G20 CLIMATE RISK ATLAS

Impacts, policy, economics

CANADA

With the scientific contribution of Enel Foundation

How to read the Atlas: graphs, colours and scenarios.

The maps used in this Atlas are taken from **The World Bank Official Boundaries** - ***https://datacatalog.worldbank.org/search/dataset/0038272*** (accessed on May 28, 2021). For the section Energy, the maps are based on Panoply Data Viewer ***https://www.giss.nasa.gov/tools/panoply/credits.html***

Each sector of this Atlas contains data and information on various climate scenarios.

When reported in graphs, the **colour black** indicates data and information referring to the current state, the past or the baseline.

When the authors refer to **RCP (Representative Concentration Pathways)**, the 3 colours used across the factsheet refer to 3 scenarios, which are 3 different development options with different levels of greenhouse gas emissions, **respectively low emissions (green), medium emissions (orange), and high emissions (red)**. The same colour code is used when RCPs are associated with Shared Socioeconomic Pathways (SSP).

In some cases, the authors refer to global warming scenarios. In these cases, the 3 colours used refer to a temperature rise of **1.5°C (green), 2°C (dark green), and 4°C (red)**.

When the authors refer exclusively to **Shared Socioeconomic Pathways - SSPs** (Population affected by river floods in the section: "Water"), data related to **SSP3** - that encompasses, among other things, slow economic growth, material-intensive consumption, and persisting or worsening inequalities – **are reported in a lighter shade**; **SSP5** – which refers to social and economic development that is coupled with an energy-intensive lifestyle and the abundant exploitation of fossil fuel resources – is shown using a **middle shade of the colour**, whereas data related to **the present** conditions **are represented in a dark shade**.

Further details on scenarios, methodologies, and the full list of references are available at: **www.g20climaterisks.org**

Concept and graphic design by element6.eu

CANADA CLIMATE

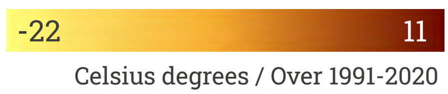
OVERVIEW

Climates and temperatures across Canada vary from region to region due to its great latitudinal distribution. Winters can be harsh in many parts of the country, particularly in the interior provinces, which experience a continental climate. In non-coastal regions, snow can cover the ground for almost six months a year, while in parts of the north snow can persist year-round. Coastal areas have a temperate climate. Much of Northern Canada is covered in ice and permafrost.

TEMPERATURE

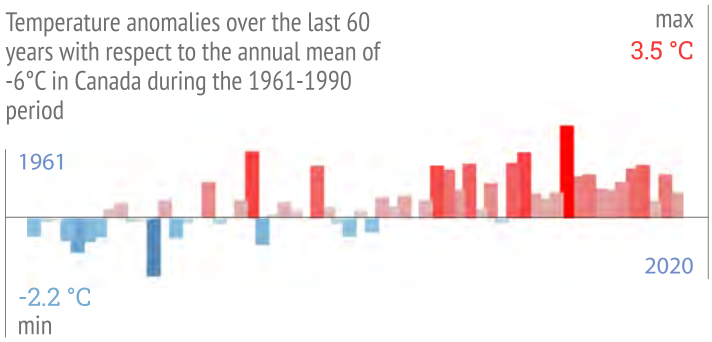
The temperature regime in Canada is highly heterogeneous. Coastal areas are usually cooler than inland areas, where temperatures during the summer have in some cases exceeded 40°C. In contrast, the northern part often experiences temperatures below 0°C.

MEAN TEMPERATURE



TEMPERATURE TREND

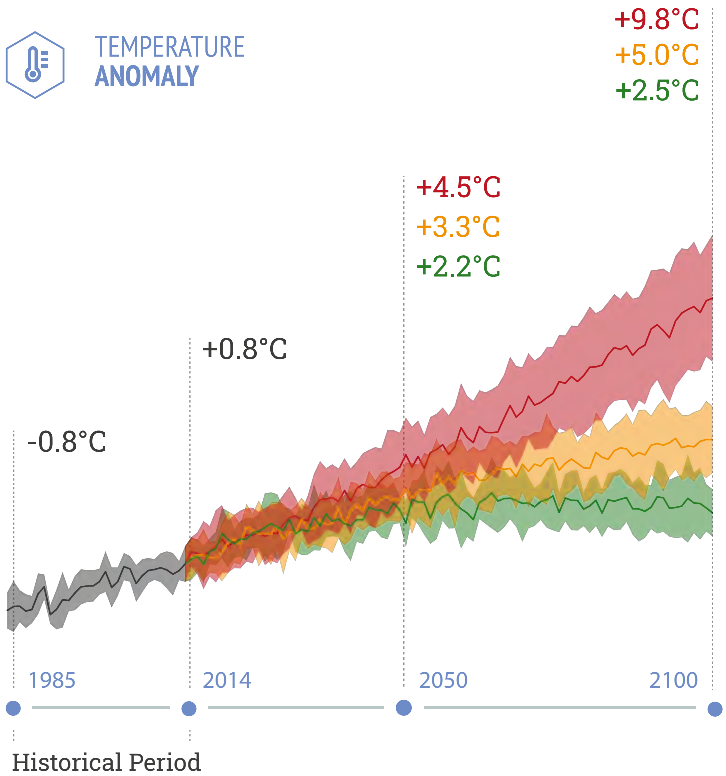
Temperature anomalies over the last 60 years with respect to the annual mean of -6°C in Canada during the 1961-1990 period



