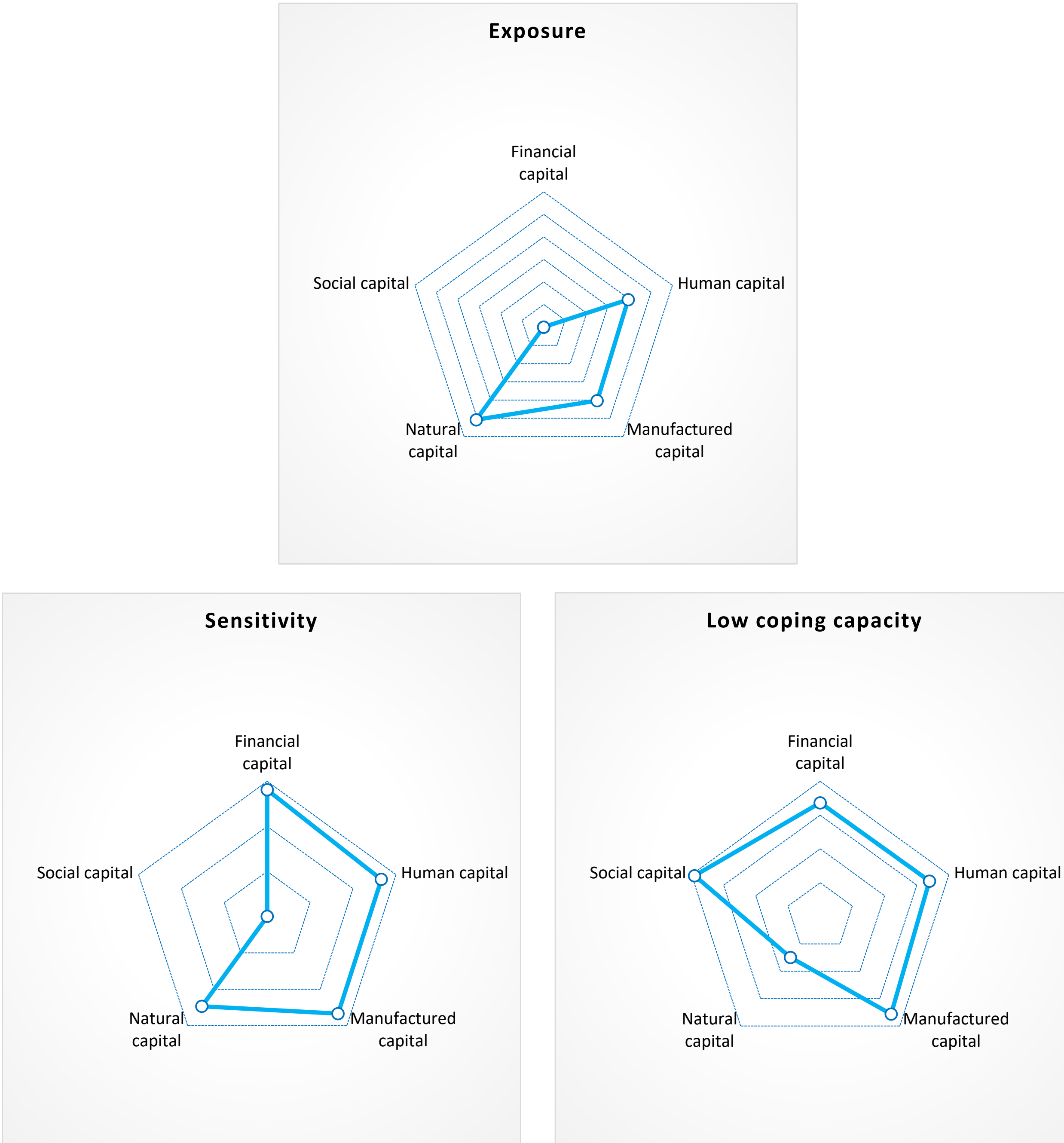


Figure 6-1. Capital with most exposure to climate-related impacts in Nova Scotia and capital exerting the greatest influence on overall sensitivity and (low) coping capacity (totals across all 19 climate hazards/impacts).

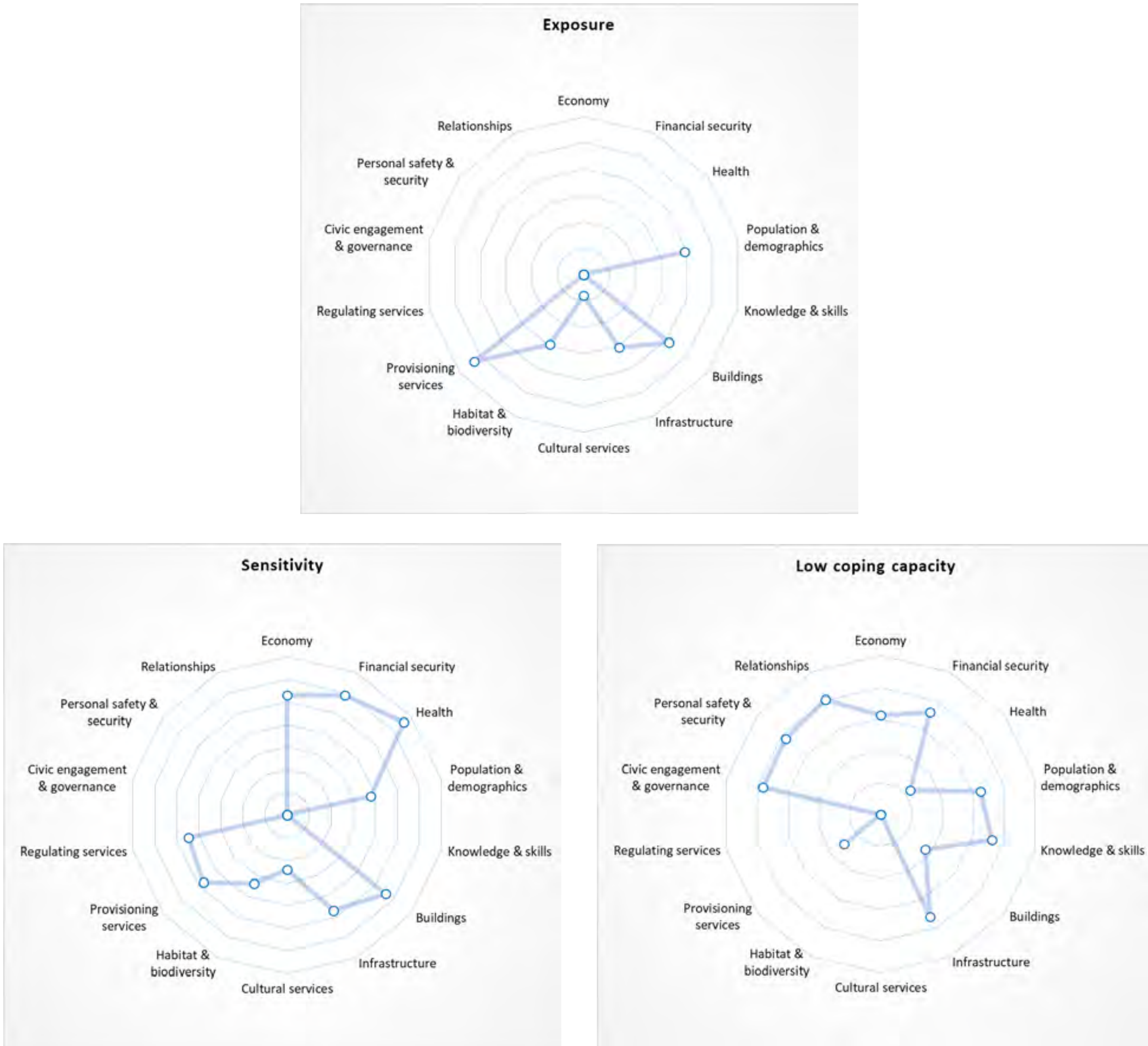


Figure 6-2. Wellbeing dimensions (sub-pillars) with most exposure to climate-related impacts in Nova Scotia and wellbeing dimensions exerting the greatest influence on overall sensitivity and (low) coping capacity (totals across all 19 climate hazards/impacts). [Not weighted by importance to Nova Scotians].

By mid-century, fluvial flooding remains a priority climate hazard. However, the relative risk to wellbeing presented by pluvial flooding reduces slightly, as the underlying climate drivers are projected to increase less across most regions of the province relative to climate-induced increases in the climatic drivers of other hazards—such as, fire weather and extreme heat events of particular relevance to human health. Indeed, with moderate levels of exposed capitals and vulnerability, the relatively large projected increase in fire (warm and dry) weather by 2050 is sufficient to make wildfire the highest rated climate hazard. Relative to other climate hazards, coping capacity across the province is lowest for wildfire (as well as SLR and coastal flooding). Details of the capitals and wellbeing dimensions (and indicators) that drive the result for wildfire are presented below (see Table 6-4, Figure 6-1 and Figure 6-2):

Exposure

Human capital [3]
Manufactured capital [2]
Natural capital [1]

Cultural services [3]
Provisioning services [2]
Habitat & biodiversity [1]

Ecosystems

Ind. ***Tree area*** (m^2)

Sensitivity

Natural capital [4]
Financial capital [3]
Manufactured capital [2]
Human capital [1]

Health [2]
Population & demographics [1]

Residents

Ind. ***Population density*** (persons per km^2) [1]
Ind. Elderly population (% of total population) [2]
Ind. Infant & children population (% of total population) [3]

Low coping capacity

Financial capital [4]
Human capital [3]
Manufactured capital [2]
Social capital [1]

Civic engagement & governance [3]
Personal safety & security [2]
Relationships [1]

Relationships

Ind. Sense of belonging (index) [2]
Ind. Av. number of social contacts (index) [4]
Ind. Adequate time to form relationships (index) [3]
Ind. Satisfaction with personal relationships (index) [5]
Ind. Social isolation (index) [6]
Ind. ***Social support*** (index) [1]
Ind. Socialize with friends in last month (index) [7]
Ind. Adequate time to socializes (index) [8]

The four most vulnerable census divisions to wildfire are listed below in rank order (1=highest) (detailed results for individual census divisions is presented in Appendix E):

	Wildfire		
	Vulnerability	Sensitivity	LCC
1	Digby	Halifax	Digby
2	Shelburne	Shelburne	Queens
3	Pictou	Colchester	Annapolis
4	Cumberland	Cumberland	Pictou

	Impact of climate change 2030 to 2080			Impact of climate change 2030 to 2080	
	WRI	Climate impact		WRI	Climate impact
Increasing adverse outcomes:			Increasing adverse outcomes:		
Drought	-0.3%	-1.0%	Drought	1.7%	6.2%
Pluvial Flooding	1.2%	5.4%	Pluvial Flooding	-3.9%	-14.5%
Fluvial Flooding	-1.4%	-5.0%	Fluvial Flooding	-2.3%	-8.2%
Heat extreme - agriculture	0.0%	0.1%	Heat extreme - agriculture	5.0%	19.4%
Heat extreme - ecosystems	0.0%	0.1%	Heat extreme - ecosystems	5.1%	19.4%
Heat extreme - human health	0.0%	0.0%	Heat extreme - human health	2.9%	10.3%
Heat extreme - transport infrastructure	-1.2%	-4.4%	Heat extreme - transport infrastructure	8.3%	33.6%
Cooling demand	0.2%	0.7%	Cooling demand	4.8%	18.1%
Agriculture pests and diseases	-0.2%	-0.7%	Agriculture pests and diseases	-0.8%	-3.1%
Shifting ecoregions	1.0%	3.9%	Shifting ecoregions	-0.8%	-2.9%
Vector-borne diseases	1.4%	5.4%	Vector-borne diseases	-2.1%	-7.4%
SLR and costal flooding	0.0%	0.0%	SLR and costal flooding	0.0%	0.0%
Wildfire	-2.5%	-11.1%	Wildfire	5.5%	22.6%
Decreasing adverse outcomes			Decreasing adverse outcomes		
Heavy snowfall	1.7%	6.4%	Heavy snowfall	1.7%	6.3%
Freeze-thaw Cycles	-0.3%	-1.2%	Freeze-thaw Cycles	2.0%	7.5%
Heating demand	0.7%	2.6%	Heating demand	-1.3%	-4.4%
Increasing beneficial outcomes			Increasing beneficial outcomes		
Summer tourism & recreation	3.0%	13.3%	Summer tourism & recreation	1.3%	5.2%
Growing season	2.8%	11.0%	Growing season	2.2%	8.4%
Decreasing beneficial outcomes			Decreasing beneficial outcomes		
Winter tourism & recreation	0.1%	0.2%	Winter tourism & recreation	1.0%	3.3%

Table 6-3. Changes in the aggregate WRI and Climate Impact Sub-index attributable to climate change between 2030 and 2080 for the median projections (50th percentile) under RCP4.5 (left) and RCP8.5 (right).

Toward the end of the century, those climate-related impacts driven by high temperatures rise to the top, they include extreme heat (for agriculture), extreme heat (for transportation infrastructure), increased cooling demand (for buildings), and extreme heat (for ecosystems). By 2080, the top-rated climate hazard is heat extremes for agriculture. Why? There are more regions of Nova Scotia where the impact of climate change on extreme heat for agriculture presents relatively more risk to wellbeing than the other hazards. Details of the capitals and wellbeing dimensions (and indicators) that drive the result for heat extremes for agriculture are presented below (numbers in square brackets indicate the importance of the Sub-index component, with 1=most influential; only relevant components are identified) (see Table 6-4, Figure 6-1 and Figure 6-2):

Exposure

Natural capital

Provisioning services

Food

Ind. Animal production: farms (count) [4]
Ind. Bee colonies (count) [3]
Ind. Crop production: farms (count) [5]
Ind. ***Agricultural land*** (acres) [1]
Ind. Orchards (m^2) [2]

Sensitivity

Natural capital [2]
Financial capital [1]

Economy [2]
Financial security [1]

Income sufficiency

Ind. **Affordable foods** (index)

Low coping capacity

Financial capital [5]
Human capital [4]
Manufactured capital [3]
Natural capital [2]
Social capital [1]

Civic engagement & governance [3]
Personal safety & security [2]
Relationships [1]

Relationships

Ind. Sense of belonging (index) [2]
Ind. Av. number of social contacts (index) [4]
Ind. Adequate time to form relationships (index) [3]
Ind. Satisfaction with personal relationships (index) [5]
Ind. Social isolation (index) [6]
Ind. ***Social support*** (index) [1]
Ind. Socialize with friends in last month (index) [7]
Ind. Adequate time to socializes (index) [8]

The four most vulnerable census divisions to extreme heat (for agriculture) are listed below in rank order (1=highest) (detailed results for individual census divisions is presented in Appendix E):

	Heat extreme (agriculture)		
	Vulnerability	Sensitivity	LCC
1	Digby	Cumberland	Victoria
2	Annapolis	Digby	Guysborough
3	Cumberland	Annapolis	Queens
4	Guysborough	Kings	Digby

The primary reason for the emergence of the four heat-related hazards as the top risks by 2080 is the underlying climatic drivers across the province are increasing more relative to the baseline period, than they are increasing for the other climate hazards. Hence, the value for the Climate Impact Sub-index in 2080 (2065-2095) is larger than it was in 2030 (2015-2045). This is evident in Table 6-3, which shows the percentage change in the Climate Impact Sub-index (and the WRI) attributable to climate change between 2030 and 2080 for the median projections.

While the percentage increase in the climatic drivers of decreasing opportunities for traditional winter-based recreation and tourism is relatively small (at +3.3%), the value of its Climate Impact Sub-index is highest across all 19 climate-related impacts in all three time periods (see Table 6-1). The percentage increase in Table 6-3 is small only because the starting score in 2030 is very high; implying that between the baseline period and 2030 the climatic drivers for this declining climate opportunity fall significantly in absolute terms compared to the projected changes in the climatic drivers of the other climate-related impacts.

In general, **the Climate Impact Sub-index scores for climate hazards driven primarily by projected increases in air temperatures show relatively high positive changes (increases) over the course of the century, in contrast to those Sub-index scores driven primarily by projected changes in precipitation trends and events**.[23] It therefore follows, **that the biggest threat to wellbeing across the majority of Nova Scotia by 2080 arises from projected increases in surface air temperatures, and in particular extremes**.

[23] Note that a negative change in the Climate Impact Sub-index does not mean the climatic drivers are projected to fall as a result of climate change, but rather that they are projected to increase less than those with positive changes.

	Most influential capital on sub-index		
	Exposure	Sensitivity	Low coping capacity*
Increasing adverse outcomes:			
Drought	Natural capital	Financial capital	Social capital
Pluvial Flooding	Natural capital	Natural capital	Social capital
Fluvial Flooding	Natural capital	Natural capital	Social capital
Heat extreme - agriculture	Natural capital	Financial capital	Social capital
Heat extreme - ecosystems	Natural capital	Natural capital	Social capital
Heat extreme - human health	Human capital	Human capital	Social capital
Heat extreme - transport infrastructure	Manufactured capital	Manufactured capital	Social capital
Cooling demand	Manufactured capital	Financial capital	Social capital
Agriculture pests and diseases	Natural capital	Financial capital	Social capital
Shifting ecoregions	Natural capital	Natural capital	Social capital
Vector-borne diseases	Human capital	Manufactured capital	Social capital
SLR and costal flooding	Manufactured capital	Human capital	Social capital
Wildfire	Natural capital	Human capital	Social capital
Decreasing adverse outcomes			
Heavy snowfall	Natural capital	Human capital	Social capital
Freeze-thaw Cycles	Manufactured capital	Manufactured capital	Social capital
Heating demand	Manufactured capital	Manufactured capital	Social capital
Increasing beneficial outcomes			
Summer tourism & recreation	Human capital	Human capital	Financial capital
Growing season	Natural capital	Financial capital	Financial capital
Decreasing beneficial outcomes			
Winter tourism & recreation	Human capital	Manufactured capital	Social capital

* for "increasing beneficial outcomes" the value measures coping capacity (to sieze benefits) as opposed to low coping capacity

Table 6-4. Capital with most exposure to each climate-related impact in Nova Scotia and capital exerting the greatest influence on sensitivity and (low) coping capacity.

Differences under RCP4.5

What are the main differences under the lower climate change scenario, RCP4.5? Recall from the presentation of the methodology in Section 5 that the Exposure, Sensitivity and Low Coping Capacity Sub-indices are not time sensitive. The only component of the Index that varies over time is the Climate Impact Sub-index; and as a result, the WRI. Under RCP4.5, the projected changes in all relevant climatic drivers will differ from those under RCP8.5. This will result in different values for the Climate Impact Sub-index for each climate-related impact, the WRI score, and thus the relative ranking of the climate-related impacts. Focusing for now on the climate hazards, the following conclusions can be drawn by contrasting Table 6-1 with Table 6-18 and the left-hand side with the right-hand-side of Table 6-3:

- By 2080, pluvial flooding and fluvial flooding remain among the top-rated climate hazards; relative to the other hazards, both these forms of flooding present more potential adverse consequences for wellbeing to more regions of Nova Scotia because of climate change.
- SLR and coastal flooding becomes a relatively more consequential hazard for wellbeing by 2080 under RCP4.5 (6th) compared with RCP8.5 (12th).
- As some climate hazards emerge as relatively more consequential under RCP4.5, others must become relatively less significant. While heat extremes for agriculture remains among the top-rated climate hazards towards the end of the century (4th under RCP4.5 compared with 1st under RCP8.5), the other heat-driven climate hazards become less consequential. Likewise, fire weather and wildfire are relatively less important as a source of wellbeing loss under RCP4.5 than under RCP8.5.
- In general, across the province, the predominance of projected changes in surface air temperature trends and extremes as drivers of the Climate Impact Sub-index scores (and hence, WRI scores) under RCP8.5 lessens under RCP4.5, with precipitation-based drivers becoming relatively more important. As a result, **the more consequential climate hazards for wellbeing by 2080 represent a mix of temperature and precipitation climate drivers, as opposed to being largely temperature driven as per RCP8.5**.

6.1.2 Wellbeing improving climate-related impacts

By 2030, the climate opportunities[24] presenting the largest benefits (highest WRI scores) are:

- **Growing season** (of the climate-related impacts with predominantly beneficial consequences today that are anticipated to increase as a result of climate change); and
- **Heating demand** (of the climate-related impacts with predominantly adverse consequences (essentially economic costs and environmental impacts) today that are anticipated to decrease as a result of climate change).

In each case, there are more regions of NS where the impact of climate change on the climate opportunity presents relatively larger improvements to wellbeing than the other opportunities in each category (denoted by the brackets). In other words, relative to other climate opportunities in each category, these two present more potential beneficial outcomes for wellbeing because of climate change.

[24] Recall, a climate opportunity is a climate-related impact resulting in predominantly positive consequences for wellbeing because of climate change.

Growing season – beneficial consequences expected to increase

Why do these two climate opportunities rise to the top in 2030? First, consider the potential for a longer **growing season**. Relative to the other climate-related impact with beneficial outcomes projected to increase with climate change (i.e., an extended summer recreation and tourism season), a longer growing season has both the highest exposure score and coping capacity score; though not the highest vulnerability score. [25] This means there are more regions of Nova Scotia with relatively high levels of capitals exposed to a longer growing season compared with capitals that support summer recreation and tourism. Further, more regions of the province have the necessary capitals and levels of wellbeing to take advantage of a longer growing season than they do for an extended summer recreation and tourism season.

The four most exposed and most vulnerable census divisions are listed below in rank order (1=highest) (detailed results for individual census divisions is presented in Appendix E):

	Growing season (longer)			
	Exposure	Vulnerability	Sensitivity	Coping Capacity
1	Halifax	Kings	Cumberland	Kings
2	Lunenburg	Cumberland	Kings	Hants
3	Cape Breton	Colchester	Annapolis	Antigonish
4	Yarmouth	Annapolis	Colchester	Cumberland

In all three time periods, more regions of the province are projected to experience larger changes in the climatic drivers for a longer growing season, than regions are anticipated to experience larger changes in the drivers of summer recreation and tourism. A longer growing season thus has the higher Climate Impact Sub-index score in 2030, 2050 and 2080.

Details of what capitals and wellbeing dimensions (and indicators) are driving the results for a longer **growing season** are presented below (numbers in square brackets indicate the importance of the Sub-index component, with 1=most influential; only relevant components are identified) (see Table 6-4, Figure 6-1 and Figure 6-2):

Exposure

Natural capital

Habitat & biodiversity [2]
Provisioning services [1]

Timber [2]
Food [1] ← Ind. ***Agricultural land*** (acres) [1]
Ind. Orchards (m^2) [2]

[25] The concept of vulnerability is challenging to describe in this scenario of increasing beneficial consequences from climate change. However, propensity to respond or degree of responsiveness to climate change (i.e., sensitivity) and coping capacity are translatable concepts.

Sensitivity

Natural capital [2]
Financial capital [1]

Economy [2]
Financial security [1]

Income sufficiency ← Ind. ***Affordable foods*** (index)

Coping capacity

Social capital [5]
Natural capital [4]
Human capital [3]
Manufactured capital [2]
Financial capital [1]

Economy [2]
Financial security [1]

Income [3]
Income sufficiency [2]
Employment [1] Ind. ***Unemployment rate*** (%)

Heating demand – adverse consequences expected to decrease

Now, consider **heating demand**. Relative to the other climate-related impacts with adverse outcomes projected to decrease with climate change, heating demand has both the highest exposure score and vulnerability score. This means there are more regions of the province with relatively high levels of capitals (in this case, buildings) exposed to heating requirements compared to the other adverse impacts anticipated to decrease as the climate warms. In terms of vulnerability, the capitals exposed to heating demand (requiring heating) are also the most sensitive compared to those exposed to heavy snowfall or freeze-thaw cycles. That is, capitals in more regions of Nova Scotia are more sensitive to heating demand, than to heavy snowfall or freeze-thaw cycles.

The four most exposed and most vulnerable census divisions are listed below in rank order (1=highest) (detailed results for individual census divisions is presented in Appendix E):

	Heating demand (for buildings)			
	Exposure	Vulnerability	Sensitivity	LCC
1	Halifax	Digby	Digby	Digby
2	Pictou	Cumberland	Cumberland	Colchester
3	Colchester	Queens	Queens	Inverness
4	Kings	Annapolis	Victoria	Cumberland

Although the relative importance of the wellbeing benefits resulting from anticipated reductions in heating demand with climate change declines slightly with time, it remains the top rated decreasing adverse impact in 2050 and 2080. The climatic drivers for heating demand are projected to decrease relatively more by 2030 (relative to the baseline) compared with heavy snowfall and freeze-thaw cycles; hence, the highest Climate Impact Sub-index score in 2030. However, by 2050 and 2080, the climatic drivers for freeze-thaw cycles are anticipated to decrease relative more than for heating demand, though not enough to supplant the latter as the top-rated impact.

Details of what capitals and wellbeing dimensions (and indicators) are driving the results for **heating demand** are presented below (numbers in square brackets indicate the importance of the Sub-index component, with 1=most influential; only relevant components are identified) (see Table 6-4, Figure 6-1 and Figure 6-2):

Exposure

Manufactured capital

Buildings

Residential [2]
ICI (non-residential) [1]

Ind. ***Buildings*** (non-residential) (m^2) [1]
Ind. Industrial sites (m^2) [2]

Sensitivity

Human capital [3]
Financial capital [2]
Manufactured capital [1]

Buildings

Residential

Ind. ***Dwellings in major need of repairs*** (% of total dwellings) [1]
Ind. Dwelling density (dwellings per km^2) [2]
Ind. Dwellings built before 1990 (% of total dwellings) [3]
Ind. Band housing (% of total dwellings) [4]

Low coping capacity

Financial capital [5]
Natural capital [4]
Human capital [3]
Manufactured capital [2]
Social capital [1]

Civic engagement & governance [3]
Personal safety & security [2]
Relationships [1]

Relationships

Ind. Sense of belonging (index) [2]
Ind. Av. number of social contacts (index) [4]
Ind. Adequate time to form relationships (index) [3]
Ind. Satisfaction with personal relationships (index) [5]
Ind. Social isolation (index) [6]
Ind. ***Social support*** (index) [1]
Ind. Socialize with friends in last month (index) [7]
Ind. Adequate time to socializes (index) [8]

Differences under RCP4.5

Concerning the climate opportunities there are no differences in priorities that emerge under RCP4.5 relative to RCP8.5 (contrasting Table 6-1 with Table 6-18 and the left-hand side with the right-hand-side of Table 6-3). A longer growing season and reduced heating demand remain the top-rated benefits for wellbeing resulting from climate change. The only noteworthy difference is that more regions of Nova Scotia are projected to experience smaller decreases in the climatic drivers of freeze-thaw cycles compared to heating demand and heavy snowfall under RCP4.5 than under RCP8.5.