TEMPERATURE PROJECTIONS

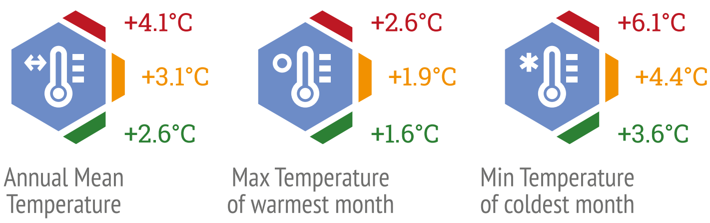
Under a low emissions scenario projected temperature variations will remain contained under +2.5°C, both by 2050 and 2100.
Under a high emissions scenario, with no reduction in GHG emissions, much greater temperature anomalies are expected by both 2050 and 2100.

TEMPERATURE ANOMALY



EXPECTED VARIATION FOR TEMPERATURE AT 2050

The indicators show variations in selected temperature characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.



PRECIPITATION

Humid air masses from the Pacific interact with mountains to cause large quantities of rain on the west coast and mountain areas. Several sites along the British Columbia coast receive high annual quantities of precipitation in summer.
On the interior plains and the North there is little precipitation. Spring and summer are wetter than winter. Ontario and Quebec have more rainfall than the interior plains because the air masses pick up water vapour from the Great Lakes. The Atlantic provinces are wetter than the provinces of Central Canada and mostly influenced by cyclones.
In general, rainfall on Canada's east coast is inferior to that of the west coast because of the prevailing offshore wind.

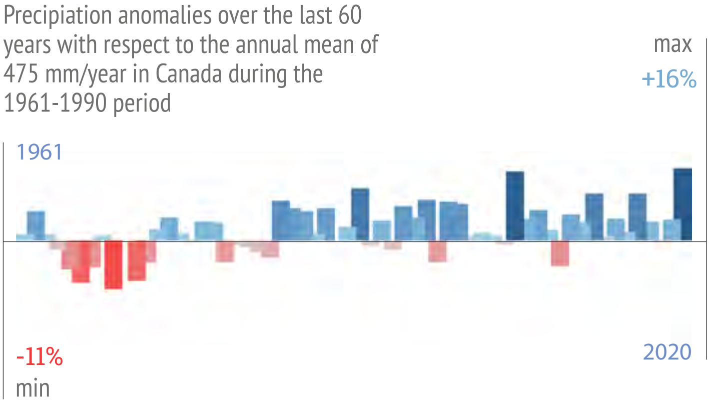
MEAN PRECIPITATION

95 — 4,571

mm/year / Over 1991-2020

PRECIPITATION TREND

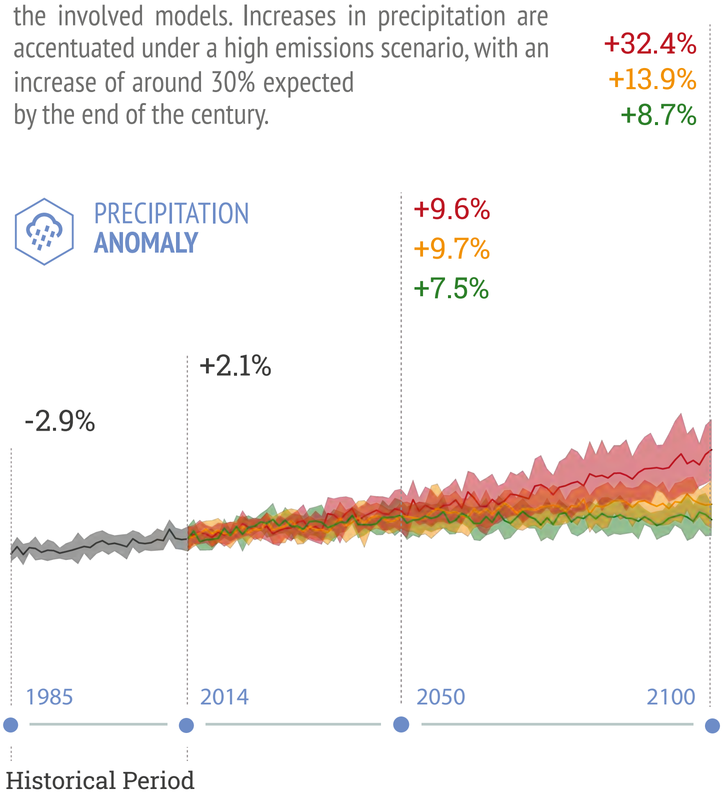
Precipiation anomalies over the last 60 years with respect to the annual mean of 475 mm/year in Canada during the 1961-1990 period