6.1.3 Weighting the importance of wellbeing dimensions

To better understand the significance of those wellbeing dimensions with greatest overall exposure to climate-related impacts, each dimension is weighted to reflect their relative importance to Nova Scotians. Derivation of the weights is explained in Box 3, which shows the most important aspect of wellbeing to Nova Scotians concerns health (specifically, access to healthcare services and feeling healthy), followed by financial security (specifically, being financially secure and being able to afford basic needs). The least important in relative terms concerns celebrating cultural identity, which is captured in our "population & demographics" sub-pillar. The weights are applied by simply multiplying the calculated (unweighted) score for each sub-pillar by the corresponding weight. The same weights are applied across all three Sub-indices. This provides insights into the importance of those wellbeing dimensions exposed to climate-related impacts, and those exerting the greatest influence on overall sensitivity and (low) coping capacity. The purpose here is solely to illustrate how weighting could change the conclusions; the weights have not been formally integrated into modeling to assess the impact of their inclusion on the calculated WRI scores and relative rankings or climate-related impacts.

Box 3 Relative importance weights for determinants of wellbeing

In a companion study to this project, MQO Research conducted a survey of wellbeing and quality of life in Nova Scotia. The purpose of the survey was to identify what factors are most important to wellbeing and quality of life for Nova Scotians. Based on the survey results MQO Research provided the median rank assigned to 23 "wellbeing factors"—e.g., access to health care services, feeling healthy, clean air, clean water, being financially secure, a sense of belonging to the community, etc. These wellbeing factors and corresponding median rankings were mapped onto the sub-pillars of the Exposure, Sensitivity and Low Coping Capacity Sub-indices as a basis for calculating importance weights.

There are multiple ways to derive importance weights from rank-ordered criteria—e.g., rank sum method, rank reciprocal (inverse) method, rank exponent method, and the rank order centroid method (Roszkowska, 2013). However, to derive importance weights for the wellbeing factors included in the MQO Research survey, we used the sum + reciprocal method recommended by Danielson and Ekenberg (2017), based on their robustness tests of the range of available rank-order methods. Their approach uses an additive weight function to combine the rank sum method and the rank reciprocal method; the formulas are found in Danielson and Ekenberg (2017). The resulting importance weights for each sub-pillar are shown in table below.

Sub-pillars for Exposure, Sensitivity and Low Coping Capacity	Assigned weight
Health	0.183
Financial security	0.101
Regulating services	0.091
Buildings	0.087
Personal safety & security	0.087
Provisioning services	0.077

Economy	0.072
Infrastructure	0.065
Knowledge & skills	0.059
Relationships	0.052
Habitat & biodiversity	0.048
Civic engagement & governance	0.046
Cultural services	0.020
Population & demographics	0.012

The discussion above is based on unweighted results. Consider Figure 6-2, which shows the wellbeing dimensions with most exposure to **all** considered climate-related impacts in Nova Scotia, as well as the wellbeing dimensions exerting the greatest influence on overall sensitivity and (low) coping capacity. The results in Figure 6-2 are unweighted. Figure 6-3 presents the same information including the importance weights. The inclusion of importance weights (see Box 3) at this aggregate level has the following implications for the results and conclusions:

- For **exposure**: Increased significance is placed on climate-related impacts that affect buildings (specifically, housing), such as all forms of flooding, and that affect habitat & biodiversity, such as shifting ecoregions.
- For **sensitivity**: Increased significance is placed on climate-related impacts where the sensitivity of exposed capitals is largely driven by indicators of health, financial security, and the economy. Human and financial capitals take on greater importance relative to natural and manufactured capitals.
- For (**low**) **coping capacity**: Increased significance is placed on climate-related impacts where coping capacity is largely driven by (lack of) financial security, (lack of) personal safety and security, and (poor) health (specifically, regarding access to health care services and the quality of those services). The importance of social capital generally declines with weighting, as both relationships and civic engagement & governance decrease in importance relative to financial and health factors.

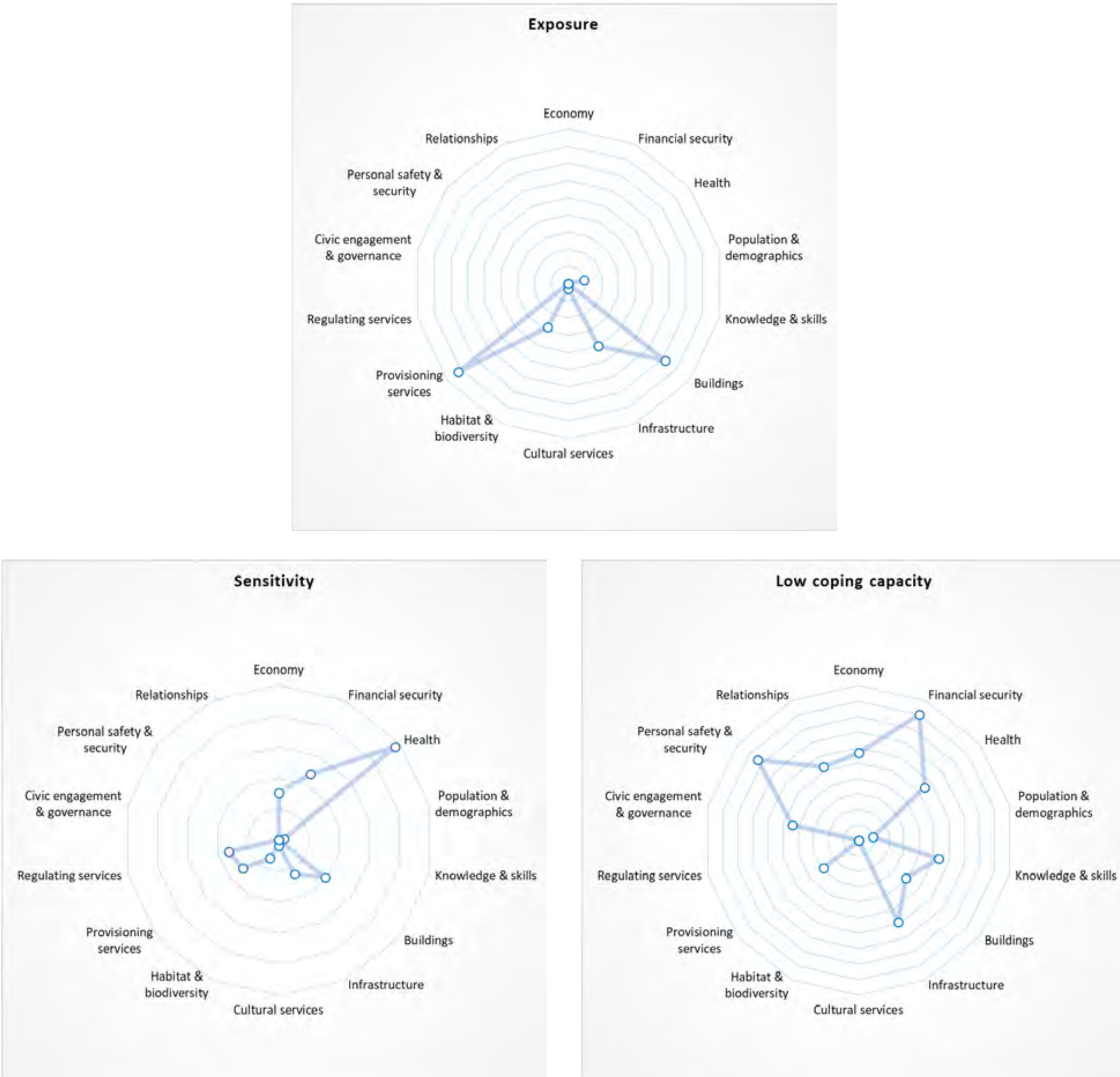


Figure 6-3. Wellbeing dimensions (sub-pillars) with most exposure to climate-related impacts in Nova Scotia and wellbeing dimensions exerting the greatest influence on overall sensitivity and (low) coping capacity (totals across all 19 climate hazards/impacts). [Weighted by importance to Nova Scotians].

6.2 Priority Regions

To inform regional priorities, we again split the climate-related impacts into two categories:

1. Impacts that are expected to result in a net deterioration in wellbeing, all else being equal; and
2. Impacts that are expected to result in a net improvement in wellbeing, all else being equal.

6.2.1 Wellbeing deteriorating climate-related impacts

For this category of impacts, the relative rankings for each census division based on aggregate scores for the WRI and each Sub-index are presented in Table 6-5 and Table 6-6 for the median projections (50th percentile) under RCP8.5. The same results for RCP4.5 are found in the Appendix H, in a separate document. By "aggregate", we mean the sum of scores across all relevant climate-related impacts (i.e., the 4 quadrants in Figure 5-4 or categories of climate impacts).

Increasing climate-related adverse outcomes[26]

Across all three time periods, the five census divisions estimated to potentially experience the largest potential deterioration in wellbeing (i.e., change in WRI score) as a result of climate-related impacts with mainly adverse consequences that are projected to worsen with climate change are (based on the sum of WRI scores in 2030, 2050 and 2080, and in descending rank order; 1=worst affected, i.e., most capitals at risk):

1. **Cumberland** (primarily driven by relatively high vulnerability, exposure of capitals and projected increases in the underlying climatic drivers);
2. **Halifax** (primarily driven by relatively high exposure of capitals);
3. **Digby** (primarily driven by relatively high vulnerability and relatively moderate projected increases in the underlying climatic drivers);
4. **Annapolis** (primarily driven by relatively high vulnerability and projected increases in the underlying climatic drivers); and
5. **Pictou** (primarily driven by relatively high vulnerability, and relatively moderate exposure of capitals and projected increases in the underlying climatic drivers).

Further details for each census division are provided in Appendix E, including the climate hazards of greatest concern.

The above rankings are driven by two factors: (1) projected changes in applicable climatic drivers as a result of climate change; and (2) *current* levels of exposed capitals, the sensitivity of those capitals, and the capacity of the region to cope with the adverse outcomes of exposures. Another

[26] Drought; Pluvial Flooding; Fluvial Flooding; Heat extreme – agriculture; Heat extreme – ecosystems; Heat extreme - human health; Heat extreme - transport infrastructure; Cooling demand; Agriculture pests and diseases; Shifting ecoregions; Vector-borne diseases; SLR and coastal flooding; and Wildfire.

way to view these results is that the above listed census division represent the regions most adversely impacted by climate hazards should they occur today, and current losses from exposure are exacerbated by climate change. In other words, **there is a current need to adapt in these regions with respect to climate-related impacts with adverse consequences for wellbeing that are anticipated to increase because of climate change. Those factors (determinants of exposure, sensitivity, and low coping capacity) contributing to the current adaptation need should be addressed as a priority to both reduce current and future risks to wellbeing**.

As the results are largely driven by what may be described as the current need for adaptation[27], the above listed census divisions with the highest WRI scores are not necessarily the regions seeing the greatest change in current risk levels (which may be relatively low) as a result of projected changes in the underlying climatic drivers—reflected by changes in the Climate Impact Sub-index score and WRI score between 2030 and 2080. This is evident from Table 6-7, which shows changes in these scores attributable to climate change between 2030 and 2080 for both RCP4.5 and 8.5. By way of example, consider Victoria. The Climate Hazard Sub-index for this region is estimated to increase by 30% between 2030 and 2080, suggesting that the underlying climate drivers across all climate hazards are increasing more as the century progresses relative to the other census divisions. Thus, Victoria's WRI also shows the largest increase between 2030 and 2080. However, because of a low adaptation need today (low exposure and sensitivity), significantly worsening climate conditions are not sufficient to dramatically change the relative risk facing the region.

Decreasing climate-related beneficial outcomes

Across all three time periods, the five census divisions estimated to potentially experience the largest potential deterioration in wellbeing as a result of the potential loss of traditional winter recreation and tourism opportunities because of climate change are (based on the sum of WRI scores in 2030, 2050 and 2080, and in descending rank order; 1=worst affected):

1. **Halifax** (primarily driven by relatively high exposure of capitals and relatively moderate levels of vulnerability—specifically, sensitivity);
2. **Hants** (primarily driven by relatively high vulnerability and projected decreases in the underlying climatic drivers, and relatively moderate exposure of capitals);
3. **Lunenburg** (primarily driven by relatively moderate exposure of capitals, moderate vulnerability and moderate projected decreases in the underlying climatic drivers);
4. **Cumberland** (primarily driven by relatively high projected decreases in the underlying climatic drivers, and relatively moderate exposure of capitals and levels of vulnerability); and
5. **Pictou** (primarily driven by relatively high projected decreases in the underlying climatic drivers, and relatively moderate exposure of capitals).

Again, the results are largely driven by what may be described as a current need for adaptation with respect to the potential loss of traditional winter recreation and tourism opportunities.

[27] Recall that each Sub-index of the WRI is assigned an equal weight of ¼. So, the Climate Hazard Sub-index is weighted ¼ and the Exposure, Sensitivity and Low Coping Capacity Sub-indices are collectively weight ¾.

	Increasing climate-related adverse outcomes									
	Impact climate change by 2015-45		Impact climate change by 2035-65		Impact climate change by 2065-95		Today			
	WRI	Climate hazard	WRI	Climate hazard	WRI	Climate hazard	Exposure	Vulnerability	Sensitivity	Low coping capacity
Annapolis	4	3	4	3	5	3	10	4	5	3
Antigonish	18	10	18	10	17	7	15	18	18	17
Cape Breton	9	18	9	14	9	14	2	12	9	13
Colchester	7	5	7	5	7	4	6	8	4	14
Cumberland	1	2	1	2	1	2	3	2	1	12
Digby	2	6	3	6	3	11	9	1	2	1
Guysborough	15	12	14	11	15	13	16	7	12	5
Halifax	3	14	2	12	2	15	1	14	6	15
Hants	10	4	11	4	11	5	8	17	16	18
Inverness	13	15	13	15	12	10	12	11	10	9
Kings	6	1	5	1	6	1	4	16	8	16
Lunenburg	8	8	8	8	8	8	5	13	14	11
Pictou	5	7	6	7	4	6	7	3	3	7
Queens	11	9	10	9	10	12	13	5	11	2
Richmond	17	11	17	13	18	16	18	15	17	10
Shelburne	14	17	15	18	16	17	14	6	7	4
Victoria	16	16	16	17	13	9	17	10	15	6
Yarmouth	12	13	12	16	14	18	11	9	13	8

Table 6-5. Increasing adverse outcomes: Most impacted census divisions for the median projections (50th percentile) under RCP8.5. [1=highest aggregate Index score for impact category = most impacted]

	Decreasing climate-related beneficial outcomes									
	Impact climate change by 2015-45		Impact climate change by 2035-65		Impact climate change by 2065-95		Today			
	WRI	Climate hazard	WRI	Climate hazard	WRI	Climate hazard	Exposure	Vulnerability	Sensitivity	Low coping capacity
Annapolis	8	12	8	13	8	14	10	4	5	5
Antigonish	11	3	11	6	12	8	11	16	8	18
Cape Breton	5	17	7	18	5	16	2	2	3	14
Colchester	7	7	6	5	7	7	4	15	11	13
Cumberland	4	1	4	1	4	1	8	7	7	12
Digby	15	14	15	14	15	13	12	14	16	4
Guysborough	12	10	12	11	13	12	17	5	10	1
Halifax	1	6	1	8	1	2	1	8	4	16
Hants	2	4	2	3	2	6	7	3	1	17
Inverness	17	15	17	15	17	17	13	10	9	11
Kings	9	5	9	7	9	10	3	18	17	15
Lunenburg	3	8	3	4	3	5	5	6	6	7
Pictou	6	2	5	2	6	3	6	12	12	8
Queens	13	11	13	10	14	11	15	9	15	2
Richmond	18	16	18	16	18	15	16	13	14	9
Shelburne	10	9	10	9	10	4	14	11	13	6
Victoria	16	18	16	17	16	18	18	1	2	3
Yarmouth	14	13	14	12	11	9	9	17	18	10

Table 6-6. Decreasing beneficial outcomes: Most impacted census divisions for the median projections (50th percentile) under RCP8.5. [1=highest aggregate Index score for impact category = most impacted]

Increasing climate-related adverse outcomes			Increasing climate-related adverse outcomes		
	Impact of climate change 2030 to 2080			Impact of climate change 2030 to 2080	
	WRI	Climate impact		WRI	Climate impact
Annapolis	0.7%	2.3%	Annapolis	0.7%	2.4%
Antigonish	-0.7%	-2.3%	Antigonish	6.9%	22.2%
Cape Breton	-0.1%	-0.6%	Cape Breton	4.9%	23.8%
Colchester	-0.3%	-1.2%	Colchester	2.4%	8.3%
Cumberland	0.3%	1.0%	Cumberland	0.3%	1.0%
Digby	0.3%	1.3%	Digby	-1.8%	-7.0%
Guysborough	-0.6%	-2.2%	Guysborough	1.4%	5.2%
Halifax	-1.2%	-5.5%	Halifax	1.1%	5.2%
Hants	-0.1%	-0.3%	Hants	1.1%	3.3%
Inverness	0.0%	0.0%	Inverness	4.9%	19.8%
Kings	-0.2%	-0.6%	Kings	1.7%	5.0%
Lunenburg	0.3%	1.3%	Lunenburg	2.0%	7.7%
Pictou	0.6%	2.5%	Pictou	4.0%	15.4%
Queens	-0.5%	-2.2%	Queens	2.3%	8.9%
Richmond	-1.2%	-3.6%	Richmond	-1.1%	-3.9%
Shelburne	-0.4%	-1.7%	Shelburne	-1.7%	-7.3%
Victoria	0.0%	-0.2%	Victoria	7.7%	30.4%
Yarmouth	0.6%	2.4%	Yarmouth	-4.3%	-17.5%

Table 6-7. Increasing adverse outcomes: Changes in the aggregate WRI and Climate Impact Sub-index attributable to climate change between 2030 and 2080 for the median projections (50th percentile) under RCP4.5 (left) and RCP8.5 (right).

Decreasing climate-related beneficial outcomes	Impact of climate change 2030 to 2080	
	WRI	Climate impact
Annapolis	1.3%	4.3%
Antigonish	2.3%	6.6%
Cape Breton	-2.6%	-22.4%
Colchester	0.5%	1.3%
Cumberland	2.1%	5.9%
Digby	1.7%	5.5%
Guysborough	0.9%	2.7%
Halifax	0.9%	3.3%
Hants	1.5%	4.7%
Inverness	-5.5%	-21.7%
Kings	1.8%	5.0%
Lunenburg	2.1%	6.9%
Pictou	0.2%	0.7%
Queens	1.3%	3.6%
Richmond	-0.3%	-1.2%
Shelburne	-0.9%	-2.4%
Victoria	-8.0%	-44.1%
Yarmouth	-0.4%	-1.1%

Decreasing climate-related beneficial outcomes	Impact of climate change 2030 to 2080	
	WRI	Climate impact
Annapolis	-1.4%	-4.7%
Antigonish	-0.7%	-1.9%
Cape Breton	0.7%	4.8%
Colchester	2.2%	6.8%
Cumberland	0.7%	1.8%
Digby	1.7%	5.4%
Guysborough	2.5%	7.3%
Halifax	2.8%	10.4%
Hants	1.6%	5.2%
Inverness	-8.0%	-31.8%
Kings	-1.2%	-3.4%
Lunenburg	3.1%	10.3%
Pictou	0.7%	2.0%
Queens	3.5%	9.9%
Richmond	7.2%	27.8%
Shelburne	4.2%	11.5%
Victoria	-8.9%	-52.6%
Yarmouth	7.1%	21.7%

Table 6-8. Decreasing beneficial outcomes: Changes in the aggregate WRI and Climate Impact Sub-index attributable to climate change between 2030 and 2080 for the median projections (50th percentile) under RCP4.5 (left) and RCP8.5 (right).

Influence of capitals on regional results

For each census division, Table 6-9 shows the capital with the most exposure to climate-related impacts with predominantly adverse consequences for wellbeing that are anticipated to *increase* as a result of climate change. The table also indicates the capital exerting the greatest influence on sensitivity and low coping capacity for each census division. Within each Sub-index in Table 6-9, a red box indicates the census division with the highest score (see Table 6-5 and Table

6-6). Table 6-10 presents the same information for climate-related impacts with predominantly beneficial consequences for wellbeing, but that are anticipated to *decrease* as a result of climate change.

Regarding climate-related impacts with *increasing adverse outcomes* attributable to climate change:

Greatest exposure:	Halifax
	↑
Most exposed capital:	Natural
	↑
Most exposed wellbeing dimensions:	Provisioning services
	↑
	Food
Highest sensitivity:	Cumberland
	↑
Capital contributing most to sensitivity:	Human
	↑
Most influential wellbeing dimensions of this capital:	Health
	↑
	Perceived mental health
Lowest coping capacity:	Digby
	↑
Capital contributing most to low coping capacity:	Social
	↑
Most influential wellbeing dimensions of this capital:	Civic engagement & governance
	↑
	Democratic engagement

Regarding climate-related impacts with *decreasing beneficial outcomes* attributable to climate change:

Greatest exposure:	Halifax
	↑
Most exposed capital:	Human
	↑
Most exposed wellbeing dimensions:	Population & demographics
	↑
	Residents
Highest sensitivity:	Hants
	↑
Capital contributing most to sensitivity:	Natural
	↑
Most influential wellbeing dimensions of this capital:	Cultural services
	↑
	Recreation & leisure
Lowest coping capacity:	Guysborough
	↑
Capital contributing most to low coping capacity:	Manufactured
	↑
Most influential wellbeing dimensions of this capital:	Infrastructure
	↑
	ICT (internet reliability)

	Increasing climate-related adverse outcomes		
	Most influential capital on sub-index		
	Exposure	Sensitivity	Low coping capacity
Annapolis	Natural capital	Natural capital	Manufactured capital
Antigonish	Natural capital	Financial capital	Social capital
Cape Breton	Human capital	Manufactured capital	Social capital
Colchester	Natural capital	Natural capital	Social capital
Cumberland	Natural capital	Human capital	Social capital
Digby	Natural capital	Human capital	Social capital
Guysborough	Natural capital	Financial capital	Manufactured capital
Halifax	Natural capital	Natural capital	Social capital
Hants	Natural capital	Natural capital	Social capital
Inverness	Natural capital	Natural capital	Manufactured capital
Kings	Natural capital	Natural capital	Social capital
Lunenburg	Natural capital	Manufactured capital	Manufactured capital
Pictou	Manufactured capital	Human capital	Social capital
Queens	Natural capital	Financial capital	Manufactured capital
Richmond	Manufactured capital	Manufactured capital	Manufactured capital
Shelburne	Natural capital	Human capital	Manufactured capital
Victoria	Natural capital	Financial capital	Manufactured capital
Yarmouth	Natural capital	Financial capital	Manufactured capital

Table 6-9. Increasing adverse outcomes: Capital with most exposure to climate-related impacts and capital exerting the greatest influence on sensitivity and low coping capacity. Red boxes indicate the census division with the highest score for the corresponding Sub-index.

	Decreasing climate-related beneficial outcomes		
	Most influential capital on sub-index		
	Exposure	Sensitivity	Low coping capacity
Annapolis	Human capital	Natural capital	Manufactured capital
Antigonish	Human capital	Human capital	Social capital
Cape Breton	Human capital	Natural capital	Social capital
Colchester	Human capital	Manufactured capital	Social capital
Cumberland	Human capital	Natural capital	Social capital
Digby	Human capital	Manufactured capital	Social capital
Guysborough	Human capital	Manufactured capital	Manufactured capital
Halifax	Human capital	Manufactured capital	Social capital
Hants	Human capital	Natural capital	Social capital
Inverness	Human capital	Financial capital	Manufactured capital
Kings	Human capital	Human capital	Social capital
Lunenburg	Human capital	Manufactured capital	Manufactured capital
Pictou	Human capital	Manufactured capital	Social capital
Queens	Human capital	Manufactured capital	Manufactured capital
Richmond	Human capital	Manufactured capital	Manufactured capital
Shelburne	Human capital	Manufactured capital	Manufactured capital
Victoria	Human capital	Financial capital	Manufactured capital
Yarmouth	Human capital	Human capital	Manufactured capital

Table 6-10. Decreasing beneficial outcomes: Capital with most exposure to climate-related impacts and capital exerting the greatest influence on sensitivity and low coping capacity. Red boxes indicate the census division with the highest score for the corresponding Sub-index.

6.2.2 Wellbeing improving climate-related impacts

For this category of impacts, the aggregate WRI and Sub-index scores and relative rankings for each census division are presented in Table 6-11 and Table 6-12 for the median projections (50th percentile) under RCP8.5. The same results for RCP4.5 are found in the Annex to this section (in Table 6-22 and Table 6-23). By "aggregate", we mean the sum of scores across all relevant climate-related impacts.

Decreasing climate-related adverse outcomes[28]

Across all three time periods, the five census divisions estimated to potentially experience the largest potential directional improvement in wellbeing because of climate-related impacts with mainly adverse consequences that are projected to decrease with climate change are (based on the sum of WRI scores in 2030, 2050 and 2080, and in descending rank order; 1=benefits most):

1. **Cumberland** (primarily driven by relatively high vulnerability and projected decreases in the underlying climatic drivers, and relatively moderate exposure of capitals);
2. **Halifax** (primarily driven by relatively high exposure of capitals);
3. **Pictou** (primarily driven by relatively high projected decreases in the underlying climatic drivers and exposure of capitals, and relatively moderate levels of vulnerability);
4. **Cape Breton** (primarily driven by relatively high exposure of capitals and projected decreases in the underlying climatic drivers); and
5. **Colchester** (primarily driven by relatively moderate exposure of capitals and projected decreases in the underlying climatic drivers).

These results are not unexpected. Cumberland, Halifax, and Pictou all had a relatively high current need for adaptation to climate hazards anticipated to worsen with climate change. So, not withstanding the fact that the current adaptation need is somewhat hazard-specific, they also stand to benefit most from hazards anticipated to decrease as the climate changes.

Cape Breton also has relatively high exposure to those climate hazards anticipated to increase with climate change. However, for those hazards, the projected changes in the underlying climatic drivers are among the lowest across regions, keeping its overall WRI relatively low. In contrast, changes in the projected (temperature-related) climatic drivers for heavy snowfall, freeze-thaw cycles and heating demand are among the highest across regions, resulting in a relatively high WRI score.

[28] Heavy snowfall; Freeze-thaw cycles; and Heating demand.

	Decreasing climate-related adverse outcomes									
	Impact climate change by 2015-45		Impact climate change by 2035-65		Impact climate change by 2065-95		Today			
	WRI	Climate hazard	WRI	Climate hazard	WRI	Climate hazard	Exposure	Vulnerability	Sensitivity	Low coping capacity
Annapolis	9	11	9	12	9	12	10	4	5	3
Antigonish	17	4	16	3	17	5	13	18	18	17
Cape Breton	4	3	4	5	4	4	2	11	12	9
Colchester	5	6	5	6	5	6	6	10	11	10
Cumberland	1	2	1	2	2	1	7	2	1	5
Digby	6	17	6	16	6	18	9	1	2	1
Guysborough	14	9	15	8	15	9	17	13	17	8
Halifax	2	7	2	10	1	8	1	14	14	11
Hants	11	8	11	7	11	7	8	17	16	18
Inverness	13	13	13	11	12	11	12	15	15	12
Kings	8	10	7	9	7	10	3	16	13	16
Lunenburg	7	12	8	13	8	13	5	8	7	13
Pictou	3	1	3	1	3	3	4	6	6	4
Queens	15	18	14	18	14	17	14	3	3	2
Richmond	10	5	10	4	10	2	15	12	9	14
Shelburne	16	15	17	17	16	16	16	5	4	7
Victoria	18	16	18	15	18	14	18	9	8	15
Yarmouth	12	14	12	14	13	15	11	7	10	6

Table 6-11. Decreasing adverse outcomes: Most impacted census divisions for the median projections (50^{th} percentile) under RCP8.5. [1=highest aggregate Index score for impact category = most impacted]

	Increasing climate-related beneficial outcomes									
	Impact climate change by 2015-45		Impact climate change by 2035-65		Impact climate change by 2065-95		Today			
	WRI	Climate hazard	WRI	Climate hazard	WRI	Climate hazard	Exposure	Vulnerability	Sensitivity	Coping capacity
Annapolis	5	5	8	6	6	2	9	7	2	13
Antigonish	12	15	12	15	13	16	13	3	11	1
Cape Breton	9	16	4	10	3	12	2	8	13	6
Colchester	4	2	5	3	5	3	11	2	5	4
Cumberland	3	4	2	4	4	5	7	5	4	7
Digby	10	3	10	1	8	1	10	15	10	17
Guysborough	16	12	15	13	15	13	16	12	9	15
Halifax	1	13	1	14	1	17	1	4	7	5
Hants	6	9	7	12	7	14	6	6	12	3
Inverness	15	17	13	17	12	11	12	9	6	11
Kings	2	8	3	11	2	10	4	1	1	2
Lunenburg	7	14	9	16	10	18	3	10	8	9
Pictou	11	10	11	9	11	9	5	13	15	10
Queens	13	7	14	8	14	6	14	17	14	18
Richmond	17	11	16	5	18	8	18	16	16	12
Shelburne	14	6	17	7	17	7	15	18	18	14
Victoria	18	18	18	18	16	15	17	11	3	16
Yarmouth	8	1	6	2	9	4	8	14	17	8

Table 6-12. Increasing beneficial outcomes: Most impacted census divisions for the median projections (50th percentile) under RCP8.5. [1=highest aggregate Index score for impact category = most impacted]

As climate change ramps up in the second half of the century under RCP8.5, Inverness and Victoria will experience the largest percentage increases in their WRI scores (see Table 6-13); that is, across all regions, these two will see the greatest percentage increase in potential benefits from reductions in heavy snowfall, freeze-thaw cycles and heating demand. However, because they both start from a small current need for adaptation with respect to these hazards, they still stand to accrue relatively small absolute benefits compared to other parts of the province.

Decreasing climate-related adverse outcomes			Decreasing climate-related adverse outcomes		
	Impact of climate change 2030 to 2080			Impact of climate change 2030 to 2080	
	WRI	Climate impact		WRI	Climate impact
Annapolis	1.0%	3.9%	Annapolis	0.2%	0.8%
Antigonish	-1.0%	-2.4%	Antigonish	-2.1%	-5.2%
Cape Breton	-1.2%	-4.0%	Cape Breton	-1.0%	-3.4%
Colchester	4.5%	16.9%	Colchester	1.1%	3.7%
Cumberland	4.5%	16.1%	Cumberland	0.7%	2.6%
Digby	2.0%	10.7%	Digby	0.7%	3.6%
Guysborough	-3.9%	-11.1%	Guysborough	1.4%	4.5%
Halifax	0.7%	3.1%	Halifax	1.4%	5.7%
Hants	0.9%	2.8%	Hants	2.7%	8.9%
Inverness	-1.1%	-4.0%	Inverness	4.8%	18.1%
Kings	1.8%	6.7%	Kings	1.1%	4.1%
Lunenburg	1.1%	5.0%	Lunenburg	-1.0%	-4.0%
Pictou	0.7%	2.2%	Pictou	-1.5%	-5.0%
Queens	0.4%	1.8%	Queens	2.7%	12.8%
Richmond	-0.3%	-0.7%	Richmond	3.0%	8.7%
Shelburne	0.0%	0.0%	Shelburne	-0.4%	-1.7%
Victoria	-0.6%	-2.4%	Victoria	3.7%	14.7%
Yarmouth	1.2%	5.7%	Yarmouth	-1.8%	-7.1%

Table 6-13. Decreasing adverse outcomes: Changes in the aggregate WRI and Climate Impact Sub-index attributable to climate change between 2030 and 2080 for the median projections (50th percentile) under RCP4.5 (left) and RCP8.5 (right).

Increasing climate-related beneficial outcomes[29]

Across all three time periods, the five census divisions estimated to potentially experience the largest potential improvement in wellbeing as a result of climate-related impacts with mainly beneficial consequences that are projected to increase with climate change are (based on the sum of WRI scores in 2030, 2050 and 2080, and in descending rank order; 1=benefits most):

1. **Halifax** (primarily driven by relatively high exposure of capitals, and relatively moderate vulnerability—specifically, capacity to take advantage of the opportunity);
2. **Kings** (primarily driven by relatively high exposure of capitals and levels of vulnerability—both sensitivity and coping capacity);
3. **Cumberland** (primarily driven by relatively high projected increases in the underlying climatic drivers and levels of vulnerability—specifically, sensitivity); and
4. **Colchester** (primarily driven by relatively high projected increases in the underlying climatic drivers and levels of vulnerability—both sensitivity and coping capacity); and
5. **Cape Breton** (primarily driven by relatively high exposure of capitals, and relatively moderate vulnerability—specifically, capacity to take advantage of the opportunity).

Again, as climate change accelerates in the second half of the century under RCP8.5, Inverness and Victoria will experience the largest percentage increases in their WRI scores (see Table 6-14). In other words, these two regions will see the greatest percentage increase in potential benefits from a longer growing season and extended summer recreation and tourism opportunities, compared to the other census divisions. Nevertheless, because the level of potential benefits is low in 2030 relative to other regions, they still stand to potentially capture relatively small absolute benefits by 2080 compared to other parts of the province, hence, the low WRI scores over time.

[29] Growing season (longer); and Summer recreation & tourism (extended).

Increasing climate-related beneficial outcomes	Impact of climate change 2030 to 2080	
	WRI	Climate impact
Annapolis	2.7%	10.9%
Antigonish	3.4%	14.9%
Cape Breton	6.7%	33.5%
Colchester	0.5%	1.8%
Cumberland	0.0%	-0.1%
Digby	2.0%	6.6%
Guysborough	1.9%	6.7%
Halifax	1.5%	8.4%
Hants	2.1%	9.7%
Inverness	12.0%	78.2%
Kings	2.1%	10.4%
Lunenburg	0.0%	-0.2%
Pictou	1.4%	5.3%
Queens	2.8%	10.4%
Richmond	3.7%	10.8%
Shelburne	-0.5%	-1.4%
Victoria	14.6%	105.3%
Yarmouth	0.6%	2.1%

Increasing climate-related beneficial outcomes	Impact of climate change 2030 to 2080	
	WRI	Climate impact
Annapolis	1.2%	4.0%
Antigonish	3.7%	17.7%
Cape Breton	10.1%	63.1%
Colchester	-0.7%	-2.2%
Cumberland	-2.0%	-6.9%
Digby	3.2%	9.7%
Guysborough	1.4%	5.1%
Halifax	-1.5%	-8.1%
Hants	-1.1%	-4.6%
Inverness	14.2%	84.7%
Kings	-1.0%	-4.2%
Lunenburg	-3.3%	-15.4%
Pictou	1.2%	4.7%
Queens	1.0%	3.1%
Richmond	4.2%	14.0%
Shelburne	-4.1%	-11.5%
Victoria	15.7%	98.1%
Yarmouth	-2.9%	-9.0%

Table 6-14. Increasing beneficial outcomes: Changes in the aggregate WRI and Climate Impact Sub-index attributable to climate change between 2030 and 2080 for the median projections (50th percentile) under RCP4.5 (left) and RCP8.5 (right).

For each census division, Table 6-15 shows the capital with most exposure to climate-related impacts with predominantly adverse consequences for wellbeing that are anticipated to *decrease* as a result of climate change. The table also indicates the capital exerting the greatest influence on sensitivity and low coping capacity for each census division. Within each Sub-index, a red box indicates the census division with the highest score (see Table 6-11 and Table 6-12). Table 6-16 presents the same information for climate-related impacts with predominantly beneficial consequences for wellbeing, but that are anticipated to *increase* as a result of climate change.

Regarding climate-related impacts with *decreasing adverse outcomes* attributable to climate change:

Greatest exposure:	Halifax
	↑
Most exposed capital:	Manufactured
	↑
Most exposed wellbeing dimensions:	Buildings
	↑
	Housing
Highest sensitivity:	Cumberland
	↑
Capital contributing most to sensitivity:	Human
	↑
Most influential wellbeing dimensions of this capital:	Health
	↑
	Perceived mental health
Lowest coping capacity:	Digby
	↑
Capital contributing most to low coping capacity:	Social
	↑
Most influential wellbeing dimensions of this capital:	Personal safety & security
	↑
	Discrimination

Regarding climate-related impacts with *increasing beneficial outcomes* attributable to climate change:

Greatest exposure:	Halifax
Most exposed capital:	Human
Most exposed wellbeing dimensions:	Population & demographics
	Residents
Highest sensitivity:	Kings
Capital contributing most to sensitivity:	Natural
Most influential wellbeing dimensions of this capital:	Provisioning services
	Food
Coping capacity:	Antigonish
Capital contributing most to coping capacity:	Human
Most influential wellbeing dimensions of this capital:	Knowledge & skills
	Educational attainment and education quality

	Decreasing climate-related adverse outcomes		
	Most influential capital on sub-index		
	Exposure	Sensitivity	Low coping capacity
Annapolis	Manufactured capital	Manufactured capital	Manufactured capital
Antigonish	Manufactured capital	Financial capital	Social capital
Cape Breton	Manufactured capital	Manufactured capital	Social capital
Colchester	Manufactured capital	Human capital	Social capital
Cumberland	Manufactured capital	Human capital	Social capital
Digby	Manufactured capital	Human capital	Social capital
Guysborough	Manufactured capital	Manufactured capital	Manufactured capital
Halifax	Manufactured capital	Financial capital	Social capital
Hants	Manufactured capital	Manufactured capital	Social capital
Inverness	Manufactured capital	Manufactured capital	Financial capital
Kings	Manufactured capital	Financial capital	Social capital
Lunenburg	Manufactured capital	Financial capital	Manufactured capital
Pictou	Manufactured capital	Human capital	Social capital
Queens	Manufactured capital	Manufactured capital	Manufactured capital
Richmond	Manufactured capital	Manufactured capital	Human capital
Shelburne	Manufactured capital	Human capital	Human capital
Victoria	Manufactured capital	Financial capital	Financial capital
Yarmouth	Manufactured capital	Manufactured capital	Manufactured capital

Table 6-15. Decreasing adverse outcomes: Capital with most exposure to climate-related impacts and capital exerting the greatest influence on sensitivity and (low) coping capacity. Red boxes indicate the census division with the highest score for the corresponding Sub-index.

	Increasing climate-related beneficial outcomes		
	Most influential capital on sub-index		
	Exposure	Sensitivity	Coping capacity
Annapolis	Natural capital	Natural capital	Financial capital
Antigonish	Natural capital	Financial capital	Human capital
Cape Breton	Human capital	Financial capital	Manufactured capital
Colchester	Human capital	Natural capital	Manufactured capital
Cumberland	Natural capital	Natural capital	Manufactured capital
Digby	Natural capital	Financial capital	Manufactured capital
Guysborough	Natural capital	Financial capital	Social capital
Halifax	Human capital	Natural capital	Manufactured capital
Hants	Human capital	Natural capital	Manufactured capital
Inverness	Natural capital	Financial capital	Human capital
Kings	Human capital	Natural capital	Manufactured capital
Lunenburg	Natural capital	Natural capital	Financial capital
Pictou	Human capital	Financial capital	Human capital
Queens	Natural capital	Financial capital	Financial capital
Richmond	Natural capital	Financial capital	Social capital
Shelburne	Natural capital	Natural capital	Financial capital
Victoria	Natural capital	Financial capital	Social capital
Yarmouth	Natural capital	Natural capital	Financial capital

Table 6-16. Increasing beneficial outcomes: Capital with most exposure to climate-related impacts and capital exerting the greatest influence on sensitivity and (low) coping capacity. Red boxes indicate the census division with the highest score for the corresponding Sub-index.

6.3 Compounding and Cascading Effects

Compound effects occur, for example, when more than one climate hazard results in the same impact chain occurring simultaneously, thus amplifying the overall impact (e.g., the same climate drivers that cause high and extreme high temperatures can also cause drought and wildfire). Cascading effects are indirect consequences of direct effects, such as when direct damages or losses to capitals that are exposed to a climate hazard leads to spin-off impacts. There are several ways that climate change can produce compounding or cascading effects.

6.3.1 Compounding effects

Various climate hazards introduced in Section 5.2.1 can occur in specific places almost simultaneously or in sequence (i.e., one after another, like the extreme heat and wildfires or succession of "atmospheric rivers" that hit British Columbia in 2021). To illustrate the power of simultaneous climate hazards, consider the case of SLR and tropical storms. Each of these two climate hazards on its own can damage coastal infrastructure, natural capital, and economic, social and cultural resources, and reduce wellbeing. Together, their compound effects are more damaging. Riding on the back of higher sea levels, storm surge from coastal storms can reach further inland—adversely affecting more wellbeing capitals. Coastal cities with rivers are also at risk to compounding effects from SLR and fluvial flooding because of dependence between flood drivers; coastal water levels, river discharge and direct precipitation into urbanized areas.

Climate hazards can also occur in sequence, acting as a series of toppling dominos that accumulate and intensify, each becoming harder to manage as capacity to cope and recover becomes more strained, ultimately turning them into disasters. For example, wildfires tend to follow periods of drought and high temperatures. In turn, charred landscapes where the vegetation is removed are more prone to landslides and flooding during extreme rainfall events. Furthermore, earlier snow melt and a longer frost—free season extends the wildfire season. In addition, earlier snow melt increases the likelihood of low flows in rivers and creeks during the dry season. In short, many climate hazards do not occur in isolation, but rather are strongly coupled.

Several of the climate hazards considered in this study are strongly coupled and represent compounding threads:

- "SLR and coastal flooding" + "extreme rainfall events (for coastal areas prone to pluvial flooding)
- "Drought" + "wildfire" + "high and extreme high temperatures"
- "Wildfire" + "extreme rainfall events" (for areas prone to landslides)

Our approach focused on the risk presented to wellbeing from single climate hazards and did not consider the web of connections between them. As a result, we are very likely understating the relative risk to wellbeing from these compounding hazards vis-à-vis the risk arising from the other hazards considered—like heavy snow events that are unlikely to generate compounding effects with other hazards. **To plan for the likely scale and nature of climate-related risks more precisely, it is necessary to better understand the overall severity of these compounding hazards, as well as the relationship each occurrence has with one another.**

While the WRI cannot be used to measure the degree to which compounding hazards amplify absolute risk, it can be used to shed light on the implications for relative risk across census divisions if the impact statements for individual compounding hazards are combined. Table 6-17 illustrates the impact statements when "drought" and "wildfire" are combined, with the resulting WRI scores shown. It is evident from the table that when the combined exposures, sensitivities, and levels of coping capacity are exposed to both climate hazards simultaneously (the combined climatic driver indicators), the *relative* risks change. For instance, some census divisions are relatively worse-off in the presence of the compound hazard than they are under each individual hazard (e.g., Colchester, Halifax). For some census divisions, the relative risk is unchanged (e.g., Richmond, Victoria), for others (e.g., Shelburne, Queens) it is reduced. Remember, we are referring to relative risk here and not absolute risk, which would very likely go up across all census divisions.

Climate hazards are also likely to intersect with non-climate stresses on society; a prime example being the COVID-19 pandemic and associated public health response. These types of compound risks will intensify and be intensified by the unfolding health and economic crisis associated with the pandemic, and by long-standing socioeconomic inequalities within and across regions, in ways that will compromise prevention, coping capacity and recovery. The exacerbated burdens will fall disproportionately on specific underserved and marginalized populations—e.g., racialized individuals, those with limited access to information and resources due to their socioeconomic circumstances, anyone facing existing health inequities, and less able-bodied individuals, like seniors, and individuals and families living in hazardous locations.

By way of example, hurricane Ida made landfall in Louisiana on August 29 this year, dropping large amounts of rain and bringing heavy winds and extremely high tides to parts of the state, which were already a hotspot for COVID-19 morbidity and mortality and under significant stress—partly due to a legacy of racial discrimination and underinvestment in healthcare services. Furthermore, extreme heat events, like those experienced this year in British Columbia and Alberta will lead to high excess morbidity and mortality (especially in urban centres). The most severe impacts will be felt by persons already at high risk of heat-related illness, including older adults, those living in poverty (who live in poor quality, crowded group housing, and who cannot afford air conditioning), and those with pre-existing health conditions; essentially, many of the same people with co-morbidities for COVID-19. Extreme heat events will serve to exacerbate pressure on an already overburdened healthcare and social assistance sector. Moreover, such events may disrupt power supplies with further cascading impacts for hospitals and emergency services. Wildfires also intersect with the COVID-19 pandemic. Acute and chronic health impacts from air pollution caused by the extreme wildfire season in Western Canada and the USA will likely exacerbate COVID-19 morbidity and mortality, and further strain the healthcare system and the economy.

Table 6-17. Illustrating the difference between compound (simultaneous) climate hazards and individual hazards – example of wildfire and drought for median projections under RCP8.5 for 2065-2095 relative to the baseline period [1 = largest relative risk].

Drought + wildfire	WRI	Drought	WRI	Wildfire	WRI
Annapolis	6	Annapolis	5	Annapolis	7
Antigonish	15	Antigonish	17	Antigonish	17
Cape Breton	10	Cape Breton	9	Cape Breton	11
Colchester	3	Colchester	8	Colchester	4
Cumberland	2	Cumberland	1	Cumberland	8
Digby	5	Digby	2	Digby	10
Guysborough	17	Guysborough	15	Guysborough	15
Halifax	1	Halifax	3	Halifax	2
Hants	9	Hants	14	Hants	6
Inverness	13	Inverness	13	Inverness	14
Kings	4	Kings	6	Kings	1
Lunenburg	8	Lunenburg	7	Lunenburg	3
Pictou	7	Pictou	4	Pictou	5
Queens	12	Queens	10	Queens	9
Richmond	18	Richmond	18	Richmond	18
Shelburne	14	Shelburne	12	Shelburne	12
Victoria	16	Victoria	16	Victoria	16
Yarmouth	11	Yarmouth	11	Yarmouth	13

Because of the potential for this form of compounding climate risks—with emergency response resources stretched across multiple crises simultaneously—governments in Nova Scotia will be faced with developing and adjusting policies that address not only non-climate stresses like the pandemic itself, but also possible intersections with rapid-onset climate hazards (extreme weather events). Coordination will be needed at every level of government to ensure coherent strategies. For example, during this fire season in British Columbia, some communities faced the prospect of evacuation. This would require decisions to be made that are coordinated with those for the pandemic, including whether and how hospitals (especially intensive care units) could be evacuated safely, and how to manage broader emergency sheltering needs given social distancing and work from home requirements.

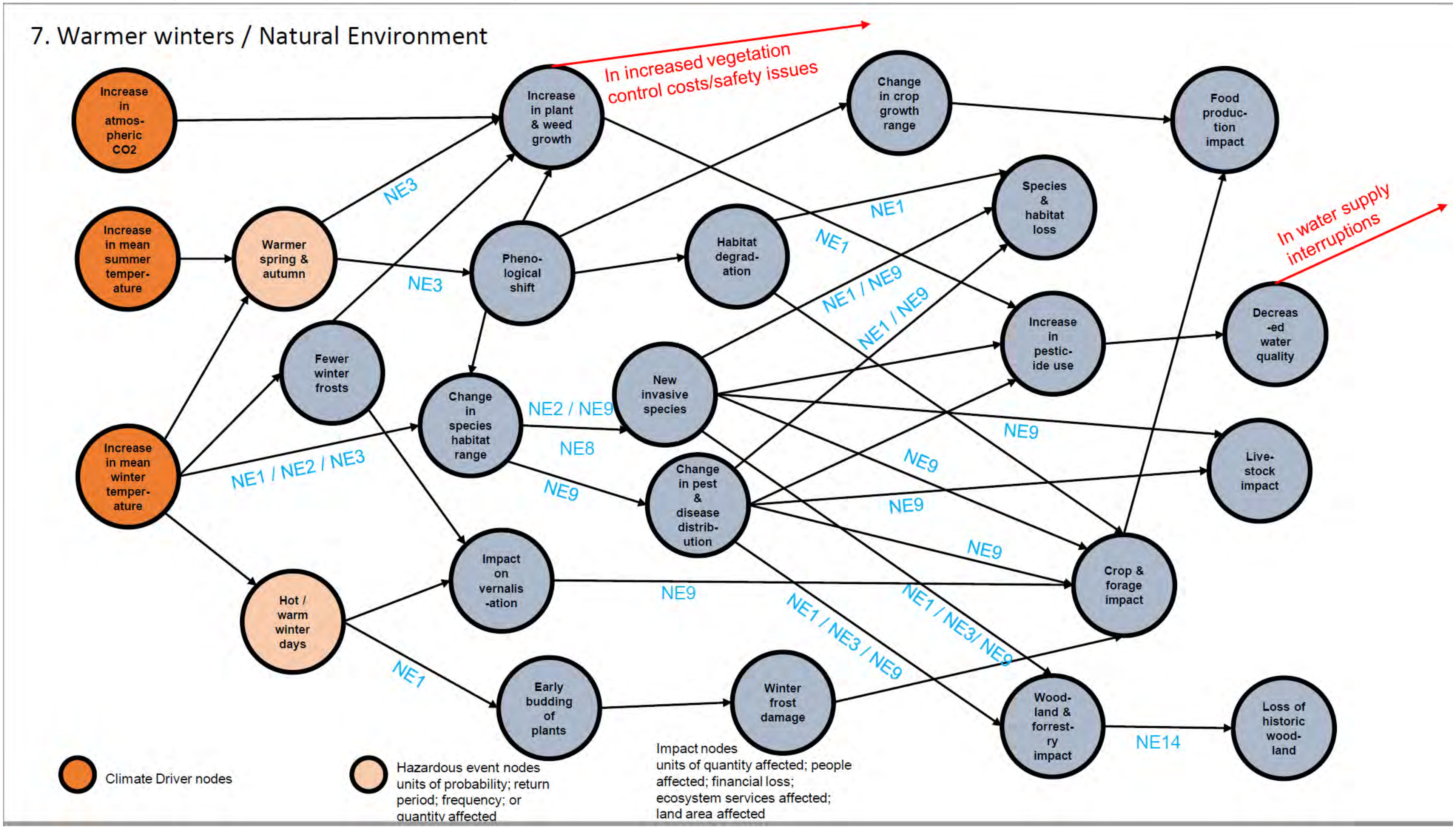
More generally, detailed plans for compound risk preparedness and adaptation are needed, taking account of regional differences in climate vulnerability, with interventions tailored to the unique vulnerabilities, needs and circumstances of affected populations.

6.3.2 Cascading effects

Most climate hazards have the potential to produce cascading effects—i.e., progressions of hazard-related impacts which produce multiple cause-effect chains. A cascading event starts from a single cause with one or more specific mechanisms leading to consequences for wellbeing (an example for the impact of warmer winters on the natural environment from the UK's Third Climate Change Risk Assessment is shown in Figure 6-4). Each of these consequences, however, can both be an effect of concern and a cause of other effects Moreover, each dual cause-effect node leads to its own causal chain of additional consequences which might also be potential causes. These cascading effects can be at least as serious as the original impact, and strongly influence the overall duration of response and recovery. Cascading effects highlight unresolved vulnerabilities in society and can be amplified by the failure of manufactured capital and the economic and social functions that depend on them, or by weaknesses in emergency management strategies (Pescaroli and Alexander, 2015).

When constructing the impact statements that drive the hazard-specific results of the WRI, cascading effects are largely captured. Indeed, the impact statements were informed by the WSP work for the UK's Third Climate Change Risk Assessment, and if the WRI impact chains were presented diagrammatically as opposed to in tables, they would look a lot like the example in Figure 6-4. Looking at "high and extreme high temperatures" in the WRI for example, the aggregate impact statement for that hazard captures potential consequences for employment and economic output with knock-on consequences for household incomes, arising from morbidity and mortality health outcomes for exposed populations. The statement also captures the knock-on effects of those health outcomes for emergency services and hospitals. Furthermore, the impact statement differentiates between health consequences for the elderly and outdoor workers, as well as perceived health status. The knock-on consequences of heat stress for agriculture and cooling demand for the affordability of local foods and utility bills, respectively, are also captured.

Figure 6-4. Example of cascading climate hazard impact chains.



Source: WSP (2020). **Note**: The letters and number provide cross-references with a table in the WSP report with more detailed information on the interactions; natural environment (NE).

6.4 Distributional Considerations

Study after study has demonstrated that the impacts of climate change are most severely felt by populations already challenged by social, economic, and political disadvantage.[30] Structural inequalities and environmental racism influence where people work, live and play, their access to resources and opportunities, and thus their exposure and vulnerability to climate-related impacts. This is especially true for Mi'kmaq and Black communities in Nova Scotia, where racist and colonial legacies and ongoing have contributed to current inequalities and disparities.[31] In addition, there is an extensive literature on the disparities of efforts to manage the impacts of climate change—documenting:

- "Acts of commission", whereby the negative effects of adaptation actions largely impact disadvantaged groups and communities—in part, because they lack access to information, resources, institutions, and other means to prepare for and avoid the risks; and
- "Acts of omission", whereby marginalized groups receive fewer adaptation benefits and are underrepresented in decision-making.[32]

Though the traditional focus of "climate justice" has been on the transition to a low carbon future, it is important not to lose sight of the fact that the need for a "just and equitable" transition is equally relevant in the context of formulating strategies to prepare for, cope with and recover from the impacts of climate change.[33]

6.4.1 Distributional implications for sub-populations of Nova Scotia

In this section we explore the distributional implications of the results for Black, female, elderly and Indigenous Nova Scotians.

Table 6-18 provides information on the prevalence of the first three of our population groups of interest in each census division; bolded values indicate the census division with the highest percentage in each column. Section 6.2 identified the five census divisions estimated to experience the largest potential deteriorations or improvements in wellbeing as a result of climate change (based on the sum of WRI scores in 2030s, 2050ss and 2080s). Cross-referencing these census divisions with the information in Table 6-18 reveals the potential for disproportionate impacts on Black, female, and elderly Nova Scotians. The impacts in a census

[30] For a synthesis of this literature see: Olsson, L., et al., 2014: Livelihoods and Poverty. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C., et al., (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 793-832.

[31] See Waldron, I., 2021: Environmental Racism and Climate Change: Determinants of Health in Mi'kmaw and African Nova Scotia Communities, www.climatechoices.ca/publications/environment-racism-and-climate-change/ [accessed 09.10.2021].

[32] See, for example, Anguelovski, I., et al., 2016: Equity impacts of urban land use planning for climate adaptation: critical perspectives from the global north and south. Journal of Planning Education and Research, 36, pp. 333–348; and Meerow, S. and Newell, J., 2019: Urban resilience for whom, what, when, where, and why? Urban Geography, 40, pp. 309–329.

[33] This includes assimilating and supporting climate migrants and people temporarily displaced by weather and climate extreme events in other parts of the province or from further afield.

division are considered potentially disproportionate if the prevalence rate for the population group of that census division exceeds the provincial average for that category.

Most affected census division by climate-related impacts	Potential for disproportionate impacts on population groups of interest
Increasing adverse consequences (loss of wellbeing)	
Cumberland	65 years and older
Halifax	Black; Black-female
Digby	65 years and older; elderly-female; Black; Black-female
Annapolis	65 years and older; elderly-female
Decreasing beneficial consequences (loss of wellbeing)	
Halifax	Black; Black-female
Hants	Mi'kmaw community
Lunenburg	65 years and older
Cumberland	65 years and older
Decreasing adverse consequences (gain of wellbeing)	
Cumberland	65 years and older
Halifax	Black; Black-female
Cape Breton	Female
Colchester	Female; Black
Increasing beneficial consequences (gain of wellbeing)	
Halifax	Black; Black-female
Kings	None
Cumberland	65 years and older
Colchester	Female; Black
Cape Breton	Female

In general, those regions with the highest prevalence of the elderly (Guysborough, Queens, Richmond) are not among those most impacted—adversely or beneficially—by climate change. Guysborough also has among the highest prevalence of Black Nova Scotians, second only to Halifax.

Table 6-18. Exposure of Black, Female and Elderly Nova Scotians by Census Division

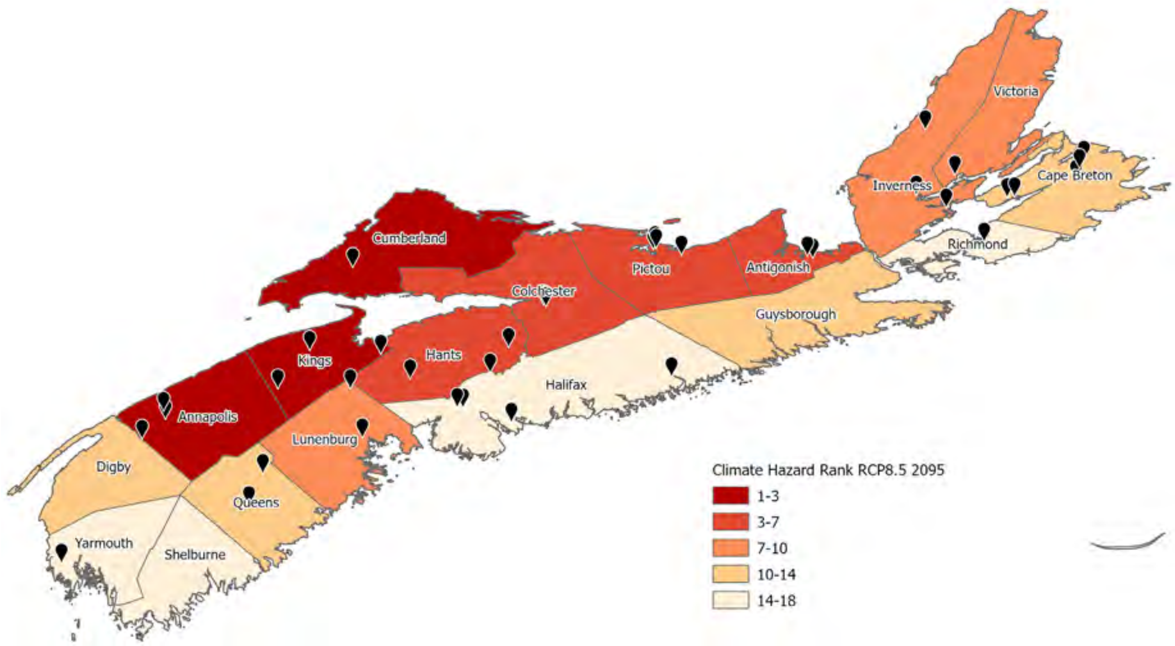
	% of total population that is female	% of total population 65 or older	% of total female population 65 or older	% of population 65 or older that is female	% of total population identifying as Black	% of total female population identifying as Black	% of population identifying as Black that is female
Annapolis	51.3%	27.1%	27.9%	52.8%	0.9%	1.0%	57.1%
Antigonish	51.7%	20.6%	21.6%	54.1%	2.0%	2.2%	58.1%
Cape Breton	**52.6%**	22.8%	24.3%	**56.0%**	1.1%	1.1%	50.5%
Colchester	51.9%	21.4%	22.5%	54.4%	1.7%	1.4%	43.0%
Cumberland	51.4%	25.7%	26.8%	53.5%	1.5%	1.6%	57.0%
Digby	51.6%	26.2%	27.4%	54.0%	2.3%	2.3%	53.9%
Guysborough	50.5%	**31.1%**	**31.8%**	51.7%	3.1%	3.2%	51.1%
Halifax	51.6%	15.7%	16.8%	55.5%	**3.8%**	**3.8%**	51.6%
Hants	51.0%	17.7%	18.5%	53.2%	1.6%	1.4%	46.3%
Inverness	51.1%	25.4%	26.3%	53.0%	0.6%	0.7%	60.0%
Kings	51.6%	21.0%	22.3%	54.7%	1.2%	1.1%	47.6%
Lunenburg	51.3%	26.0%	27.2%	53.5%	0.3%	0.3%	44.4%
Pictou	51.6%	22.7%	23.8%	54.3%	1.6%	1.4%	44.1%
Queens	51.1%	28.2%	29.3%	53.1%	1.4%	1.4%	50.0%
Richmond	51.3%	27.7%	28.4%	52.6%	0.4%	0.2%	25.0%
Shelburne	50.5%	23.9%	25.1%	53.1%	1.6%	2.0%	**63.6%**
Victoria	50.4%	25.2%	25.9%	51.7%	0.6%	0.9%	60.0%
Yarmouth	52.0%	23.4%	24.7%	54.8%	2.0%	1.9%	48.5%

Source: Statistics Canada, Data Tables, Census 2016 (https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/dt-td/Index-eng.cfm)

To shed light on the potential exposure of Mi'kmaw individuals to climate-related impacts as well effects on wellbeing we opted to use mapped visualizations of 13 Mi'kmaw communities and satellite locations in relation to climate hazards (Figure 6-5) and the WRI (Figure 6-6).[34] As shown by these map overlays, climate change threatens the wellbeing of Mi'kmaw individuals throughout the province, including in census divisions estimated to experience the largest potential deteriorations in wellbeing caused by climate change.

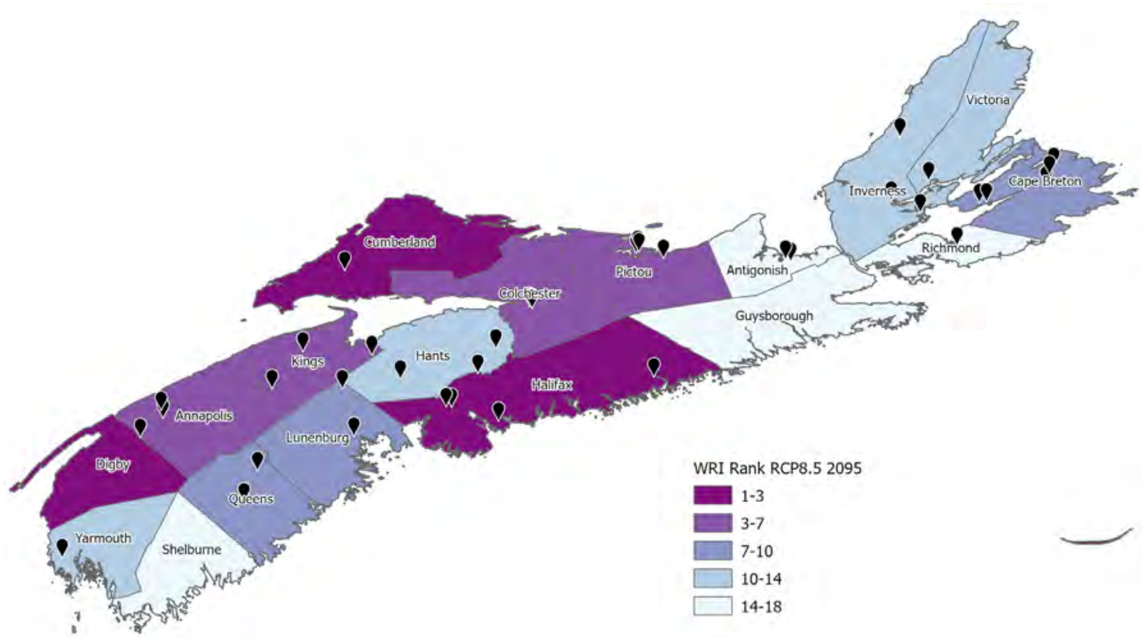
[34] Statistics Canada has introduced improvements to the self-selection options for Indigenous peoples in the 2021 Census, including the ability to distinguish between citizens of Métis governments that have signed the Canada-Métis Nation Accord and Métis individuals outside these entities. These distinctions are not available for the 2016 Census data used in this study, making it harder to distinguish between different groups within the Aboriginal category of the 2016 Census. In addition, Mi'kmaw communities experience additional constraints within census divisions due to the reserve system (i.e., sub-census division), with locations often near the coast. This may underrepresent Mi'kmaw living off-reserve, particularly in Halifax CD.

Figure 6-5: Presence of Mi'kmaw communities and satellite locations across census divisions in Nova Scotia, with census divisions colour coded by climate hazard rank (1=highest aggregate index score for climate impacts with increasing adverse outcomes).



Source: Locations of Mi'kmaw communities and satellite locations are from the Nova Scotia Office of L'nu Affairs. Climate hazards rankings are based on median projections (50th percentile) under RCP8.5. These rankings are in Table 6.11.

Figure 6-6: Presence of Mi'kmaw communities and satellite locations across census divisions in Nova Scotia, with census divisions colour coded by WRI rank (1=wellbeing most impacted by increasing adverse outcomes of climate change).



Source: Locations of Mi'kmaw communities and satellite locations are from the Nova Scotia Office of L'nu Affairs. WRI rankings are based on median projections (50th percentile) under RCP8.5. These ranking are in Table 6.11.

In general, over all three time periods, the most consequential climate hazard and climate opportunity (based on the sum of WRI scores in 2030, 2050 and 2080) are, respectively, increased pluvial flooding and a longer growing season. Below, we explore how vulnerability to these two climate-related impacts varies across our population groups of interest by examining a handful of indicators for which data are readily available.[35]

Determinants of sensitivity

Based on available data, the following three indicators of sensitivity are considered:

1. **Dependency upon agriculture and forestry** for wages (based on NAICS 11 which also includes hunting and fishing).

At the provincial level, only 3.8% of the total labour force population aged 15 years and older work in this sector. Participation in the sector by females in the labour force is less than half this amount, at 1.6%. The dependency on this sector for employment and income is also low for Black Nova Scotians; only 1.4% and 0.5% of the Black and Black-female labour force, respectively, work in the sector. In contrast, about 6.8% of the total Aboriginal labour force work in the sector. However, if we strip out “fishing, hunting and trapping” from NAICS 11, this figure drops to 0.8%. Aboriginal-females are even less dependent on the sector for employment and income as their male counterparts, with only 1.5% of the female labour force in NAICS 11 and 0.5% involved with “fishing, hunting and trapping”.

2. **Diversity of employment** (based on arithmetic average of Shannon-Weiner Index and Simpson’s Index of Diversity).

The diversity of employment sources for female Nova Scotians is significantly less than for males—about 21% lower. Greater diversity reduces the sensitivity of employment generally to climate-related damage or disruption that may disproportionately impact one or more sectors of the economy, like flooding. The diversity of employment sources for Black Nova Scotians is about 8% lower than for the total labour force in the province, i.e., employment is concentrated in fewer sectors of the economy, placing them at greater risk to workplace disruption. Black-females are at significantly higher risk than Black-males, with a gender gap of nearly 24%. Nova Scotians identifying as Aboriginal are even more concentrated in fewer sectors of the economy. The diversity of employment sources for Aboriginal Nova Scotians is about 52% lower than for the total labour force in the province. However, the gender gap for Aboriginal-females is not as large as for Black-females, at 8%.

3. **Resilience of housing stock**

At the provincial level, 8.6% of the population reside in residential dwellings (including rental and subsidized housing) and 8.5% in owner-occupied dwellings that are in need of “major repairs”. These homes will of course be less resilient and the occupants more at risk to climate hazards,

[35] Because of its exploratory nature this analysis does include 2016 Statistics Canada data for individuals self-identifying as Aboriginal (the term used then). In this section of the report, we retain the term “Aboriginal” to denote the anachronism and lack of distinction.

like flooding events. The proportion of people aged 65 years or older in dwellings in need of major repair is slightly less at 7.3% (8.0% for owner-occupied dwellings). For Nova Scotians identifying as Aboriginal, the proportion of people living in homes in need of major repair is nearly double that for all Nova Scotians, at 15.9%. The data does not distinguish between female and male maintainers of homes, and no data are available for Black Nova Scotians.

Determinants of coping capacity

Based on available data, the following three indicators of general coping capacity are considered:

1. **Low-income status** (based on after-tax LICO).

The prevalence of low-income among Black Nova Scotians is about 32%, which is double the rate for Nova Scotians not identifying as a visible minority (16%). The prevalence of low-income among Black-females, is slightly higher at 33%, just less than double the rate for non-visible minorities (17%), but two percentage points higher than for Black-males (31%) resulting in a gender gap of about 7%. Black Nova Scotians 65 years and older have a lower rate than for all individuals identifying as Black—at 28%—which is still considerably higher than the prevalence rate for non-visible minority elderly individuals (18%).

The prevalence of low-income among Nova Scotians identifying as Aboriginal is about 21%, which is four percentage points higher than the rate for Nova Scotians not identifying as Aboriginal (17%). The prevalence of low-income among Aboriginal-females, is slightly higher at 22%, compared with 18% for non-Aboriginal females in the province. The gender gap to Aboriginal-males is 13%. Aboriginal Nova Scotians 65 years and older have a slightly higher rate than for all individuals identifying as Aboriginals—at 22%—which is four percentage points higher than the rate for non-Aboriginal elderly individuals (18%).

Considering all elderly Nova Scotians, the prevalence of low income is substantially higher among females (21%) than males (15%), with a gender gap of 39%. The gender poverty gap for the elderly is largest in Pictou and Cape Breton; two of the top five impacted regions.

2. **Disposable income** (based on after-tax total income of individuals).

The median after-tax total income of Black Nova Scotians is $22,700 (2015 dollars); about 14% less than the total population of income recipients (median = $26,500). The median after-tax income of Black-females is on par with females in general, as well as with Black-males; i.e., there is no gender gap among Black Nova Scotians. However, median after-tax income for Black-males is about 29% lower than for all males in the province. Looking at Black Nova Scotians aged 65 and older, there is a large gender gap (17%) when it comes to median after-tax income.

The median after-tax total income of Nova Scotians identifying as Aboriginal is $24,100 (2015 dollars); about 9% less than the total population of income recipients. The median after-tax income of Aboriginal-females is about 6% lower than for all female Nova Scotians; $21,300 compared with $22,700. Among Aboriginals, the gender gap for after-tax income (all individuals aged 15 years and older) is significant at $9,800 or 31%. The gap in median after-tax income between elderly Aboriginals (total sex) and all Aboriginals aged 15 years and older is about $2,500 or 10%.

3. **Educational attainment**.

About 27% of Black Nova Scotians aged 15 years and older do not hold a certificate, diploma or degree. This compares with 20% for the general population. The gender gap for Black-females is negative 20%, which in this case means that a higher proportion of Black-females are achieving higher levels of educational attainment than Black-males. The gender gap for the general population of female Nova Scotians is negative 14%.

The picture is very similar for Nova Scotians identifying as Aboriginal. About 27% of individuals with Aboriginal identity (all ages) do not hold a certificate, diploma, or degree. Like Black-females, the gender gap for Aboriginal-females is also negative 20%; about 1/5th more Aboriginal-females are achieving higher levels of educational attainment than Aboriginal-males. Among Aboriginals aged 65 years and older, about 41% have not attained at least a certificate, diploma or degree; 10 percentage points higher than the total population of elderly Nova Scotians.

6.4.2 Implications of existing inequalities and disparities for coping capacity

Many structural determinants of inequalities and disparities in Nova Scotia—like income, employment, crime, discrimination, education, etc.—are already captured by the indicators used to construct the WRI. This is evident from a review of Table 5-3; and the indicators of financial, human, and social capital. Differences in these indicators across census divisions is what drives the WRI results—specifically, the Exposure, Sensitivity and Low Coping Capacity Sub-index scores. To understand the role of existing inequalities and disparities in determining outcomes, we have performed a series of sensitivity tests on a generalized version of the Low Coping Capacity Sub-index; by “generalized”, we mean only those indicators that are included in the Low Coping Capacity Sub-index of *all* the climate-related impacts considered in the report are captured. Put another way, indicators of Low Coping Capacity specific to individual climate-related impacts are excluded. The indicators included in this generalized Low Coping Capacity Sub-index are listed in Table 6-18. Detailed descriptions of these indicators are provided in Table 5-3.

The estimated scores for this generalized Low Coping Capacity Sub-index by census division are shown in Table 6-19; this represents the base case for the sensitivity tests. The scores are based on a simple arithmetic average of the normalized values across all 32 indicators of the index. For this exercise, we do not differentiate between capitals and sub-pillars. In terms of interpretation, the higher the score, the lower the coping capacity compared to other regions. As evident from Table 6-19, the three census divisions with the lowest levels of coping capacity generally, are Digby, Cumberland, and Pictou. In contrast, the regions with the highest levels of general coping capacity are Antigonish, Victoria and Inverness.

The sensitivity tests involve taking each of the 32 indicators one-by-one and:

1. Removing differences in values across census divisions by assigning a score of one to each Division;
2. Recalculating the generalized Low Coping Capacity Sub-index; and
3. Subtracting the new index scores by census division from the base case index scores shown in Table 6-19.

The first step is equivalent to *removing* prevailing disparities across census divisions, where disparities refer to avoidable or remediable differences (or lack of parity) between groups of people defined geographically—in this case, by census divisions. Assigning a value of one to all census divisions for an indicator represents an improvement in outcomes, except for the Division that has a score of one under the base case.[36] For two of the indicators, “new immigrants” and “recent migrant movers”, this is of course not typically perceived as an improved outcome. Hence, these two indicators are excluded from the sensitivity tests.

The newly calculated index score will always be lower than the base case scores, as one source of disparity driving the results has been removed. A key question of policy relevance is thus: creating parity across census divisions for what specific indicator results in the largest improvement in coping capacity? The results of the sensitivity tests for each indicator are provided in Table 6-20. The third column (coloured) in the table shows the aggregate change across all census divisions for each indicator relative to the base case. Indicators highlighted in green produce the largest improvement in coping capacity when prevailing disparities across the province are removed by raising levels of wellbeing in all but the best performing census division.

[36] Recall from the description of the Index in Section 5 that a value of one described desirable condition, whereas a value of 10 describes undesirable conditions.

Table 6-19. Generalized Low Coping Capacity Index: Indicators

Indicator	ID	Units
Unemployment rate	ind.21	(%)
Gini coefficient (AT household income)	ind.33	(index)
Median after-tax income individuals (all sources)	ind.34	($ 2015)
Prevalence low income	ind.35	(%)
Average monthly shelter costs	ind.40	($ 2015)
Financial wellbeing	ind.41	(score: 12=good_fin_health)
Spending 30% or more of income on shelter costs	ind.42	(% of housholds)
Neither English nor French	ind.49	(% of total pop)
New immigrants	ind.50	(% of total population)
Recent migrant movers	ind.58	(% of total population)
Adults (25-64) with no certificate; diploma or degree	ind.60	(% of total pop)
Education opportunities	ind.61	(score: 7=extreme_satisfied)
Reliability of internet service	ind.90	(score: 5=excellent]
Interest in politics	ind.156	(score: 10=a lot_of_interest)
Participate in democracy 1	ind.157	(score: 1=yes; 2=no)
Participate in democracy 2	ind.158	(score: 10=always_time)
Participate in democracy 3	ind.159	(score: 7=extreme_satisfied)
Political efficacy 1	ind.160	Score out of 7, 7 = very strongly agree
Political efficacy 2	ind.161	(score: 7=extreme_satisfied)
Trust in institutions	ind.162	(score: 7=trusted_alot)
Trust in others	ind.163	(score: 7=trusted_alot)
Volunteered in last year	ind.164	(score: 1=yes; 2=no)
Discriminated against	ind.165	(score: 7=all_the_time)
Perceived safety	ind.166	(score: 7=very_safe)
Sense of belonging	ind.167	(score: 7=extreme satisfied)
Social contacts 1	ind.168	(count)
Social contacts 2	ind.169	(score: 10=always_enough)
Social contacts 3	ind.170	(score: 7=extreme_satisfied)
Social isolation	ind.171	(score: 7=strongly_agree)
Social support	ind.172	(score: 7=strongly_agree)
Socialize 1	ind.173	(days per month)
Socialize 2	ind.174	(score: 10=always_enough)

Table 6-20. Generalized Low Coping Capacity Index: Results by Census Division [high score = lower coping capacity; rank of 1 = lowest coping capacity]

	Score	Rank
Annapolis	5.7	6
Antigonish	3.8	18
Cape Breton	5.8	5
Colchester	5.4	10
Cumberland	6.7	2
Digby	7.1	1
Guysborough	4.9	14
Halifax	5.6	7
Hants	5.5	9
Inverness	4.7	16
Kings	4.9	13
Lunenburg	5.2	12
Pictou	6.2	3
Queens	5.6	8
Richmond	4.8	15
Shelburne	5.8	4
Victoria	4.2	17
Yarmouth	5.4	11

Eliminating disparities (i.e., creating parity across census divisions) for the following five indicators, results in the largest increases in coping capacity, as measured by our generalized Low Coping Capacity Index:

1. **Social support** (arithmetic average of four indicators: people in this community are available to give help if somebody needs it, if I need help, this community has many excellent services to meet my needs, if I had an emergency, people I do not know would be willing to help me, and in this community, people are not willing to help those in need) (ind.172);
2. **Participate in democracy 3** (satisfaction with how well democracy is working) (ind.159);
3. **Sense of belonging** (arithmetic average of three indicators: sense of belonging to community, satisfaction with sense of belonging to this community, and satisfaction with neighbourhood as place to live) (ind.167);
4. **Median after-tax income individuals** (all sources) (ind.34); and
5. **Participate in democracy 1** (ind.157) (participate in democratic event in community in last 12 months).

Put another way, these five indicators have the largest total disparities across all census divisions (i.e., the largest cumulative gap from each census division to the Division with the 'best' value). As this gap exerts a positive (+) influences the base case results, its removal will reduce the generalized Low Coping Capacity Index.

To provide some insights into the potential effectiveness of "policy themes" that could improve coping capacity, we also simulated the removal of existing disparities for groups of indicators that could be targeted by themed interventions. The results of these sensitivity tests are provided below; rank-ordered from largest change to smallest change.

Themes for improvements	Relevant indicators from Table 6-18[37]	Average improvement in coping capacity[38]
Belief in government	ind.159, ind.160, ind.161	3.0%
Work-life-balance	ind.158, ind.169, ind.174	2.9%
Personal safety and security	ind.165, ind.166,	2.7%
Incomes and income equality	ind.33, ind.34, ind.35, ind.41	2.5%
Educational outcomes and quality	ind.60, ind.61,	2.4%
Housing affordability	ind.40, ind.42,	2.1%

Looking at which census divisions stand to benefit most from the removal of prevailing disparities across the indicators listed in Table 6-18, Table 6-21 shows the aggregate reduction in the generalized Low Coping Capacity Index from eliminating disparities across each indicator. As expected, those census divisions with the lowest level of coping capacity (see Table 6-19) will also benefit the most if disparities with respect to the best performing census division on each indicator are eliminated: Digby, Cumberland, Pictou, Shelburne, and Cape Breton.

[37] The sensitivity tests involved removing existing disparities for all the listed indicators simultaneously. See Table 5-3 for descriptions of the indicators.

[38] Strictly speaking, the listed values measure the normalized percentage decrease in the base case generalized Low Coping Capacity Index over all modified indicators.

Table 6-21. Generalized Low Coping Capacity Index: Results of Sensitivity Tests, by Indicator [high score = largest total reduction in the generalized Low Coping Capacity Index (or the largest total increase in coping capacity) across all census divisions from eliminating current disparities with respect to each individual indicator]

Indicator	ID	Aggregate change in LCC Sub-index	Rank: Improvement in LCC
Social support	ind.172	-4.31	1
Participate in democracy 3	ind.159	-4.13	2
Sense of belonging	ind.167	-4.12	3
Median after-tax income individuals (all sources)	ind.34	-4.09	4
Participate in democracy 1	ind.157	-4.07	5
Social contacts 2	ind.169	-4.02	6
Volunteered in last year	ind.164	-3.93	7
Political efficacy 2	ind.161	-3.93	8
Participate in democracy 2	ind.158	-3.88	9
Social contacts 1	ind.168	-3.87	10
Political efficacy 1	ind.160	-3.81	11
Social contacts 3	ind.170	-3.73	12
Perceived safety	ind.166	-3.66	13
Discriminated against	ind.165	-3.65	14
Social isolation	ind.171	-3.60	15
Socialize 1	ind.173	-3.59	16
Socialize 2	ind.174	-3.55	17
Spending 30% or more of income on shelter costs	ind.42	-3.54	18
Prevalence low income	ind.35	-3.54	19
Financial wellbeing	ind.41	-3.49	20
Education opportunities	ind.61	-3.49	21
Interest in politics	ind.156	-3.48	22
Reliability of internet service	ind.90	-3.44	23
Adults (25-64) with no certificate; diploma or degree	ind.60	-3.31	24
Gini coefficient (AT household income)	ind.33	-2.88	25
Trust in institutions	ind.162	-2.87	26
Unemployment rate	ind.21	-2.74	27
Average monthly shelter costs	ind.40	-2.68	28
Trust in others	ind.163	-2.60	29
Neither English nor French	ind.49	-2.36	30

Table 6-22. Generalized Low Coping Capacity Index: Results of Sensitivity Tests, by Census Division [high score = largest improvement in coping capacity of census division from eliminating disparities across each indicator, highlighted in green]

	Aggregate change in LCC score
Annapolis	-4.3
Antigonish	-2.5
Cape Breton	-4.7
Colchester	-4.1
Cumberland	-5.6
Digby	-5.8
Guysborough	-3.8
Halifax	-4.2
Hants	-4.3
Inverness	-3.5
Kings	-3.6
Lunenburg	-4.0
Pictou	-5.0
Queens	-4.4
Richmond	-3.7
Shelburne	-4.6
Victoria	-3.2
Yarmouth	-4.2

7 Information Gaps and Study Limitations

7.1 Information Gaps

Throughout the implementation of the WRI analytical framework and preparation of this report, we took note of information gaps at two levels: 1) understanding of impacts of climate change on elements of the five capitals; and 2) representation of risk categories (climate hazard exposure, sensitivity, or low coping capacity) via indicators and metrics from existing datasets. This section briefly outlines our observations. It is not a comprehensive gap analysis.

- Adaptation entails reducing adverse impacts of climate change and taking advantage of opportunities. There is a lack of specific information about the potential opportunities for Nova Scotia from the impacts of climate change, such as those that could arise from extended growing seasons and comparative advantages in attracting tourists. It's notable that the province outlines a few opportunities on the climate change website[39] (e.g., biomass production on marginal land). The lack of exploration of potential opportunities in the literature is not unique to Nova Scotia; the lack of coverage of opportunities arises when preparing assessments of the state of knowledge of climate change impacts and adaptation nationally, as well.
- Of the five capitals included in the wellbeing framework (see Figure 3-1 and Figure 5-7), natural and manufactured capitals are most discussed or examined in the literature on the impacts of climate change in Nova Scotia. Even within these categories, though, it is possible to identify information gaps or areas of research that would advance understanding of climate change risks to Nova Scotian's wellbeing. One example is detailed assessment of the vulnerability of the province's forests to climate change, which in turn would inform analyses of climate change effects on elements of human and financial capital. Another is assessment of federally-owned and managed infrastructure, since the province is home to 40% of Canada's military assets. This latter example illustrates the importance of cross-scale collaboration in setting priorities to fill information gaps.
- Information on the interaction between climate change and social capital for Nova Scotia is limited. Current statistics related to safety and security for Nova Scotia suggest that women are more likely to feel unsafe, and at greater rates, than men. Young people (25 and under) and racialized populations experience more discrimination than other groups. And rates of domestic violence against women are increasing. Analyses of these social trends and conditions using a climate lens could shed light on barriers or enablers to mobilizing coping and adaptive capacity in anticipation and response to slow and event-based impacts of climate change. We also note that there are relational aspects between people and nature, such as place attachment, that factor into feelings of security (Schröter et al. 2021). These relational aspects are not well covered in the capitals or wellbeing frameworks that underpinned this study.

[39] https://climatechange.novascotia.ca/adapting-to-climate-change/impacts/agriculture

- Elements of human capital are critically important for adaptation to a changing climate. Our literature review shed light on a few trends and conditions worth further exploration, including the large proportion of Nova Scotians (one in four) living with mobility limitations, the province's high rates of food insecurity compared to other provinces, the expressed loss of culture by Indigenous communities in Nova Scotia, and the inadequate capture of perspectives of these communities in population data. Research to illuminate dynamics in coping and adaptive capacity should be consistent with the asset-based approach the Nova Scotia government is pursuing to analyze climate change risk and guide adaptation action.
- In the area of human capital, we also noted the lack of information on the impacts of a changing climate on Nova Scotians' knowledge and skills. With the high value placed on the province's education system, and with so many universities and colleges, investigating the potential effects of climate change on the education system is critical, including compounding and cascading effects across capitals. For example, physical damage to public infrastructure like school buildings, college and university campuses may hinder educational opportunities, as would disruptions to services provided by critical public infrastructure like internet and telephone services. The education system, both formal and informal, also influences the work force's readiness to adapt to climate change, with broader learning systems for adaptation an emerging area for research and practice in Canada. There is also a lack of information on the impacts of a changing climate on work-life balance. In general (not just in Nova Scotia) the scholarship and literature on the future of work in a climate-disrupted world is weak compared to what exists for the low carbon transition.
- With respect to financial capital, much of the research and literature has focused on the impacts of climate change on primary industries and resource sectors (e.g., agriculture, forestry, fisheries and aquaculture), as they are directly climate sensitive. Within resource sectors, less information is available on the impacts of climate change on the province's mining sector, a historically important generator of financial capital. Mining in Nova Scotia generated $610.7 million in 2019 (value in chained 2012) (Government of Canada 2021). As one of the province's highly-valuable resource sectors and contributor to manufacturing, and construction, this stands out as an information gap.
- In the area of financial capital, we also noted limited information on the impacts of a changing climate in the most productive industries (as conventionally measured), including real estate, rental and leasing as well as information and cultural industries. Risks and opportunities from climate change to service-based and tourism-related small businesses are also underexplored in the literature despite the heightened importance of the small business sector for smaller towns.
- Equity-based impacts of climate change are poorly studied or understood in Nova Scotia and in Canada more broadly, although environmental or climate justice lenses are increasingly applied in adaptation discussions.[40] The importance of adopting intersectional approaches in climate change vulnerability and adaptation assessment is recognized but still under-applied. There is a paucity of data for Nova Scotia to facilitate intersectionality analysis. Particular gap areas include women, individuals living on low-income, individuals living with a dis/ability, recent immigrants, African Nova Scotian communities and LGBTQTS+ communities, and the intersections between at least two of these identities. Disparities in

[40]See recent case studies here: https://climatechoices.ca/publications/environmental-racism-and-climate-change/

access to health care services and in health outcomes resulting from the COVID-19 pandemic crisis can likely provide lessons applicable to responses to climate-related disasters. For example, Etowa et al. (2021) studied difficulties accessing non-emergency and emergency health services comparing white native-born to visible minority immigrants to Canada, showing that visible minority immigrants face unique struggles when it comes to emergency services and urgent care. Researchers used Statistics Canada's Crowdsourcing Data on the Impacts of COVID-19 on Canadians and applied a multiplicative approach to this intersectionality research. Intersectionality analysis is possibly most advanced in health research but there are challenges in bringing theory into quantitative methodology, even in this discipline (Bauer et al. 2021).

- Section 4 of this report discusses baseline inequities in access to capitals by different social groups in Nova Scotia and why they exist. However, this is a brief literature review. Deeper and systematic exploration of the more specific ways racialized, or marginalized individuals and communities currently experience wellbeing and vulnerability to climate hazards is critical to inform socially-just adaptation measures. Along these lines, gender issues are underexplored in the literature for Nova Scotia (and Canada in general), and the extent to which gender and climate change interact to put people of diverse identities at increased risk or vulnerability to impacts is unknown.

With respect to datasets to populate indicators for climate hazards, exposure, sensitivity, low coping capacity we observed instances where access to data was an issue and instances where the issue was availability. Below are a few key highlights:

- The lack of readily accessible Intensity-Duration-Frequency (IDF) projections at the scale we needed meant that we could not include storm hazards in our study. During the project we were unable to obtain access to the full gridded dataset of precipitation IDF projections, thus we lacked summaries at the level of census divisions. Further, the baseline period for modelled historical data of 1981-2010 was not available, only a 1979-2013 baseline was available. IDF projections remain an area of emerging research. A complete and rigorous study of IDF projections for Nova Scotia could include further attempts to obtain all gridded data from the IDF tool authors, including the historical modelled baseline and use of a 7% per degree increase in precipitation amounts, as discussed in Cannon et. al. (2020).
- Baseline and projection data for indicators of wind speed / pressures, wind-driven rain, and freezing precipitation were also unavailable for use in this study. These are significant hazards, and this study does not include them – nor could we include tropical cyclones as a consequence. Despite our exclusion of these hazards in this version of the WRI analysis, "freezing precipitation" and "wind (strong)" are built into the WRI model and, therefore, should the climate data needed to construct climate impact indicators become available, NC ECC could update the model.
- In gathering data to populate sub-indices we observed the following gaps in data availability, which limited our ability to represent climate exposure and sensitivity as accurately as possible at the desired scale of analysis (i.e., census division):
    - Data access and availability limited our ability to populate indicators for air quality. Key data gaps include average concentration of ground-level ozone (which can be population weighted) and % of year with Air Quality Health Index of 7 or higher;
    - Indicators relating to propensity for soil erosion;

- Indicators of observed water quality (as opposed to perceived water quality), like: % of sites rated good or excellent (or conversely, fair, marginal or poor) on the Canadian Council of Ministers of the Environment's Water Quality Index;
- Indicators for stormwater drainage (linear) infrastructure and indicators for drinking water supply (linear) infrastructure;
- Indicators for observed health outcomes (as opposed to perceived outcomes), like: Life expectancy at birth, Life expectancy at birth - gender disparities, Life expectancy at age 25 - education disparities, Life expectancy at age 25 - income disparities, Premature mortality, Premature mortality - gender disparities, Prevalence of obesity, Prevalence of daily smoking, Prevalence of chronic diseases and Prevalence of mood disorders;
- Indicators of observed crime (as opposed to perceived safety), like: Violent crimes, Non-violent crimes, Homicides, Incident-based crimes, Violent crimes and traffic violations causing bodily harm or death, Violent crimes and traffic violations causing bodily harm or death - gender disparities.

7.2 Study Limitations

Increasingly, jurisdictions in Canada and abroad are leading periodic climate change risk assessments to inform priority action and investments on adaptation. Our observation as systems scientists and adaptation practitioners is that these climate change risk assessments are typically high level and mainly sectoral, tend to ignore or not fully integrate non-climate factors that shape climate change vulnerability and fail to illuminate social disparities in the distribution of climate change risk along with their root causes. Steered by the goals and vision of the NS ECC, the WRI analysis undertaken for this project is an attempt to address some of the criticisms of climate change risk assessments. Nevertheless, our study and approach have limitations related to scenarios, data inputs and mechanisms of climate impact:

Scenarios

- One limitation of our study is that Nova Scotian society, economy and nature base are static through to the end of the century. This means that exposure, sensitivity, and low coping capacity sub-indices do not vary over time, and we are essentially overlaying future climate conditions on today's Nova Scotia. Fit for purpose socioeconomic scenarios are needed to allow for the detailed evaluation of climate-related risk and vulnerability. These socioeconomic scenarios should allow for growth (positive or negative) across all sub-pillars and pillars in the wellbeing at risk index (WRI). In the absence of these socioeconomic scenarios, the current analytical framework is limited to one sub-index (climate hazard exposure) changing with time. Integrating customized socioeconomic scenarios into the WRI framework would equip users to test development pathways that either increased or decreased resilience (decrease or increase risk). At a minimum, scenario analysis should explore how different growth rates for different sub-pillars influence outcomes. Desirable scenarios could then be identified, and strategies formulated to achieve them, which may involve developing coping and adaptive capacity, and building human and social capital. Expert views on the value of including socioeconomic scenarios in climate change assessment vary. On the other hand, including socioeconomic scenarios adds uncertainty to the analysis, as predicting variables such income levels, property values, economic growth, population growth out 80 years can seem like “science fiction”. As well, even if reliable socioeconomic scenario outputs are available, they are generally available at the national level, which means intricate assumptions need to be made to downscale them to the grid level or, in this case, the census division. Although including socioeconomic scenarios (population, economic growth, etc.) adds a layer of uncertainty to the analysis, conceptually it is the right thing to do since we recognize that vulnerability to climate change is function of exposure, sensitivity to climate hazards and coping / adaptive capacity, and these relationships are dynamic across time.

Data inputs

- Sea-level rise and coastal flooding indicators could be improved. Ideally, developing a relative sea-level rise exposure score for each census division (CD) would be done using province-wide 2-dimensional (2D) storm surge flood mapping for different sea-level rise scenarios, overlaying building/structure maps on the flood maps, and calculating the area, number, or density of buildings exposed using map algebra. Since no province-wide 2D storm surge flood mapping was available for Nova Scotia at the time we were undertaking the work, we devised a method using a 10m elevation zone above sea level as our “exposure zone”, calculating the area of buildings/structures inside that zone, and combining these results into a relative index with the Geological Survey of Canada’s Coastal Sensitivity Index (CSI) to capture the variation in coastal sensitivity within each census division.

Mechanisms of climate impact

- Within the WRI model, the interaction between climate change and affected wellbeing capitals is hardwired through the formulation of “hazard-specific impact statements”, as outlined in section 5.4.2 in this report. Formulation of these impact statements involved desk-based research and application of the consulting team’s expert judgement. In doing so we have made numerous choices about the mechanisms of climate impact and, even if all these choices are correct, there may be criticisms if users of the analysis perceive our approach as lacking transparency and traceability, or if the consulting team’s knowledge of mechanisms of climate impact is not fully transferable to Nova Scotia’s context. Therefore, future improvements to the WRI analysis should include a step to bring together knowledge holders to validate and adjust the hazard-specific impacts statements through a robust participatory process. The WRI model has the flexibility to toggle indicators on and off and can, therefore, accommodate any material adjustments to these impact statements identified through such a participatory process.
- Section 6.3 of this report illustrates the importance of considering compounding and cascading effects of climate change in informing adaptation choices. These indirect and interacting impacts of climate change defy quantitative and semi-quantitative risk assessments of the scope typically desired at the national or provincial level (e.g., breadth of climate hazards included). The WRI model developed for this project allows for exploration of the implications to wellbeing from interacting climate impacts. Our focus was to provide an example of how this could be done and what the outputs could look like. Further scenarios of compounding and cascading impacts should be explored and discussed, as part of adaptation planning processes.

8 Conclusions and Recommendations on Priorities

The following conclusions emerge from our analysis:

Pluvial flooding, fluvial flooding, wildfire, and extreme heat (agriculture) are the climate hazards of greatest concern for the end of the century. Our analysis shows that Nova Scotia will confront a range of climate impacts between now and the end of the century. Climate impacts likely to cause increasingly adverse impacts are much more numerous than impacts with potential benefits or opportunities. Pluvial flooding, fluvial flooding, wildfire, and extreme heat (agriculture) are the climate hazards of greatest concern in terms of their potential to negatively affect wellbeing because of climate change. Heating demand (decreased) and (lengthened) growing season are the climate-related impacts with the potential to bring the largest benefits to wellbeing because of climate change. Underlying drivers of relative risks and opportunities are highly variable. For example, for pluvial flooding, wellbeing dimensions that most drive results include exposed agricultural land (natural capital), sensitive wetlands (natural capital) and social support & sense of belonging as part of low coping capacity (social capital).

Results show a need for an adaptive approach to climate change adaptation since the nature of the threats and opportunities shifts over time and global greenhouse gas emissions pathways. Climate impacts likely to cause increasingly adverse impacts (i.e., wellbeing deteriorating) under RCP8.5 are pluvial and fluvial flooding by 2030s. By the 2050s, fluvial flooding remains a high priority climate hazard, but pluvial flooding is less of a concern and wildfire becomes the climate hazard of greatest concern due to a marked increase in fire weather and low coping capacity across the province to address this hazard. By 2080s temperature-related hazards have the most potential to negatively affect wellbeing in relative terms; these hazards include extreme heat (for agriculture, transportation infrastructure, ecosystems) and increased cooling demand. In a scenario of lower global GHG concentrations in the atmosphere, the relative importance of climate hazards that negatively affect wellbeing differ from those under RCP8.5. Under RCP4.5 pluvial and fluvial flooding have more prominence through to the 2080s as drivers of adverse climate change effects on wellbeing than is the case under RCP8.5. As well, under RCP4.5, sea-level rise and coastal flooding become more consequential in the 2080s relative to other climate hazards, a pattern that does not show up under RCP8.5. Because of the shifting nature of risk profiles, building capacity and preparedness for an adaptive and “all hazards” approach will become increasingly relevant in a climate-disrupted world.

Some regions in Nova Scotia have a substantial need for adaptation to address impacts experienced now and in the near-term. Our analysis identifies a subset of census divisions (CDs) that merit particular attention because of their consistently high ranking of WRI scores when summed across time periods and climate impacts. Under RCP 8.5 Halifax, Cumberland, Cape Breton, and Colchester are among the top five CDs for both positive impact types (decreasing-adverse & increasing-beneficial); Halifax, Cumberland, and Pictou are among the top five CDs for both negative impact types (increasing-adverse & decreasing beneficial). These CDs are the regions most affected by climate impacts should they occur today, reflecting a need for adaptation, both in terms of moderating harm and taking advantage of opportunities. Determinants of exposure, sensitivity, and low coping capacity contributing to the current adaptation shed light on priorities to reduce current and future risks to wellbeing. For example, because of Halifax's size and relative concentration of people and assets, exposure of residents (human capital) and housing (manufactured capital) in that census division are among the wellbeing dimensions that significantly drive results across climate impact types. This study provides detailed results at the CD level on underlying elements of wellbeing that may be most influential in determining relative risks from climate change.

The impacts of climate change on wellbeing will fall disproportionately on individuals and communities with historic and ongoing disadvantages. Nova Scotians' experience with and response to a changing climate depends on their social context. Forces like colonialism, racism, sexism, ageism, poverty, intergenerational trauma, and others, shape how impacts from climate change are felt from person to person, and community to community; they will also shape people's ability to successfully adapt to a changing climate. The study briefly reviews baseline inequities in access to capitals by different social groups and why they exist, as a point of departure to understand root causes of climate change vulnerability and risk. Distributional analysis further explores i) the prevalence of Black, female, and older Nova Scotians as well as Mi'kmaq across CDs most affected by climate-related impacts, ii) how the vulnerability (sensitivity and coping capacity) to the two most consequential climate-related impacts varies across the groups of interest, and iii) how existing inequalities and disparities shape wellbeing outcomes by looking at results of a generalized Low Coping Capacity Sub-Index. Results of this analysis complemented by literature reviews suggest that the dependence of Indigenous individuals on fishing, hunting, and trapping for wages, subsistence and tradition confers sensitivity to climate-related disruptions to these activities. Additionally, women and Black Nova have a lower diversity of employment sources when compared with the total labour force for the province, rendering these groups more sensitive to climate-related damage or disruption to work that may disproportionately impact one or more sectors of the economy. General coping capacity of Black, female, older and individuals self-identifying as Indigenous is lower than that for Nova Scotia's overall population, meaning these groups may have less capacity to deal with adverse consequences of climate hazards and take advantage of any benefits from climate change impacts at present. **Deeper and systematic exploration of the more specific ways racialized and marginalized individuals and communities currently experience wellbeing and vulnerability to climate hazards is critical to inform socially-just adaptation measures.**

Several opportunities exist to prepare Nova Scotians for the impacts of climate change and protect or enhance wellbeing, including broadly-based actions to continuously enhance coping and adaptive capacity. Understanding the nature of climate change vulnerability and risk and the relative consequences of these risks clarifies priorities for adaptation and informs which strategies to adopt. Table 8-1 lists the 19 climate impact drivers explored as part of this study, differentiating between their potential to cause adverse or beneficial outcomes for wellbeing and whether these are expected to increase or decrease over time. Several high-level strategies exist to manage risk, including preventing risk, mitigating, or lessening the consequences of the threat and investing in capturing benefits. Table 8-1 maps these strategies to climate impact drivers, which can support provincial adaptation efforts that are sectoral or hazard focused. Another approach to climate preparedness is to support broad-based improvement in coping and adaptive capacity. In undertaking sensitivity analysis with the WRI modelling framework, we identified a range of action areas with the potential to improve coping capacity by removing disparities in levels of wellbeing across the province in all but the census divisions with most existing coping capacity. **According to our analysis, enhancing**

belief in government, work-life balance, personal safety and security, incomes and income equality, educational outcomes and quality, and housing affordability would help position Nova Scotians to better cope with today's climate-related impacts and future climate impacts.

Table 8-1. Summary of types of responses to climate impact drivers according to WRI analysis in this study.

<table>
<tr><th>Climate Impact-Drivers</th><th>Impact category</th><th>Type of impact</th><th>Type of response</th></tr>
<tr><td>Drought</td><td>Water shortage for humans and ecosystems</td><td>Increasing adverse</td><td rowspan="14">Avoid risk by changing land use, siting decisions, timing of activities, and practices.

Mitigate risk (i.e., actions to prepare for and lessen the effects of threats), including all efforts to improve adaptive capacity, lessen sensitivity, and lessen exposure.</td></tr>
<tr><td>Extreme Rainfall Event</td><td>Pluvial flooding</td><td>Increasing adverse</td></tr>
<tr><td>Extreme Rainfall Event</td><td>Fluvial flooding</td><td>Increasing adverse</td></tr>
<tr><td>High temperatures</td><td>Agriculture</td><td>Increasing adverse</td></tr>
<tr><td>High temperatures</td><td>Ecosystems</td><td>Increasing adverse</td></tr>
<tr><td>High temperatures</td><td>Human health</td><td>Increasing adverse</td></tr>
<tr><td>High temperatures</td><td>Transport infrastructure</td><td>Increasing adverse</td></tr>
<tr><td>High temperatures</td><td>Cooling demand</td><td>Increasing adverse</td></tr>
<tr><td>Mean air temperatures, precipitation</td><td>Agriculture pests and diseases</td><td>Increasing adverse</td></tr>
<tr><td>Mean air temperatures, precipitation</td><td>Shifting ecoregions</td><td>Increasing adverse</td></tr>
<tr><td>Mean air temperatures, precipitation</td><td>Vector-borne diseases</td><td>Increasing adverse</td></tr>
<tr><td>Sea-level rise</td><td>Inundation, flooding, erosion</td><td>Increasing adverse</td></tr>
<tr><td>Fire weather</td><td>Wildfire</td><td>Increasing adverse</td></tr>
<tr><td>Low temperatures</td><td>Winter tourism & recreation</td><td>Decreasing beneficial</td></tr>
<tr><td>Heavy Snowfall</td><td>Snow loading</td><td>Decreasing adverse</td><td rowspan="3">Low priority risk mitigation</td></tr>
<tr><td>Low temperatures</td><td>Freeze-thaw cycles</td><td>Decreasing adverse</td></tr>
<tr><td>Low temperatures</td><td>Heating demand</td><td>Decreasing adverse</td></tr>
<tr><td>Mean air temperatures</td><td>Summer tourism & recreation</td><td>Increasing beneficial</td><td rowspan="2">Invest in capturing benefits</td></tr>
<tr><td>Mean air temperatures</td><td>Growing season</td><td>Increasing beneficial</td></tr>
</table>

Our literature review, WRI analysis and observations on information gaps suggests the following actions are worth pursuing. These suggestions are not exhaustive. Users of study results, particularly those with specific regional and system knowledge of the state of adaptation, will be able to identify additional opportunities for action.

<u>Continued Attention</u>

- The results of this study indicate that heat extremes, in combination with other climate impact drivers (e.g., pests and disease), will increasingly affect food production and the wellbeing of Nova Scotia. Although a lengthening growing season can offer benefits, a comprehensive, sectoral approach will better position Nova Scotia to take advantage of benefits while addressing risks. Continuation and expansion of ongoing efforts within the agricultural sector can support Nova Scotian farmers and other actors across the agri-food value chain to adapt to the changing climate.
- Sea-level rise, coastal inundation, and flooding from heavy rainfall are now and will continue to impact Nova Scotians, ecosystems and natural assets, as well as critical built

infrastructure (e.g., transportation). The results of this study indicate the need to continue efforts to better understand, manage, and reduce risk from flooding, sea-level rise, and coastal inundation. Consider additional investigation of the full range of adaptation options, including nature-based solutions to reduce risks from fluvial and pluvial flooding, along with efforts to improve adaptive capacity specific to these climate hazards.

Monitor

Future risk assessments can be used to identify changes to risks as conditions change. In addition, this study identified two areas to consider for ongoing monitoring now.

- Monitor the coping capacity in regions with higher estimates of coping capacity (e.g., Lunenburg, Hants, Kings) now and intervene to augment or further mobilize coping capacity should this decline over time. Safeguarding high levels of coping capacity is important to support effective responses to climate-related hazards.
- Monitor critical elements of the transport system in the province for their relative vulnerability to freeze / thaw cycles and heat stress. These climate hazards may become an important threat to the sector in the future, depending on the emissions pathways realized.

Explore Adaptation Options:

- Build capacity to adapt using an all-hazards approach, which considers a full scope of hazards in planning and in implementation. Improving the integration of disaster risk reduction and climate change adaptation is a goal increasingly embraced in Canada and abroad.[41] Our WRI analysis emphasized how climate-related hazards could shift in relative importance over time and contingent on emissions pathways realized. Therefore, it is important for the province to have the capacity to understand these interacting, time-variant hazards and corresponding shifts in risk profiles and to anticipate the kind of responses that might be needed. In staying vigilant on shifting hazards and risk profiles, paying particular attention to regions, groups, and individuals with high vulnerability (i.e., high sensitivity, low coping capacity) is important, even if exposure and anticipated climate impact is lower than other areas. Exposure to climate hazards can be easier to communicate and understand but risk lies at the nexus of climate impact, exposure, and vulnerability.
- Investigate adaptation options to take advantage of relative opportunities from extended summer recreation & tourism and to buffer impacts from less suitable conditions for winter recreation & tourism.
- Use asset-based approaches to enhance adaptive capacity for those with the potential to face disproportionate impacts and high vulnerabilities. For example, investigate potential gains in coping and adaptive capacity across the province from diversifying employment sources for females, Black and Indigenous peoples in Nova Scotia.
- Work with Halifax, Cumberland, Cape Breton, Colchester, Annapolis, Digby, and Pictou regions as sentinels of wellbeing impacts of climate change, paying particular attention to differentiated vulnerabilities and resilience to climate impact. For example, the potential exists for disproportionate impacts (adverse or beneficial) on Black and Black females in Halifax; older Nova Scotians in Cumberland, and older Nova Scotians, older females, Black Nova Scotians, and black females in Digby.

[41] See recent report by the Council of Canadian Academies: https://cca-reports.ca/reports/disaster-resilience/

- On a partnered basis, address key information gaps on unique aspects of the province's climate change vulnerability and potential for adaptation. Research areas include the resilience of federally-managed infrastructure, the interaction between climate change and social capital, opportunities from a changing climate and from early action to adapt, climate change and the education sector at different scales (e.g., system, institutions, workforce readiness, individual knowledge, and skills to adapt), and climate change risks and opportunities for the mining sector.

The following recommendations on priority issues serve to inform the province's climate change adaptation choices. We further recommend that equity and social justice form a cross-cutting theme for each:

1. Investigate natural capital resilience to climate hazards of high concern. In particular, the focus should be on two ecosystem types: i) wetlands and ii) forests. These ecosystems provide a range of services highly valued by Nova Scotians, yet often difficult to quantify and monetize, such as spiritual values through traditional cultural practices. Enhancing the climate resilience of wetlands and forests is also an adaptation approach with GHG mitigation co-benefits. For wetlands, relevant climate hazards include overland flooding, sea-level rise, and coastal flooding, and shifting ecosystems. For forest ecosystems, relevant climate hazards include inland flooding, heat stress, shifting ecosystems, and extended growing seasons. Investigations should take a socio-ecological approach to both environmental resilience and adaptive capacity and corresponding human resilience and adaptive capacity.
2. Investigate the climate resilience of Nova Scotia's housing / residential sector, particularly regarding flood risk, sea-level rise, wildfires, and extreme heat, with a special effort placed on Indigenous households and communities as initial analysis suggests that this group disproportionately lives in homes in need of major repairs. Exploration of the housing sector is also an opportunity to advance adaptation, low carbon development and wellbeing goals together.
3. Investigate the climate resilience of Nova Scotia's healthcare system, particularly regarding physical and mental health risks from flooding, extreme heat, and wildfires, as well as capacity to manage compounding hazards. Leverage recent and ongoing experience and lessons learned managing the COVID-19 pandemic.

9 References

Alexander, I., Barber-Dueck, C., Provenzano, M., Wang, J. (2018). Provincial and Territorial Natural Resource Indicators, 2009 to 2016. Available at: https://www150.statcan.gc.ca/n1/en/pub/13-604-m/13-604-m2018088-eng.pdf?st=lo6h-JBu. Accessed Feb 26, 2021.

American Psychological Association, Climate for Health & EcoAmerica. (2017). Mental health and our changing climate: Impacts, implications, and guidance. https://www.apa.org/news/press/releases/2017/03/mental-health-climate.pdf

Azetsu-Scott, K. (2019). "Ocean Acidification in Canadian Waters". In The Future of Ocean Governance and Capacity Development. Leiden, The Netherlands: Brill | Nijhoff. doi: https://doi.org/10.1163/9789004380271_038

Bauer, G. , Churchill, S., Mahendran, M., Walwyn, C., Lizotte, D., & Villa-Rueda, A. (2021). Intersectionality in quantitative research: A systematic review of its emergence and applications of theory and methods. SSM-population health, 100798.

BC Centre for Disease Control (BCCDC) (2018). Healthy Built Environment Linkages Toolkit: making the links between design, planning and health, Version 2.0. Vancouver, B.C. Provincial Health Services Authority, 2018. Requests for use can be emailed to pph@phsa.ca.

Beagan, B., Etowa, J., and Thomas Bernard, W. (2012). 'With God in our lives he gives us the strength to carry on': African Nova Scotian women, spirituality, and racism-related stress. Mental Health, Religion & Culture 15(2), 103-120.

Berger, E. and Hodgins, D. (2012). Policy brief no. 7-Age discrimination and paid work. Population Change and Lifecourse Strategic Knowledge Cluster Research/Policy Brief. 1(3), 1-4.

Bernier, N. , and K.Thompson. (2006), Predicting the frequency of storm surges and extreme sea levels in the northwest. Atlantic, Journal of Geophysical Research, 111, C10009, doi:10.1029/2005JC003168.

Bickerton, J. and Graham, G. (2020). Electoral parity or protecting minorities? Path dependency and consociational districting in Nova Scotia. Canadian political science review. 14(1), 32-54.

Biodiversity Panel of Expertise (2010). The Foundation for Environmental, Social and Economic Prosperity in Nova Scotia. Prepared in part for the Nova Scotia Natural Resources Strategy 2010 process. Available at: https://novascotia.ca/natr/strategy/pdf/phase2-reports/Biodiversity.pdf

Böhnke-Henrichs, A., Baulcomb, C., Koss, R., Hussain, S. S., & de Groot, R. S. (2013). Typology and indicators of ecosystem services for marine spatial planning and management. Journal of Environmental Management, 130(11), 135-145. doi:10.1016/j.jenvman.2013.08.027

Bowers, R. (2010). A Mi'kmaq First Nation cosmology: investigating the practice of contemporary Aboriginal Traditional Medicine in dialogue with counselling – toward an Indigenous therapeutics. Asia Pacific Journal of Counselling and Psychotherapy. 1(2), 111-124.

Boyd, R., Eyzaguirre, J., Poulsen, F., Siegle, M., Thompson, A., Yamamoto, S., Osornio-Vargas, Erickson, A., and Urcelay, A. (2020). Costing Climate Change Impacts on Human Health Across Canada. Prepared by ESSA Technologies Ltd. for the Canadian Institute for

Climate Choices. Available at: https://choixclimatiques.ca/wp-content/uploads/2021/06/ESSA-Technical-Report-March2021.pdf
Bundy, J. (2019). We'll deal with it later: African Nova Scotian women's perceptions and experiences of the police. Canadian Journal of Sociology. 44(4), 319-342.
Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON. 444 p.
Byrnes, M. (2013). Climate justice, Hurricane Katrina, and African American environmentalism. Journal of African American Studies, 18(3), 305-314.
Canada Energy Regulator [online], (n.d.). Provincial and Territorial Energy Profiles – Nova Scotia. Available at: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-nova-scotia.html. Accessed Dec 20, 2020.
Canadian Human Rights Commission. (2017). [online] Left out: Challenges faced by persons with disabilities in Canada's schools. https://www.chrc-cdp.gc.ca/sites/default/files/challenges_disabilities_schools_eng.pdf
Canadian Index of Wellbeing (2018). Nova Scotia Quality of Life Index: 1994-2014. Prepared for Engage Nova Scotia. 68 pp.
Canadian Institute for Climate Choices [CICC] (2020). Tip of the Iceberg: Navigating the Known and Unknown Costs of Climate Change For Canada. December 2020. Available at: https://climatechoices.ca/reports/tip-of-the-iceberg/.
Canadian Institute for Climate Choices [CICC] (2021). The Health Costs of Climate Change: How Canada can Adapt, Prepare and Save Lives. https://climatechoices.ca/wp-content/uploads/2021/06/ClimateChoices_Health-report_Final_June2021.pdf
Canadian Water Network (2020). Flood Risk Management in the Era of Climate Change – A Case Study of Halifax, Nova Scotia. Prepared by Thistlethwaite, J. Available at: https://cwn-rce.ca/wp-content/uploads/CWN-EN-Thistlethwaite-FloodRiskMgmt-2020-Web.pdf.
Cannon, A. , Jeong, D., Zhang, X., & Zwiers, F. (2020). Climate-resilient buildings and core public infrastructure: An assessment of the impact of climate change on climatic design data in Canada. Government of Canada, Ottawa, ON, Canada.
Casey, R. (2015). Disability and unmet health care needs in Canada: a longitudinal analysis. Disability and Health Journal. 8(2), 173-181.
Carroll, B., Morbey, H., Balogh, R., and Araoz, G. (2009). Flooded homes, broken bonds, the meaning of home, psychological processes and their impact on psychological health in a disaster. Health and Place, 15(2): 540-547.
CBC (2021) [online]. How Nova Scotia coastal communities are planning for climate change. Published Feb 10, 2021. Available at: https://www.cbc.ca/news/canada/nova-scotia/coastal-communities-climate-change-plans-halifax-mahone-bay-1.5906194. Accessed March 3, 2021.
CBC News (2018) [online]. Floodwaters may have contaminated much of this season's fiddleheads. Retrieved March 2020, from https://www.cbc.ca/news/canada/new-brunswick/nb-flood-fiddleheads-unsafe-contaminated-1.4656021
CBCL Limited. (2009). The 2009 State of Nova Scotia's Coast—Technical Report.
Chai, C-L., Ueland, K., and Phiri, T. (2018). The use of human capital and limitations of social capital in advancing economic security among immigrant women living in central Alberta, Canada. Social Sciences. 7(11), 220 (25 p.) doi:10.3390/socsci7110220

Chakraborty, L., Thistlethwaite, J., Minano, A., Henstra, D., & Scott, D. (2021). Leveraging Hazard, Exposure, and Social Vulnerability Data to Assess Flood Risk to Indigenous Communities in Canada. International Journal of Disaster Risk Science, 1-18.

Cherng, S. T., Cangemi, I., Trostle, J. A., Remais, J. V., & Eisenberg, J. N. (2019). Social cohesion and passive adaptation in relation to climate change and disease. Global Environmental Change, 58, 101960.

Chmura, G.L., and van Ardenne, L. B. (2019). The Bay of Fundy Blue Carbon Story - Storymaps. McGill University Department of Geography. Available at: https://www.arcgis.com/apps/MapJournal/index.html?appid=dfa52f8f91754c24804b6d63e782fb7f.

Choi, H., (2019) Assessment of Aggregation Frameworks for Composite Indicators in Measuring Flood Vulnerability to Climate Change. Scientific Reports: Nature Research, 9, 19371.

Clayton, S., Manning, C. M., Krygsman, K., and Speiser, M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.: American Psychological Association, and ecoAmerica.

ClimAction Services (2017). Climate Observations and Projections in Support of Risk Assessment for Protected Areas across Nova Scotia. ClimAction Services (Halifax) under contract. February 15, 2017.

Cloutier, C., Locat, J., Geertsema, M., Jakob, M., & Schnorbus, M. (2017). Potential impacts of climate change on landslides occurrence in Canada. (1st ed., pp. 71-104). CRC Press. https://doi.org/10.1201/9781315387789-3

Cochran, M., Manuel, P., Rapaport, E. (2012). Yarmouth: A Case Study in Climate Change Adaptation: Part 2 – Section 5: Social Vulnerability to Climate Change in Yarmouth, Nova Scotia. School of Planning, Dalhousie University, Halifax, Nova Scotia. 142 pp. Available at: https://atlanticadaptation.ca/en/islandora/object/acasa%3A611

Cohen, S., Bush, E., Zhang, X., Gillett, N., …& Watson, E. (2019) Synthesis of Findings for Canada's Regions; Chapter 8 in Canada's Changing Climate Report, (ed.) E. Bush and D.S. Lemmen; Government of Canada, Ottawa, Ontario, p. 424–443.

Colpitts, E., & Gahagan, J. (2016). "I feel like I am surviving the health care system": understanding LGBTQ health in Nova Scotia, Canada. BMC Public Health, 16(1), 1-12.

Conference Board of Canada. (n.d.) [online] Racial Wage Gap. https://www.conferenceboard.ca/hcp/provincial/society/racial-gap.aspx. Retrieved: December 23, 2021

Conger, T. (2018). Coastal green infrastructure as a sea level rise adaptation measure: assessing environmental, local, and institutional contexts (T). University of British Columbia. Retrieved from https://open.library.ubc.ca/collections/ubctheses/24/items/1.0375779

Cox, A. (2021). The educational opportunity gap: A comparison of reading ability and component literacy skills between African Nova Scotian students and their peers. Diss. Mount Saint Vincent University.

Crawford, C. (2013). Looking into poverty: Income sources of poor people with disabilities in Canada. Toronto: Institute for Research and Development on Inclusion and Society (IRIS) and Council of Canadians with Disabilities. 88 p.

Creese, G. and Wiebe, B. (2012). 'Survival employment': Gender and deskilling among African immigrants in Canada. International Migration. 50(5), 56-76.

Cullen, D., Castleden, H., and Wien, F. (2021). The Historical Roots of Social Assistance: An Inadequate Response to the Colonial Destruction of Mi'kmaw Livelihood in Nova Scotia. The International Indigenous Policy Journal. 12(3), 1-22.

Cutter, S. , Barnes, L., Berry, M., Burton, C., …& Webb, J. (2008). A Place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18, 598-606. DOI: 10.1016/j.gloenvcha.2008.07.013

Cutter, S., Boruff, B., and Shirley, W. (2003). Social vulnerability to environmental hazards. Social science quarterly, 84(2), 242-261. DOI: 10.1111/1540-6237.8402002

Cutter, S., Emrich, C., Webb, J., and Morath, D.. (2009) Social Vulnerability to Climate Variability Hazards: A Review of the Literature. Final Report to Oxfam America, Department of Geography, University of South Carolina, Columbia, S.C.

Daigle, R. (2020). Updated Sea-Level Rise and Flooding Estimates for New Brunswick Coastal Sections 2020 – Based on IPCC 5th Assessment Report. January 2020. Available at: https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Flooding-Inondations/SeaLevelRiseAndFloodingEstimates2020.pdf

Davenport, J., Rathwell, T. A., & Rosenberg, M. (2009). Aging in atlantic Canada: service-rich and service-poor communities. *Healthcare policy = Politiques de sante*, *5*(1), e145–e160.

Davidson, A. (2015). Social determinants of health: A comparative approach. Toronto: Oxford.

De Groeve, T., Poljansek, K. and Vernaccini, L. (2014) Index for Risk Management – InforRM: Concept and Methodology. Version 2014. EUR 26528 EN, Institute for the Protection and the Security of the Citizen, European Commission-JRC: IT, 67 p.

Department of Fisheries and Oceans Canada (DFO) (2009). Economic Impact of Marine Related Activities in Canada. Gardner Pinfold Statistical and Economic Analysis Series. Publication. No.1-1 125 p.

Department of Fisheries and Oceans Canada (DFO) (2018a). Canada's Oceans Now: Atlantic Ecosystems 2018. Fisheries and Oceans Canada. Available at: https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2018/atlantic-ecosystems-ecosystemes-atlantiques/index-eng.html. 47 pp.

Department of Fisheries and Oceans Canada (DFO) (2018b). Zonal Interchange File [database]. Ottawa. Available at: https://www.dfo-mpo.gc.ca/stats/commercial/land-debarq/sea-maritimes/s2018pq-eng.htm

Department of Fisheries and Oceans Canada (DFO) (2018c). 2018 Atlantic & Pacific coasts commercial landings by province. Available at: https://www.dfo-mpo.gc.ca/stats/commercial/land-debarq/sea-maritimes/s2018pq-eng.htm

Derksen, C., Burgess, D., Duguay, C., Howell, S., …& Kirchmeier-Young, M. (2019) Changes in snow, ice, and permafrost across Canada; Chapter 5 in Canada's Changing Climate Report, (ed.) E. Bush and D.S. Lemmen; Government of Canada, Ottawa, Ontario, p.194–260.

Devanney, M. (2010). Profile of agricultural land resources in Nova Scotia. Nova Scotia Department of Agriculture. https://novascotia.ca/agri/documents/business-research/AL1000%20Nova%20Scotia.pdf

Didkowsky, N. (2016). A substantive theory of youth resilience in rural Nova Scotia. Diss. Dalhousie University.

Dietz, S. and Arnold, S. (2021). Atlantic Provinces; Chapter 1 in Canada in a Changing Climate: Regional Perspectives Report, (ed.) F.J. Warren, N. Lulham and D.S. Lemmen; Government of Canada, Ottawa, Ontario. https://www.nrcan.gc.ca/sites/nrcan/files/earthsciences/Atlantic%20Provinces%20Chapter%20-%20Regional%20Perspectives%20Report.pdf

Dhunna, S. and Tarasuk, V. (2021). Black–white racial disparities in household food insecurity from 2005 to 2014, Canada. Canadian Journal of Public Health. 112, 888-902.

Djoudi, H., Locatelli, B., Vaast, C., Asher, K., Brockhaus, M., & Sijapati, B. B. (2016). Beyond dichotomies: Gender and intersecting inequalities in climate change studies. Ambio, 45(3), 248-262.

Dlamini, S.N, Kwakyewah, C., and Hardware, S. (2019). Youth perspectives on community activism: From the personal to the political. Tikkun beyond borders. Ontario: University of Windsor.

Dunham, R. (2017). A Cultural Legacy under Threat: Managing Eroding Coastal Heritage at the Fortress of Louisbourg National Historic Site, Ocean Yearbook Online, 31(1), 27-54. doi: https://doi.org/10.1163/22116001-03101003

Easterbrook, A., Bulk, L., Jarus, T., Hahn, B….& Parhar, G.f (2019). University gatekeepers' use of the rhetoric of citizenship to relegate the status of students with disabilities in Canada. Disability & Society. 34(1), 1-23.

Edwards, P. (2012). Elder abuse in Canada: A gender-based analysis. Public Health Agency of Canada, Division of Aging and Seniors. https://publications.gc.ca/collections/collection_2012/aspc-phac/HP10-21-2012-eng.pdf.

Endresz, K. (2020). Understanding the ecological linkages between salt marsh ecosystems and nearshore fisheries. Dalhousie University. Available at: https://dalspace.library.dal.ca/handle/10222/80262

Environment and Climate Change Canada (ECCC) (2010). Flooding events in Canada: Atlantic Provinces [website]. https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/floods/events-atlantic-provinces.html

Environment and Climate Change Canada (ECCC) (2020). Climate Science 2050: Advancing Science Knowledge on Climate Change. p. 66. Available at: http://publications.gc.ca/site/eng/9.892783/publication.html

Equal Measures 2030 (2018). Data Driving Change: Introducing the EM2030 SDG Gender Index. Equal Measures 2030, Woking, Surrey, UK., 107 p.

Eriksen, C., Simon, G. L., Roth, F., Lakhina, S. J., Wisner, B., Adler, C., ... & Prior, T. (2020). Rethinking the interplay between affluence and vulnerability to aid climate change adaptive capacity. Climatic Change, 162(1), 25-39.

Etowa, J., Beagan, B., Eghan, F., and Thomas Bernard, W. (2017). 'You feel you have to be made of steel': The strong Black woman, health, and well-being in Nova Scotia. Health Care for Women International. 38(4), 379-393.

Etowa, J., Sano, Y., Hyman, I., Dabone, C., Mbagwu, I., Ghose, B., ... & Mohamoud, H. (2021). Difficulties accessing health care services during the COVID-19 pandemic in Canada: examining the intersectionality between immigrant status and visible minority status. International Journal for Equity in Health, 20(1), 1-11.

Expert Panel on Climate Change Adaptation and Resilience Results.(2018). Measuring Progress on Adaptation and Climate Resilience: Recommendations to the Government of Canada. Environment and Climate Change Canada, Ottawa.

Ferguson, H., Bovaird, S., and Mueller, M. (2007). The impact of poverty on educational outcomes for children. Paediatrics & Child Health. 12(8), 701–706.

First Nations Health Authority (2014). Traditional Wellness Strategic Framework. Available at: https://www.fnha.ca/WellnessSite/WellnessDocuments/FNHA_TraditionalWellnessStrategicFramework.pdf 54 pp.

Frank, L. (2018). 'Hungry for an Education': Prevalence and Outcomes of Food Insecurity Among Students at a Primarily Undergraduate University in Rural Nova Scotia. Canadian Journal of Higher Education/Revue canadienne d'enseignement supérieur. 48(2), 109-129.

Frank, L., and Fischer, L. (2019). 2019 Report Card on Child and Family Poverty in Nova Scotia: Three decades lost. Canadian Centre for Policy Alternatives. Available at: https://www.policyalternatives.ca/publications/reports/2019-report-card-child-and-family-poverty-nova-scotia

Frank, L., Fisher, L. and Saulnier, C. (2020). 2020 Report Card on Child and Family Poverty in Nova Scotia Willful Neglect? Developed for The Canadian Centre for Policy Alternatives - Nova Scotia, December 2020. Available at: https://www.policyalternatives.ca/publications/reports/2020-report-card-child-and-family-poverty-nova-scotia

Frank, L., Fisher, L., and Saulnier, C. (2021). 2021 Report Card on Child and Family Poverty in Nova Scotia. Developed for The Canadian Centre for Policy Alternatives - Nova Scotia, November 2021. Available at: https://policyalternatives.ca/publications/reports/2021-report-card-child-and-family-poverty-nova-scotia.

Fuentes-Yaco, C., King, M., and Li, W.K.W. (2015). Mapping areas of high phytoplankton biomass in the offshore component of the Scotian Shelf Bioregion: A remotely-sensed approach. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/036. iv + 40 p.

Gaard, G. (2015). Ecofeminism and climate change. Women's Studies International Forum, 49, 20-33.

Gagnon, M., Gaudrealt, V., and Overton, D. (2008). Analysis Brief: Age of Public Infrastructure: A Provincial Perspective. Prepared for Statistics Canada. 27 pp.

Garbary, D., and Hill, N. (2021). Climate Change in Nova Scotia: Temperature Increases from 1961 to 2020. Proceedings of the Nova Scotian Institute of Science (NSIS). January 2021. Available at: https://www.researchgate.net/publication/354544664_CLIMATE_CHANGE_IN_NOVA_SCOTIA_TEMPERATURE_INCREASES_FROM_1961_TO_2020

Gearhart, S., Perez-Patron, M., Hammond, T., Goldberg, D., Klein, A. & Horney,J. (2018). The Impact of Natural Disasters on Domestic Violence: An Analysis of Reports of Simple Assault in Florida (1999-2007). Violence and Gender. 5(2): 87–92. https://doi.org/10.1089/vio.2017.0077

Getty, G. (2013). An Indigenist Perspective on the Health/Wellbeing and Masculinities of Mi'kmaq men. Diss. Dalhousie University Halifax.

Gibson, B. and Mykitiuk, R. (2012). Health care access and support for disabled women in Canada: falling short of the UN Convention on the Rights of Persons with Disabilities: a qualitative study. Women's health Issues. 22(1), e111-e118.

Gilmour, H. (2012). [online] Social participation and the health and well-being of Canadian seniors. Health Reports, Statistics Canada Catalogue: 82-003-XPE. 23(4), 23-32.

Giorgi, F. & Francisco, R. (2000). Evaluating uncertainties in the prediction of regional climate change. Geophysical Research Letters, 27(9), 1295-1298, doi:10.1029/1999GL011016.

Goddard, P., Yin, J., Griffies, S., and Zhang, S. (2015). An extreme event of sea-level rise along the Northeast coast of North America in 2009–2010. Nat Commun 6, 6346 (2015). https://doi.org/10.1038/ncomms7346

Government of Alberta (2019). Wellbeing and Resiliency: A Framework for Supporting Safe and Healthy Children and Families. Prepared by the Government of Alberta, as represented by the Minister of Children's Services. Available at: https://open.alberta.ca/publications/9781460141939 38 pp.

Government of Canada (2001). Inclusion for all: A Canadian Roadmap to Social Cohesion - Insights from Structured Conversations. Report prepared for the Department of Justice

Canada, by Steven Bittle. 37 pp. Available at: https://www.justice.gc.ca/eng/rp-pr/csj-sjc/jsp-sjp/tr01-rt01/index.html

Government of Canada (2017). Science Narrative – Climate Change Impacts on the Health of Canadians: Protecting and Empowering Canadians to Improve Their Health. Available at: http://publications.gc.ca/site/archivee-archived.html?url=http://publications.gc.ca/collections/collection_2017/aspc-phac/HP5-122-2017-eng.pdf 36 pp.

Government of Canada (2020). Key Small Business Statistics – 2020. Available at: https://www.ic.gc.ca/eic/site/061.nsf/eng/h_03126.html#3.1. Accessed Dec 21, 2021.

Government of Canada (2021) [online]. Gross domestic product - Canadian Industry Statistics. Available at: https://www.ic.gc.ca/app/scr/app/cis/gdp-pid/21. Accessed Dec 21, 2021.

Government of Canada. (n.d.) [online] Rights of people with disabilities. https://www.canada.ca/en/canadian-heritage/services/rights-people-disabilities.html Retrieved: Dec 21, 2021

Government of Nova Scotia (2013). Our Parks and Protected Areas – A Plan for Nova Scotia. Available at: https://novascotia.ca/parksandprotectedareas/pdf/Parks-Protected-Plan.pdf.

Government of Nova Scotia (2014) [online]. The Military in Nova Scotia – Key Facts. Available at: https://novascotia.ca/iga/milrelkey.asp. Accessed on Feb 26, 2021.

Government of Nova Scotia (2016). Consolidated Canadian Classification of Functions of Government, 2014. Available at: https://www.novascotia.ca/finance/statistics/news.asp?id=11716. Accessed Dec 21, 2021.

Government of Nova Scotia (2017a). Mental health adult community-based services: Health care wait times. Halifax, NS. Available at: https://waittimes.novascotia.ca/procedure/mental-health-adult-community-based-services

Government of Nova Scotia (2017b). State of the Forest 2016. Prepared by the Nova Scotia Department of Natural Resources Renewable Resources Branch. Available at: https://novascotia.ca/natr/forestry/reports/State_of_the_Forest_2016.pdf. 90 pp.

Government of Nova Scotia (2018a). Province Adopts New Heat Alert System. Published June 29, 2018. Available at : https://novascotia.ca/news/release/?id=20180629001

Government of Nova Scotia (2018b). Five Year Highway Improvement Plan 2019-2020 Edition. Available at: https://novascotia.ca/tran/highways/5yearplan/highways-5-year-plan-2019-20.pdf. 30 pp.

Government of Nova Scotia (2019). Natural Resources Education Centre (NREC). Nova Scotia Lands and Forestry. Available at: https://novascotia.ca/natr/Education/NREC/. Accessed Sep 27, 2021.

Government of Nova Scotia (2020a). Budget 2020 to 2021. Published February 25, 2020. Available at: https://novascotia.ca/budget/ 72 pp.

Government of Nova Scotia [online] (2020b). Nova Scotia Annual Population Estimates as of July 1, 2020. Developed by the Nova Scotia Finance and Treasury Board, September 2020. Available at: https://novascotia.ca/finance/statistics/news.asp?id=16179#:~:text=As%20of%20July%201%2C%202020%2C%20Nova%20Scotia's%20population%20is%20estimated,as%20'annual'%20population%20estimates.

Government of Nova Scotia [online] (2020c). Finance and Treasury Board - Tourism Employment 2018. Available at: https://novascotia.ca/finance/statistics/news.asp?id=15880. Accessed Feb 24th, 2021.

Government of Nova Scotia (2020d) [online]. Indicators of Prosperity. Finance and Treasury Board. Updated September 2020. Available at: https://novascotia.ca/finance/statistics/topic.asp?fto=24x. Accessed March 10, 2021.

Government of Nova Scotia (2020e). Export Opportunities for Nova Scotia's Forestry Sector Market Intelligence Summary - Fall 2020. Available at: https://novascotia.ca/forestry-sector-support/docs/Forestry%20Export%20Opportunities%202020.pdf. Accessed March 10th, 2021.

Government of Nova Scotia (2020f) [online]. Nova Scotia Hospitals. Available at: https://novascotia.ca/dhw/about/hospitals.asp. Accessed on Feb 26, 2021.

Government of Nova Scotia (2021). Survey Of Financial Security, 2019. Available at: https://novascotia.ca/finance/statistics/news.asp?id=16442.

Government of Nova Scotia (n.d. a) [online]. Climate Impacts. Available at: https://climatechange.novascotia.ca/climate-impacts. Accessed on Feb 26, 2021.

Government of Nova Scotia (n.d. b) [online]. Our Acadian Culture. Available at: https://www.novascotia.com/trip-ideas/stories/our-acadian-culture. Accessed March 10th, 2021.

Government of Nova Scotia (n.d. c) [online]. Species at Risk Overview - NS Endangered Species Act: Legally Listed Species. Available at: https://novascotia.ca/natr/wildlife/biodiversity/species-list.asp

Greco, S., Ishizaka, A., Tasiour, M., Torrisi, G. (2019). On the Methodological Framework of Composite Indices: A Review of the Issues of Weighting, Aggregation and Robustness. Social Indicators Research, 141, 61-94.

Green, H. (2021). Environmental Racism and Violence in Rural Nova Scotia. Environmental History.

Greenan, B., Shackell, N.., Ferguson, K., Greyson, P., …. & Saba, V. (2019b). Climate change vulnerability of American lobster fishing communities in Atlantic Canada. Frontiers in Marine Scienc. https://doi.org/10.3389/fmars.2019.00579

Greenan, B., Cogswell, A., Greyson, P., Jean, D., …& Fan, W. (2018). Small Craft Harbours Coastal Infrastructure Vulnerability Index Pilot Project. Canadian Technical Report of Fisheries and Aquatic Sciences. 3245: xiv + 73 p.

Greenan, B., Zhai, L., Hunter, J., James, T. S., & Han, G. (2015). Estimating sea-level allowances for atlantic canada under conditions of uncertain sea-level rise. Proceedings of the International Association of Hydrological Sciences, 365, 16-21. https://doi.org/10.5194/piahs-365-16-2015

Greenan, B., James, T., Loder, J., Pepin, P., …& Perrie, W. (2019a): Changes in oceans surrounding Canada; Chapter 7 in (eds.) Bush and Lemmen, Canada's Changing Climate Report; Government of Canada, Ottawa, Ontario, p. 343–423.

Gupta, R.P.-S., Wit, M., and McKeown, D. (2007). The impact of poverty on the current and future health status of children. Paediatrics & Child Health. 12(8), 667-672.

Haigh, R., Ianson, D., Holt, C., Neate, H., & Edwards, A.. (2015). Effects of ocean acidification on temperate coastal marine ecosystems and fisheries in the northeast pacific. *PloS One, 10*(2), e0117533-e0117533. https://doi.org/10.1371/journal.pone.0117533

Halifax Regional Municipality (2018). Building Poverty Solutions: Ideas for Action – A Community Report. Prepared by United Way Halifax. 62 pp.

Hamilton-Hinch, B., Harkins, M.J., and and Seselja, D. (2017). [online] Implementing culturally sensitive pedagogies. Proceedings of the Atlantic Universities' Teaching Showcase. 21, 99-114.

Hankivsky, O. (Ed.). (2012). An Intersectionality-Based Policy Analysis Framework.Vancouver, BC: Institute for Intersectionality Research and Policy, Simon Fraser University.

Harbison, J., Coughlan, S., Beaulieu, M., Karabanow, J., et. al. (2012). Understanding "elder abuse and neglect": A critique of assumptions underpinning responses to the mistreatment and neglect of older people. Journal of Elder Abuse & Neglect. 24(2), 88-103.

Health Canada (2015). First nations mental wellness continuum framework. Ottawa, Om: Government of Canada. 64 pp.

Heard, L. (2019). Nordic and American Social Capital and its Effects on Climate Change Adaptation.

Heritage Newfoundland and Laborador (2009). Precontact Mi'kmaq Land Use. Newfoundland and Labrador Heritage Web Site: https://www.heritage.nf.ca/articles/aboriginal/mikmaq-land-use.php Accessed Feb 10th, 2021

Ho, E., Clarke, A., and Dougherty, I. (2015). Youth-led social change: Topics, engagement types, organizational types, strategies, and impacts. Futures. 67, 52-62.

Howarth, L., Coughlin, M., Reid, G. (2021) Assessing climate change vulnerability of seafood industry-dependent communities in Nova Scotia: Informing adaptation. Centre for Marine Applied Research (CMAR), Dartmouth, Nova Scotia, Canada. 81 pages.

IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, M.L., Canziani, O.F., Palutikof, J.P., et al.(eds.)], Cambridge University Press, Cambridge, UK, 976 p.

IPCC (2014a) Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

IPCC (2014b) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 688 pp.

IPCC (2018): Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, et al. (eds.)]. In Press.

IPCC (2021) Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

IPCC. (2022). Summary for Policymakers [Pörtner, H.-O., Roberts, D.C., Poloczanska, E.S., Mintenbeck, K., Tignor, M., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A. (Eds.)]. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

James, T. , Canada, G. (2014). Canadian Publications From 2013, & Canada. Relative sea-level projections in Canada and the adjacent mainland united states. Natural Resources Canada.

James, T. , Robin, C., Henton, J. , & Craymer, M. (2021). Relative sea-level projections for Canada based on the IPCC Fifth Assessment Report and the NAD83v70VG national crustal velocity model. Geological Survey of Canada, Open File 8764, 1 .zip file. https://doi.org/10.4095/327878

Jean-Pierre, J. (2021). How African Nova Scotians envision culturally relevant and sustaining pedagogy as civic repair. British Journal of Sociology of Education. 1-19.

Jones, L., Norton, L., Austin, Z., Browne, A.L., …& Manley, W., (2016). Stocks and flows of natural and human-derived capital in ecosystem services. Land use policy, 52, pp.151-162.

Julian, A. and Denny, I. (2016). Kina'muanej Knjanjiji'naq mut ntakotmnew tli'lnu'ltik (In the Foreign Language, Let us Teach our Children not to be Ashamed of Being Mi'kmaq). Education. 22(1), 148-160.

Kaijser, A., & Kronsell, A. (2014). Climate change through the lens of intersectionality. Environmental politics, 23(3), 417-433.

Kalich, A., Heinemann, L., and Ghahari, S. (2016). A scoping review of immigrant experience of health care access barriers in Canada. Journal of Immigrant and Minority Health. 18(3), 97-709.

Karabanow, J., Aube, C., and Naylor, T. (2014). From place to space: Exploring youth migration and homelessness in rural Nova Scotia. Journal of Rural and Community Development. 9(2), np

Karim, F. (2019). How do second homes and coastal short-term rentals affect municipal planning and decision making in the context of climate change? Diss. Dalhousie University Halifax, Nova Scotia. 109 pp.

Kassam, A. (2017). Indigenous Canadians face a crisis as climate change eats away island home. The Guardian. Retrieved December 2020, from https://www.theguardian.com/world/2017/jan/18/canada-island-climate-change-sea-level-rise-lennox

Kim, I.-H., Carrasco, C., Muntaner, C., McKenzie, K., and Noh, S. (2013). Ethnicity and postmigration health trajectory in new immigrants to Canada. American Journal of Public Health. 103(4), e96-e104.

Kirilenko, A. P., & Sedjo, R. A. (2007). Climate change impacts on forestry. Proceedings of the National Academy of Sciences - PNAS, 104(50), 19697-19702. https://doi.org/10.1073/pnas.0701424104

Knutson, T. [online] (2021). Global Warming and Hurricanes. Geophysical Fluid Dynamics Laboratory (GFDL). Published August 9, 2021. Accessed August 16, 2021. https://www.gfdl.noaa.gov/global-warming-and-hurricanes/.

Kothari, M. (2009). Special Rapporteur on adequate housing as a component of the right to an adequate standard of living, and on the right to non-discrimination in this context: Mission to Canada. UN General Assembly, Human Rights Council. https://documents-dds-ny.un.org/doc/UNDOC/GEN/G09/115/02/PDF/G0911502.pdf?OpenElement

Kulp, S. A., & Strauss, B. H. (2019). New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. Nature Communications, 10(1), 4844-4844. https://doi.org/10.1038/s41467-019-12808-z

Lagacé, M, Charmarekeh, H., Laplante, J., and Tanguay, A. (2015). How ageism contributes to the second-level digital divide: The case of Canadian seniors. Journal of Technologies and Human Usability. 11(4), 1-13.

Lamond, J. E., Joseph, R.D., and Proverbs, J. (2015). An exploration of factors affecting the long term psychological impact and deterioration of mental health in flooded households. Environmental Research. 140: 3250334. DOI: 10.1016/j.envres.2015.04.008. Epub 2015 Apr 22

Larmer, J.R. (2018). The highway runs east: Poverty, policing, and the missing and murdered Indigenous women of Nova Scotia. Dalhousie Journal of Legal Studies. 27, 89-136.

Lauer, S., Wilkinson, L., Yan, M.C., Sin, R., and Tsang, A.K.T. (2012). Immigrant youth and employment: Lessons learned from the analysis of LSIC and 82 lived stories. Journal of International Migration and Integration. 13(1), 1-19.

Lavell, A., M. Oppenheimer, C. Diop, et al., 2012: Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, et al. (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 25-64.

Lefort, N., and Dennis, C. (2014). Malikewe'j: Understanding the Mi'kmaq Way. Prepared for the Mi'kmaq Environmental Learning Centre. 28 pp.

Lemmen, D.S., Warren, F.J., James, T.S. and Mercer Clarke, C.S.L. editors (2016): Canada's Marine Coasts in a Changing Climate; Government of Canada, Ottawa, ON, 274p.

Lemmen, D.S., Warren, F.J., Lacroix, J. and Bush, E. (ed.) (2008): From Impacts to Adaptation: Canada in a Changing Climate 2007; Government of Canada, Ottawa, Ontario. 448 p. http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2007/pdf/full-complet_e.pdf

Levesque, M. (2016). Searching for persons with disabilities in Canadian provincial office. Canadian Journal of Disability Studies. 5(1), 73-106.

Lewis, D. (2020). Tlilnuo'lti'k-Weji-sqalia'timk-How we will be Mi'kmaq on our land: Working together with Pictou Landing First Nation to redefine a healthy community. Diss. Dalhousie University.

Maack, M. and Davidsdottir, B. (2015). Five capital impact assessment: Appraisal framework based on theory of sustainable well-being. Renewable and sustainable energy reviews, *50*, pp.1338-1351.

MacDougall, J., D., Cann, J., Hilchey. (1963). Soil Survey of Halifax County Nova Scotia. Prepared for the Minister of Supply and Services Canada. Reprinted in 1981. Available at: https://sis.agr.gc.ca/cansis/publications/surveys/ns/ns13b/ns13b_report.pdf. 55 pp

MacEwen, A. and Saulnier, C. (2010). The cost of poverty in Nova Scotia. Canadian Centre for Policy Alternatives-Nova Scotia.

MacGregor, S. (2009). A stranger silence still: The need for feminist social research on climate change. Sociological Review, 57 (2), 124-140.

MacKinnon, S. (2016). Youth crisis: Unemployment and outmigration in Nova Scotia. Diss. University of Toronto.

Malloy, J. and Ashcraft, C. (2020). A framework for implementing socially just climate adaptation. Climatic Change. 160, 1–14. https://doi.org/10.1007/s10584-020-02705-6

Manos, S., Cui, Y., MacDonald, N., Parker, L., and Drummer, T. (2014). Youth health care utilization in Nova Scotia: What is the role of age, sex and socio-economic status? Canadian Journal of Public Health. 105(6), e431-e437.

Manson, G.K., Couture, N.J., & James, T.S. (2019). CanCoast 2.0: data and indices to describe the sensitivity of Canada's marine coasts to changing climate. Geological Survey of Canada open file 8551. 20pp.

Manuel, P., Rapaport, E., Bryce, D., Kang, B., Webster, T., Crowell, N., Parker, N. (2014). Representing the Social Vulnerability of Coastal Populations in Nova Scotia – Draft Report March 28, 2014. 55 pp.

Manuel, P., Rappaport, E., Kang, B., Bryce, D., Webster, T., Cowell, N., & Parker, N. (2016). The first 10 meters: Coastal flooding and social vulnerability of populations in Nova Scotia. Poster presentation. Dalhousie University.

Markham, A., Osipova, E., Lafrenz Samuels, K., & Caldas, A. (2016). *World heritage and tourism in a changing climate*. UNESCO Publishing.

Maroto, M. and Aylsworth, L. (2016). Catching up or falling behind? Continuing wealth disparities for immigrants to Canada by region of origin and cohort. Canadian Review of Sociology/Revue canadienne de sociologie. 53(4), 374-408.

Marr, E. (2015). Assessing transportation disadvantage in rural Ontario, Canada: A case study of Huron County. Journal of Rural and Community Development. 10(2), 1-22.

McGillis, A., MacCallum, I. (2010). Infrastructure Risk Assessment of Coastal Roads in Nova Scotia. Paper prepared for presentation at the Climate Change Implications for Shoreline Erosion Session of the 2010 Annual Conference of the Transportation Association of Canada, Halifax, Nova Scotia. Available at: http://conf.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2010/docs/c3/maccallum.pdf. 21 pp.

McMillan, J., Glode-Desrochers, P. (2014). Final Report - Urban Aboriginal Wellbeing, Wellness and Justice: A Mi'kmaw Native Friendship Centre Needs Assessment Study for Creating a Collaborative Indigenous Mental Resiliency, Addictions and Justice Strategy. Prepared by UAKN Atlantic Regional Research Centre for Social Sciences and Humanities Research Council of Canada. 135 pp.

Metro Vancouver (2016). Climate Projects for Metro Vancouver – Report. Available at: http://www.metrovancouver.org/services/air-quality/climate-action/regional-program/Pages/default.aspx. 80 pp.

Michalos, A., Smale, B., Labonté, R., Muhajarine, N., Scott, K.,….&Hyman, I. (2011). The Canadian Index of Wellbeing. Technical Report 1.0. Waterloo, ON: Canadian Index of Wellbeing and University of Waterloo, ON.

Millennium Ecosystem Assessment (2003). Ecosystems and Human Well-being: A Framework for Assessment. Available at: https://www.millenniumassessment.org/en/index.html 212 pp.

Mistry, N, Rooprai, P., Mistry, S., and Rooprai, K. (2021). Ageism in the context of healthcare in Canada. University of Ottawa Journal of Medicine. 10(2), 24-27.

Moreau, B. (2016). Black Nova Scotian Women's Schooling and Citizenship: An Education Of Violence in Contesting Canadian Citizenship. [eds.] Chunn, D., Menzies, R., and Adamoski, R. University of Toronto Press. 293-312.

Moser, A. (2007). Gender and Indicators: Overview Report. Bridge Development–Gender. Institute of Development Studies, University of Sussex, Brighton, UK., 55 p.

MQO. 2021. Nova Scotia perspectives on wellbeing: The importance of factors that impact quality of life. Prepared by MQO Research for Nova Scotia Environment and Climate Change. Pp. 73.

Murison, L. (2017). Lack of Plankton, Climate Change, and its implications for Right Whales. In: New Brunswick Naturalist.. 44(3). Nature NB.

Nardo, M., Saisana, M., A. Saltelli, S. Taramtola, A. Hoffman, E. Giovannini, 2005. Handbook On Constructing Composite Indicators: Methodology and user guide – OECD Statistics Working Paper. European Commission. Joint Research Centre, Organisation for Economic Co-operation and Development (OECD). 108 pp.

Nardo, M., Saisana, M., Saltelli, A., and Tarantola, S. (2005). Tools for Composite Indicator Building. Institute for the Protection and the Security of the Citizen, European Commission-JRC: IT, 133 p.

Natural Resources Canada (NRCAN) (2019) [online]. Canadian Forest Services – Statistical Data. Available at: https://cfs.nrcan.gc.ca/statsprofile/employment/ns. Accessed March 6, 2021

ND-GAIN (2018) Urban Adaptation Assessment Technical Document. Notre Dame Global Adaptation Initiative (ND-GAIN), University of Notre Dame, South Bend, Indiana, 51 p.

Ndlovu, T., Charlebois, S. (2020). Impacts of Climate Change: Can Fisheries and Aquaculture Sectors Survive the Wave? International Journal of Global Sustainability 4(1)., 13. Available at: https://pdfs.semanticscholar.org/4b9c/c0ac2f2fdc228a074e826719e9ade34550a9.pdf

New Zealand Treasury (2018). Our People, Our Country, Our Future, Living Standards Framework: Background and Future Work. New Zealand Treasury, Wellington, NZ, 57 p.

Newell, F., Williams, P.L., and Watt, C. (2014). Is the minimum enough? Affordability of a nutritious diet for minimum wage earners in Nova Scotia (2002-2012). Canadian journal of public health = Revue canadienne de sante publique. 105(3), e158-65.

Nguyen, T., Bonetti, J., Rogers, K. and Woodroffe, C. (2016). Indicator-based Assessment of Climate Change Impacts on Coasts: A Review of Concepts, Methodological Approaches and Vulnerability Indices. Ocean and Coastal Management, 123, 18-43.

Nguyen, N.H., Subhan, F., Williams, K., and Chan, C. (2020). Barriers and Mitigating Strategies to Healthcare Access in Indigenous Communities of Canada: A Narrative Review. Healthcare. 8(2), doi:10.3390/healthcare8020112.

Nocera, J. (2005). Benefits and Risks of Agro-Ecosystem Management to Grassland Birds in Nova Scotia – Final Report to Nova Scotia Habitat Conservation Fund. Available at: https://novascotia.ca/natr/wildlife/habfund/final04/Nocera.pdf. 33 pp.

Nova Scotia Advisory Council on the Status of Women (NSACSW) (2020). The Domestic Violence in Nova Scotia 2020 fact sheet Available at: https://women.novascotia.ca/sites/default/files/2020-12/Domestic%20Violence%20fact%20sheet_2020_WEB.pdf

Nova Scotia Business Inc. (NSBI) (2018) [online]. Nova Scotia Mines a Rich Future. Accessed Sep. 23, 2021. Available at: https://www.novascotiabusiness.com/articles/nova-scotia-mines-rich-future

Nova Scotia Business Inc. (NSBI) (n.d.) [online]. Seafood. Available at: https://www.novascotiabusiness.com/business/seafood#:~:text=In%202019%2C%20Nova%20Scotia%20exported,products%20to%20over%2080%20countries.&text=The%20province's%20seafood%20industry%20also,harvest%20to%20processing%20to%20distribution. Accessed Feb 27, 2021.

Nova Scotia Department of Energy and Mines (2018). Nova Scotia Mining Operations 2018. Prepared by the Mineral Development and Policy Section of the Geoscience and Mines Branch. Available at: https://novascotia.ca/natr/meb/data/mg/ofi/pdf/ofi_2019-001.pdf.

Nova Scotia Department of Environment (NSE) (2005). Adapting to a Changing Climate in Nova Scotia: Vulnerability Assessment and Adaptation Options. Prepared by: DeRomilly and DeRomilly Limited, Dillon Consulting Limited, Alan Bell Environmental Management Services, Cameron Consulting, and Environment Canada Inter-Cultural Development Innovations, NS, 105 p.

Nova Scotia Department of Environment (NSE) (2009). The Air We Breathe: Nova Scotia's Air Quality Report, 2000-2007. Air Quality Branch, Nova Scotia Environment. 48 pp. Available at: http://www.gov.ns.ca/nse/air/

Nova Scotia Department of Finance (2021). Provincial Tourism Satellite Account 2017. Available at: https://novascotia.ca/finance/statistics/topic_news.asp?id=16754&fto=23w&rdval=2021-04

Nova Scotia Department of Municipal Affairs (NSMA) (2016). Municipal Climate Change Action Plans – 2015 Summary Report, NS. 64 pp.

Nova Scotia Department of Natural Resources (2013). Economic Impact of the Mineral Industry in Nova Scotia: 2012 Update. Available at: https://novascotia.ca/natr/meb/data/pubs/13ofr03/ofr_me_2013-003.pdf 54 pp.

Nova Scotia Federation of Agriculture (NSFA) (2013). Assessment of Environmental Stewardship Programs in Nova Scotia - November 2013. 56 pp.

Nova Scotia Power (2020). "Hurricane Dorian: One Year Later." September 8th, 2020. Available at: https://www.nspower.ca/about-us/articles/details/articles/2020/09/08/hurricane-dorian-one-year-later. Accessed on March 10th, 2021.

Nova Scotia Power (n.d.). Nova Scotia Power An Emera Company – Website. https://www.nspower.ca/

Ochuodho, T., Lantz, V., Loyd-Smith, P., and Benitez, P. (2012). Economic impacts of climate change and adaptation in Canadian forests: a CGE modeling analysis. Forest Policy and Economics, 25, 100-12.

OECD and JRC (2008). Handbook on Constructing Composite Indicators – Methodology and User Guide. Organisation for Economic Co-operation and Development (OCED) Publications, Paris, FR., 158 p.

OECD (2001). The Wellbeing of Nations: The Role of Human and Social Capital. Organisation for Economic Co-operation and Development (OECD), Paris, FR., 118 p.

OECD (2011a). Compendium or OECD Wellbeing Indicators. OECD Better Life Initiative, Organisation for Economic Co-operation and Development (OECD), Paris, FR., 37 p.

OECD (2011b) How's Life? Measuring Wellbeing. OECD Better Life Initiative, Organisation for Economic Co-operation and Development (OECD), Paris, FR., 282 p.

OECD (2013): How's Life? 2013, Measuring Wellbeing. OECD Better Life Initiative, Organisation for Economic Co-operation and Development (OECD), Paris, FR., 282 p.

Osborne, N. (2015). Intersectionality and kyriarchy: A framework for approaching power and social justice in planning and climate change adaptation. Planning Theory, 14(2), 130-151

Oxman-Martinez, J., Rummens, A., Moreau, J., Choi, Y.R.,… & Armstrong, R. (2012). Perceived ethnic discrimination and social exclusion: newcomer immigrant children in Canada. American Journal of Orthopsychiatry. 82(3), 376-388.

Palko, K. and Lemmen, D.S. (Eds.). (2017). Climate risks and adaptation practices for the Canadian transportation sector 2016. Ottawa, ON: Government of Canada.

Palmater, P. (2016). Shining light on the dark places: Addressing police racism and sexualized violence against Indigenous women and girls in the national inquiry. Canadian Journal of Women and the Law. 28(2), 253-284.

Papadimitriou, E. and Giulio, C. (2019). JCR Statistical Audit of the Equal Measures 2030 SDG Gender Index. EUR 29777 EN, Luxembourg: Publications Office of the European Union, 22 p.

Papadimitriou, E., Neves, A. and Becker, W. (2019). JCR Statistical Audit of the Sustainable Development Goals Index and Dashboards. EUR 29776 EN, Luxembourg: Publications Office of the European Union, 30 p.

Paul, D. (2006). We were not the savages: Collision between European and Native American civilizations. 3rd Edition. Fernwood Publishing.

Perennia (2018). Nova Scotia Soil – Fact Sheet. Available at: http://nsnewfarmer.ca/wp-content/uploads/sites/5/2018/02/Nova-Scotia-Soil.pdf. 3 pp.

Picot, W., and Yuqian L. (2017). Chronic low income among immigrants in Canada and its communities. Analytical Studies Branch Research Paper Series, Statistics Canada. Catelogue no. 11F0019M-No. 397.

Port of Halifax [online] (n.d.). Port History. Available at: https://www.portofhalifax.ca/about-us/port-history/#1700s. Accessed Sep 27, 2021.

Porter, J., Bancroft, and Crossland (2010). A Natural Balance: Working Toward Nova Scotia's Natural Resource Strategy. Panels of Expertise Addendum Natural Resources Strategy 2010. Available at: https://novascotia.ca/natr/strategy/pdf/phase2-reports/Natural%20Balance_Addendum.pdf. 47 pp.

Prosper, K., McMillan, L.J., and Davis, A. (2011). Returning to Netukulimk: Mi'kmaq cultural and spiritual connections with resource stewardship and self-governance. International Indigenous Policy Journal. 2(4). Retrieved from: http://ir.lib.uwo.ca/iipj/vol2/iss4/7

R Core Team. (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Rao, S. (2020). A natural disaster and intimate partner violence: Evidence over time. Social Science & Medicine 247: 112804. https://doi.org/https://doi.org/10.1016/j.socscimed.2020.112804

Rapaport, E., Manuel, P., Krawchenko, T., & Keefe, J. (2015). How Can Aging Communities Adapt to Coastal Climate Change? Planning for Both Social and Place Vulnerability. Canadian Public Policy, 41(2), 166-177.

Rapaport, E., Starkman, S., and Towns, W. (2017). Atlantic Canada. In K. Palko and D.S. Lemmen (Eds.), Climate risks and adaptation practices for the Canadian transportation sector 2016 (pp. 218-262). Ottawa, ON: Government of Canada

Rapaport, E., Manuel, P., and Keefe, J. (2013). Implications of sea level rise and extreme flooding impacts in rural coastal communities with aging populations: Case studies from Nova Scotia. Nova Scotia Department of Environment, Halifax, NS.

Ravensbergen, F. and VanderPlaat, M. (2010). Barriers to citizen participation: the missing voices of people living with low income. Community Development Journal. 45(4), 389-403.

Reid, G., Gurney-Smith, H., Marcogliese, D, Knowler, D....& De Silva, S. (2019). Climate change and aquaculture: considering biological response and resources. Aquaculture Environment Interactions. 11, 569-602.

Rezaee, S., Pelot, R., & Ghasemi, A. (2016). The effect of extreme weather conditions on commercial fishing activities and vessel incidents in Atlantic Canada. *Ocean & Coastal Management*, *130*, 115-127.

Richards, W. and Daigle, R. (2011). Scenarios and Guidance for Adaptation to Climate Change and Sea Level Rise – NS and PEI Municipalities. Nova Scotia Department of the Environment and Atlantic Climate Adaptations Solutions Association. Retrieved from ACASA website: https://atlanticadaptation.ca/en/islandora/object/acasa%3A660 (January 10, 2019).

Richler, N. (2019). “Opinion: In Rural Nova Scotia, Dorian's Wake Shows the Importance of Community and Self-Reliance.” *The Globe and Mail*, 15 Sept. 2019, www.theglobeandmail.com/opinion/article-in-rural-nova-scotia-dorians-wake-shows-the-importance-of-community/. Accessed March 10th 2021.

Richler, J. (2019a). Social capital supports action. Nature Climate Change, 9(3), 186-186.

Robin, C., Craymer, M., Ferland, R., James, T.S., Lapelle, E., Piraszewski, M., and Zhao, Y. (2020). NAD83v70VG: A new national crustal velocity model for Canada; Geomatics Canada, Open File 0062, 1 .zip file. https://doi.org/10.4095/327592

Rochette, A. (2016). Climate change is a social justice issue: The need for a gender-based analysis of mitigation and adaptation policies in Canada and Québec. Journal of Environmental Law and Practice, 29, 383-410.

Rome, E., Bogen, M., Luckerath, D.,Worst, R., Xie, J., and Bogen, M. (2017). IVAVIA Guideline: Impact and Vulnerability Analysis of Vital Infrastructure and Built-up Areas. RESIN Project: Supporting Decision-making for Resilient Cities, EU H2020 RESIN (GA no. 653522), Fraunhofer Institute for Intelligent Analysis and Information Systems, Sankt Augustin, Germany, 76 p.

Rossiter, M., Hatami, S., Ripley, D., and Rossiter, K. (2015). Immigrant and refugee youth settlement experiences: “A new kind of war”. International Journal of Child, Youth and Family Studies. 6(4-1), 746-770.

Rozanova, J., Keating, N., and Eales, J. (2012). Unequal social engagement for older adults: constraints on choice. Canadian Journal on Aging/La Revue canadienne du vieillissement 31(1), 25-36.

Saisana, M. and Saltelli, A. (2010). Uncertainty and Sensitivity Analysis of the 2010 Environmental Performance Index. EUR 24269 EN, Institute for the Protection and the Security of the Citizen, European Commission-JRC: IT, 27 p.

Saisana, M. and Tarantola, S. (2002) State-of-the-art report on Current Methodologies and Practices for Composite Indicator Development, EUR 20408 EN, Institute for the Protection and the Security of the Citizen, European Commission-JRC: IT, 72 p.

Saisana, M. (2008) The 2007 Composite Learning Index: Robustness Issues and Critical Assessment, EUR 23274 EN, Institute for the Protection and Security of the Citizen, European Commission-JRC: IT, 84 p.

Saisana, M., Saltelli, A. and Tarantola, S. (2005) Uncertainty and Sensitivity Analysis Techniques as Tools for the Quality Assessment of Composite Indicators. Journal of the Royal Statistical Society: Series A (Statistics in Society), 168 (2), 307-323.

Sangster, A. (n.d.) Nova Scotia Soil Fact Sheet. Prepared by Perennia Food and Agriculture Inc. Available at: http://nsnewfarmer.ca/wp-content/uploads/sites/5/2018/02/Nova-Scotia-Soil.pdf

Savage, L. (2021). Intimate partner violence: Experiences of women with disabilities in Canada, 2018. Statistics Canada. https://www150.statcan.gc.ca/n1/pub/85-002-x/2021001/article/00006-eng.htm

Savard, J.P., van Proosdij, D. and O'Carroll, S. (2016). Perspectives on Canada's East Coast region; *in* Canada's Marine Coasts in a Changing Climate, (ed.) D.S. Lemmen, F.J. Warren, T.S. James and C.S.L. Mercer Clarke; Government of Canada, Ottawa, ON, p. 99-152.

Schröter, M., Başak, E., Christie, M., Church, A., Keune, H., Osipova, E., ... & Martín-López, B. (2020). Indicators for relational values of nature's contributions to good quality of life: the IPBES approach for Europe and Central Asia. Ecosystems and People, 16(1), 50-69.

Senneville, S., St-Onge, S., Dumont, D., Bihan-Poudec, M.-C., Belemaalem, Z. …& Villeneuve, R. (2014). Rapport final : Modélisation des glaces dans l'estuaire et le golfe du Saint-Laurent dans la perspective des changements climatiques; report prepared by the Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski (UQAR) for the ministère des Transports du Québec. http://www.bv.transports.gouv.qc.ca/mono/1147874.pdf. 384 pp.

Sherren, K., Bowron, T., Graham, J. M., Rahman, H. M. T., & van Proosdij, D. (2019a). Coastal infrastructure realignment and salt marsh restoration in Nova Scotia, Canada. Responding to rising seas: OECD country approaches to tackling coastal risks, 111-135.

Sherren, K., Bowron, T., Graham, J. M., Rahman, H. M. Tuihedur and van Proosdij, D. (2019b). Coastal infrastructure realignment and salt marsh restoration in Nova Scotia, Canada. *Responding to Rising Seas: Comparing OECD Countries' Approaches to Coastal Adaptation*, Lisa Danielson Ed. (Organization for Economic Collaboration and Development: Paris, France).

Sherren, K., & Greenland-Smith, S. (2019c). Farm management fragmentation in Nova Scotia does not affect farm habitat provision. The Canadian Geographer/Le Géographe canadien, 63(2), 297-311.

Sherren, K., Ellis, K., Guimond, J., Kurylyk, B., …& Wells, E.. (2021). Understanding multifunctional Bay of Fundy dykelands and tidal wetlands using ecosystem services – a baseline. *FACETS 6: 1446–1473. doi:10.1139/facets-2020-0073*

Shippee, T., Wilkinson, L., Schafer, M., and Shippee, N. (2019). Long-term effects of age discrimination on mental health: The role of perceived financial strain. Journals of Gerontology: Social Sciences. 74(4), 664-674.

Smale, B., Gao, M., and Jiang, K. (2020). An Exploration of Wellbeing in Nova Scotia: A Summary of Results from the Nova Scotia Quality of Life Survey. Waterloo. ON: Canadian Index of Wellbeing and the University of Waterloo, 279 pp.

Smith, D.-L., and Peck, J. (2004). Wksitnuow wejkwapniaqewa-Mi'kmaq: A voice from the people of the dawn. McGill Journal of Education/Revue des sciences de l'éducation de McGill. 39(3), 342-353.

Smith, J. , Anderson, D. , & Moore, R. (2012). Social capital, place meanings, and perceived resilience to climate change. Rural Sociology, 77(3), 380-407.

Smith, L., Case, J., Smith, H., Harwell, L., and Summers, J.K. (2013) Relating ecosystem services to domains of human wellbeing: foundation for a U.S. index. Ecological Indicators, 28, 79-90.

Spinney, J. and Millward, H. (2010). Time and money: a new look at poverty and the barriers to physical activity in Canada. Social Indicators Research. 99(2), 341-356.

Soubry, B., Sherren, K., & Thornton, T. (2020). Farming along desire lines: Collective action and food systems adaptation to climate change. People and Nature, 2(2), 420-436.

Standing Committee on the Status of Women (2019). Elect Her: A Roadmap for Improving the Representation of Women in Canadian Politics. Report of the Standing Committee on the Status of Women. April 2019, 42nd Parliament, 1st Session.

Stantec (2012). Tools For Community Climate Change Adaptation in Nova Scotia: Socio-Economic Indicators & Scenario Planning. Report Version 2 (July 5, 2012). Prepared by Marty Janowitz, Eric Dunford, Aviva Savelson, Hamish Aubrey, Ryan Meyers, Dave Ronn for Kyla Milne, NS Climate Change Directorate. 98 pp.

Statista (2021) [online]. GDP Distribution of Nosva Scotia, Canada, by industry 2019. Available at: https://www.statista.com/statistics/607879/gdp-distribution-of-nova-scotia-canada-by-industry/ Accessed Feb 10th, 2021.

Statistics Canada (2016a). 2016 Census of Agriculture. Statistics Canada. Released May 10, 2017. Available at: https://www150.statcan.gc.ca/n1/pub/95-640-x/95-640-x2016001-eng.htm.

Statistics Canada (2016b) [online]. More Farms in Nova Scotia. Available at: https://www150.statcan.gc.ca/n1/pub/95-640-x/2011001/p1/prov/prov-12-eng.htm. Accessed Feb 25th, 2021.

Statistics Canada (2017). Nova Scotia [Province] and Canada [Country] (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 14, 2021).

Statistics Canada (2020a) [online]. Annual Demographic Estimates: Canada, Provinces and Territories, 2020. September 29, 2020. Available at: https://www150.statcan.gc.ca/n1/pub/91-215-x/91-215-x2020001-eng.pdf (accessed February 9, 2021).

Statistics Canada (2020b) [online]. Canadian Community Health Survey: Household food insecurity in Canada 2017/2018: Table 13-10-0385-01 (Household food security by living arrangement). Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310038501&pickMembers%5B0%5D=1.4&cubeTimeFrame.startYear=2017+%2F+2018&cubeTimeFrame.endYear=2017+%2F+2018&referencePeriods=20170101%2C20170101. Accessed Jan 27th, 2021.

Statistics Canada (2020c) [online]. Population estimates on July 1st, by age and sex: Table 17-10-0005-01. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501&pickMembers%5B0%5D=1.4&pickMembers%5B1%5D=2.1&cubeTimeFrame.startYear=2016&cubeTimeFrame.endYear=2020&referencePeriods=20160101%2C20200101 Accessed Feb 10th 2021.

Statistics Canada (2020d) [online]. Canadian Community Crime Tracker. Available at: https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2018008-eng.htm#about, Accessed Feb 25th, 2021.

Statistics Canada (2020e) [online]. Table 33-10-0267-01. Canadian Business Counts, with employees, June 2020. DOI: https://doi.org/10.25318/3310026701-eng. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3310026701. Accessed Dec 21, 2021.

Statistics Canada (2021a) [online]. Table 14-10-0215-01 Employment for all employees by enterprise size, annual. DOI: https://doi.org/10.25318/1410021501-eng. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1410021501. Accessed Dec 21, 2021.

Statistics Canada (2021b) [online]. Table 11-10-0241-01 Low income cut-offs (LICOs) before and after tax by community size and family size, in current dollars. DOI: https://doi.org/10.25318/1110024101-eng. Available at:

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110024101. Accessed: Apr 25, 2021.

Statistics Canada (2021c) [online]. Table 36-10-0480-01 Labour productivity and related measures by business sector industry and by non-commercial activity consistent with the industry accounts. DOI: https://doi.org/10.25318/3610048001-eng. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610048001&pickMembers%5B0%5D=1.4&pickMembers%5B1%5D=2.1&cubeTimeFrame.startYear=2016&cubeTimeFrame.endYear=2020&referencePeriods=20160101%2C20200101. Accessed: Mar 14, 2021.

Statistics Canada (2021d) [online]. Table 11-10-0057-01 Assets and debts by after-tax income quintile, Canada, provinces and selected census metropolitan areas, Survey of Financial Security (x 1,000,000) DOI: https://doi.org/10.25318/1110005701-eng. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110005701&pickMembers%5B0%5D=1.5&pickMembers%5B1%5D=2.1&pickMembers%5B2%5D=4.1&cubeTimeFrame.startYear=2005&cubeTimeFrame.endYear=2019&referencePeriods=20050101%2C20190101. Accessed Jan 14, 2021.

Steenberg, J., Duinker, P., Bush, P. (2013). Modelling the effects of climate change and timber harvest on the forests of central nova scotia, Canada. Annals of Forest Science, 70(1), 61-73. https://doi.org/10.1007/s13595-012-0235-y

Subedi, R. and Rosenberg, M. (2014). Determinants of the variations in self-reported health status among recent and more established immigrants in Canada. Social Science & Medicine. 115, 103-110.

Sutherland, D. (2008). Woodlot Management Home Study Module 13: Non Timber Forest Productions – Growing Opportunities. Prepared for the Government of Nova Scotia – Natural Resources. Available at: https://novascotia.ca/natr/education/woodlot/modules/module13/pdf/module13.pdf. 44 pp.

Swart, R., Fons, J., Geertsema, We., van Hove, L., and Jacobs, C. (2012). Urban Vulnerability Indicators: A Joint Report of the ETC-CCA and the ETC-SIA. Report prepared for the European Environment Agency, Copenhagen, DK.

Talukder, B., Hipel, K. and van Loon, G. (2017). Developing Composite Indicators for Agricultural Sustainability Assessment: Effect of Normalization and Aggregation Techniques. Resources, 6, 66.

Tate, E. (2012). Social Vulnerability Indices: A Comparative Assessment using Uncertainty and Sensitivity Analysis. Natural Hazards, 63, 325-347.

Tate, E. (2013). Uncertainty Analysis for a Social Vulnerability Index. Annals of the Association of American Geographers, 103 (3), 526-543.

Taylor, R. (2007). Understanding Nova Scotia's coastlines; Natural Resources Canada, Geological Survey of Canada—Atlantic. https://www.publications.gc.ca/collections/collection_2007/nrcan-rncan/M34-4-2-2007E.pdf

Taylor, A. R., MacLean, D. A., Neily, P. D., Stewart, B., Quigley, E., Basquill, S. P., ... & Pulsifer, M. (2020). A review of natural disturbances to inform implementation of ecological forestry in Nova Scotia, Canada. *Environmental Reviews*, (999), 1-28.

Terashima, M. (2015). Nova Scotia Deprivation Index Construction Guide. Prepared for the Nova Scotia Department of Health and Wellness, January 2015. 39 pp.

The ENRICH Project (nd). Welcome to the Africville Story Map. Available at: https://dalspatial.maps.arcgis.com/apps/Cascade/index.html?appid=e7847621b45148b3b21e0800a4e73419&embedd

Tompa, E., Samosh, D., and Boucher, N. (2020). [online] Skill Gaps, Underemployment and Equity of Labour-Market Opportunities for Persons with Disabilities in Canada. Public Policy Forum. https://ppforum.ca/wp-content/uploads/2020/01/SkillsGap-Disabilities-PPF-JAN2020-Feb6.pdf

Tourangeau, W. and Sherren, K. (2021). Why is grazing management being overlooked in climate adaptation policy? Agroecology and sustainable food systems. 45(6), 843-867. DOI: 10.1080/21683565.2020.1870645.

Tourism Nova Scotia (2018). Driving Export Revenue: 2018-2023 Strategic Plan. Available at: https://www.tourismns.ca/sites/default/files/Tourism%20Driving%20Export%20Revenue%20Strategy%202018.pdf 48 pp.

Tourism Nova Scotia (n.d.) [online]. Tourism Statistics – Tourism Revenues. Available at: https://www.tourismns.ca/research/tourism-statistics/tourism-revenues#:~:text=Nova%20Scotia%20Tourism%20Revenues%20(as,for%202018%20of%20%242.73%20billion. Accessed Feb 10th, 2021.

van Proosdij, D., Ross, C. and Matheson, G. (2018). Risk Proofing Nova Scotia Agriculture: Nova Scotia Dyke Vulnerability Assessment. Final report submitted to Nova Scotia Federation of Agriculture, 51 pp. https://nsfa-fane.ca/wp-content/uploads/2018/08/Nova-Scotia-Dyke-Vulnerability-Assessment.pdf

Veenstra, G. and Patterson, A. (2016). Black–white health inequalities in Canada. Journal of Immigrant and Minority Health. 18(1), 51-57.

Versey, H. (2021). Missing Pieces in the Discussion on Climate Change and Risk: Intersectionality and Compounded Vulnerability. Policy Insights from the Behavioral and Brain Sciences. 8(1), 67-75.

Vervaecke, D. and Meisner, B. (2021). Caremongering and assumptions of need: The spread of compassionate ageism during COVID-19. The Gerontologist. 61(2), 159-165.

Vukic, A., Gregory, D., Martin-Misener, R., and Etowa, J. (2011). Aboriginal and Western conceptions of mental health and illness. Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health. 9(1), 65-86.

Waldron, I. (2016). Experiences of Environmental Health Inequalities in African Nova Scotian Communities. Dalhousie University, September 20, 2016. 40 pp.

Waldron, I. (2018). There's Something in the Water: Environmental Racism in Indigenous and Black Communities. Halifax: Fernwood: https://fernwoodpublishing.ca/book/there8217s-something-in-the-water

Waldron, I. (2020). In your place and out of place: mapping spatial violence in urban and rural African Nova Scotian communities. Canadian Review of Sociology/Revue canadienne de sociologie. 57(4), 733-736.

Waldron, I. (2021). Environmental racism and climate change: Determinants of health in Mi'kmaw and African Nova Scotian communities. Canadian Institute for Climate Choices. Retrieved December 20, 2021, from https://climatechoices.ca/publications/environmental-racism-and-climate-change/

Waldron, I. (2021a). Structural Determinants of Health in Mi'kmaw & African Nova Scotian Communities: A Framework for Understanding the Health Impacts of Environmental Racism & Climate Change. Prepared for the Canadian Institute for Climate Choices. March 2021.

Waldron, I., MacDougall, E., and Weeks, L. (2021). Hear my cry: Breaking the code of silence around intimate partner violence among Black women in and beyond midlife. Atlantis: Critical Studies in Gender, Culture & Social Justice/Atlantis: études critiques sur le genre, la culture, et la justice. 42(1), 18-30.

Walker, H. , Culham, A., Fletcher, A. , and Reed, M. (2019). Social dimensions of climate hazards in rural communities of the global North: An intersectionality framework. Journal of Rural Studies, 72, 1-10.

Walsh, J. (2014). Intensified warming of the arctic: Causes and impacts on middle latitudes. Global and Planetary Change, 117, 52-63. https://doi.org/10.1016/j.gloplacha.2014.03.003

Wang, L., Guruge, S., and Montana, G. (2019). Older immigrants' access to primary health care in Canada: A scoping review. Canadian Journal on Aging/La Revue canadienne du vieillissement 38(2), 193-209.

Warren, F.J. and Lemmen, D.S., editors (2014) Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation; Government of Canada, Ottawa, ON, 286p.

Waterston, S., Grueger, B., and Samson, L. (2015). Housing need in Canada: Healthy lives start at home. Paediatrics & Child Health. 20(7), 403-407.

Weeks, L. and LeBlanc, K. (2010). Housing concerns of vulnerable older Canadians. Canadian Journal on Aging/La Revue Canadienne du Vieillissement. 29(3), 333-347.

Weis, S., Agostini, V., Roth, L., Gilmer, B., Schill, S., Kowles, J., and Blyther, R. (2016) Assessing Vulnerability: An Integrated Approach for Mapping Adaptive Capacity, Sensitivity and Exposure. Climatic Change, 136, 615-629.

Whitman, E., Sherren, K., and Rapaport, E. (2015). Increasing daily wildfire risk in the Acadian Forest Region of Nova Scotia, Canada, under future climate change. Regional environmental change, 15(7), 1447-1459.

Woodhall-Melnik, J. and Grogan, C. (2019). Perceptions of mental health and wellbeing following residential displacement and damage from the 2018 St. John Rover Flood. Int. J. Environ. Res. Public Health 2019, 16(21), 4174; https://doi.org/10.3390/ijerph16214174

World Health Organisation [WHO]. (2011). The social dimensions of climate change. https://www.who.int/publications/i/item/the-social-dimensions-of-climate-change

Wortley, S. (2019). [online] Halifax, Nova Scotia: Street Checks Report. Halifax: Nova Scotia Human Rights Commission. https://humanrights.novascotia.ca/streetchecks

Wyndham-West, C. M., Odger, A., and Dunn, J. (2021). A narrative-based exploration of aging, precariousness and housing instability among low-income older adults in Canada. Cities & Health. doi: 10.1080/23748834.2021.1919976

Yang, L. (2014): An Inventory of Composite Measures of Human Progress. Occasional Paper on Methodology, UNDP Human Development Report Office, United Nations Development Programme, New York, NY, 120 p.

Yeung, S., Castleden, H., and Pictou Landing First Nation. (2020). 'We all know each other': A Strengths-based Approach to Understanding Social Capital in Pictou Landing First Nation. International Journal of Indigenous Health. 15(1), 119-132.

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., …& Kharin, V.V. (2019). Changes in Temperature and Precipitation Across Canada; Chapter 4 *in* Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, pp 112-193.

ESSA

600-2695 Granville Street,
Vancouver, BC, V6H 3H4
P: (604) 733-2996
E : info@essa.com

Suite 1200 – 150 Isabella Street
Ottawa, ON Canada K1S 5H3
Phone: (613) 798-1300
Email: international@essa.com