PRECIPITATION PROJECTIONS

Precipitation trends show a clear tendency to increase following all scenarios with a large variability among the involved models. Increases in precipitation are accentuated under a high emissions scenario, with an increase of around 30% expected by the end of the century.

PRECIPITATION ANOMALY



EXPECTED VARIATION FOR PRECIPITATION AT 2050

The indicators show variations in selected precipitation characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.

Indicator	High	Medium	Low
Annual total precipitation	+12.1%	+9.4%	+8.6%
Precipitation of wettest month	+11.4%	+8.8%	+8.0%
Precipitation of warmest quarter	+6.5%	+5.6%	+5.6%

VARIATION OF SPECIFIC CLIMATE INDICATORS

Climate indicators variation showing impacts of climate change on sectors such as agriculture, health and water. Analysis considers 3 threshold average temperature increase: **+1.5°C**, **+2°C**, **+4°C**.

Indicator	Unit	+4°C	+2°C	+1.5°C
Agricultural drought proportion of time	% of time	+29%	+13%	+11%
Hydrological drought proportion of time	% of time	+14%	+8%	+7%
Heatwave duration	% of time	+1,306%	+181%	+63%
Runoff increase	% of area	+9%	+1%	+0%
Agricultural drought frequency	% of change	+62%	+31%	+23%
Hydrological drought frequency	% of change	+11%	+6%	+11%
Heatwave frequency	% of change	+83%	+27%	+14%
Runoff decrease	% of area	+45%	+27%	+14%

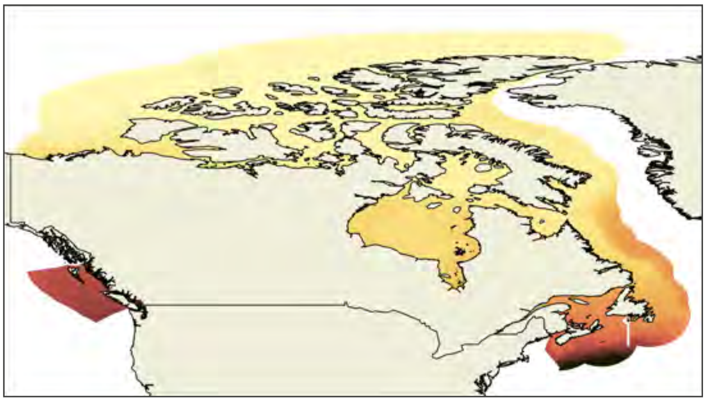
CANADA
OCEAN

OCEAN IN CANADA

Canada's marine exclusive economic zone (EEZ) is characterized by polar to temperate coastal waters, which host a large variety of ecosystems such as coral reefs, eelgrass and kelp beds. In particular, coastal systems can be divided into three main areas, namely Arctic, Atlantic and Pacific marine regions.

CURRENT CLIMATE CONDITIONS

Mean sea surface temperature reflects the different climate regimes, from the cold waters in the polar northern coasts to the temperate areas in the Atlantic and Pacific.

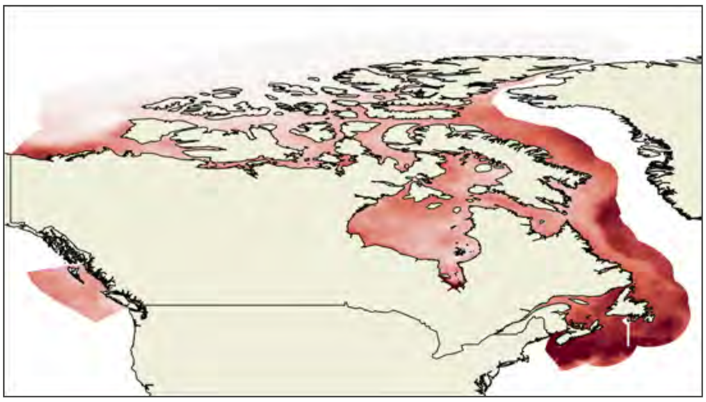


MEAN

SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

TREND

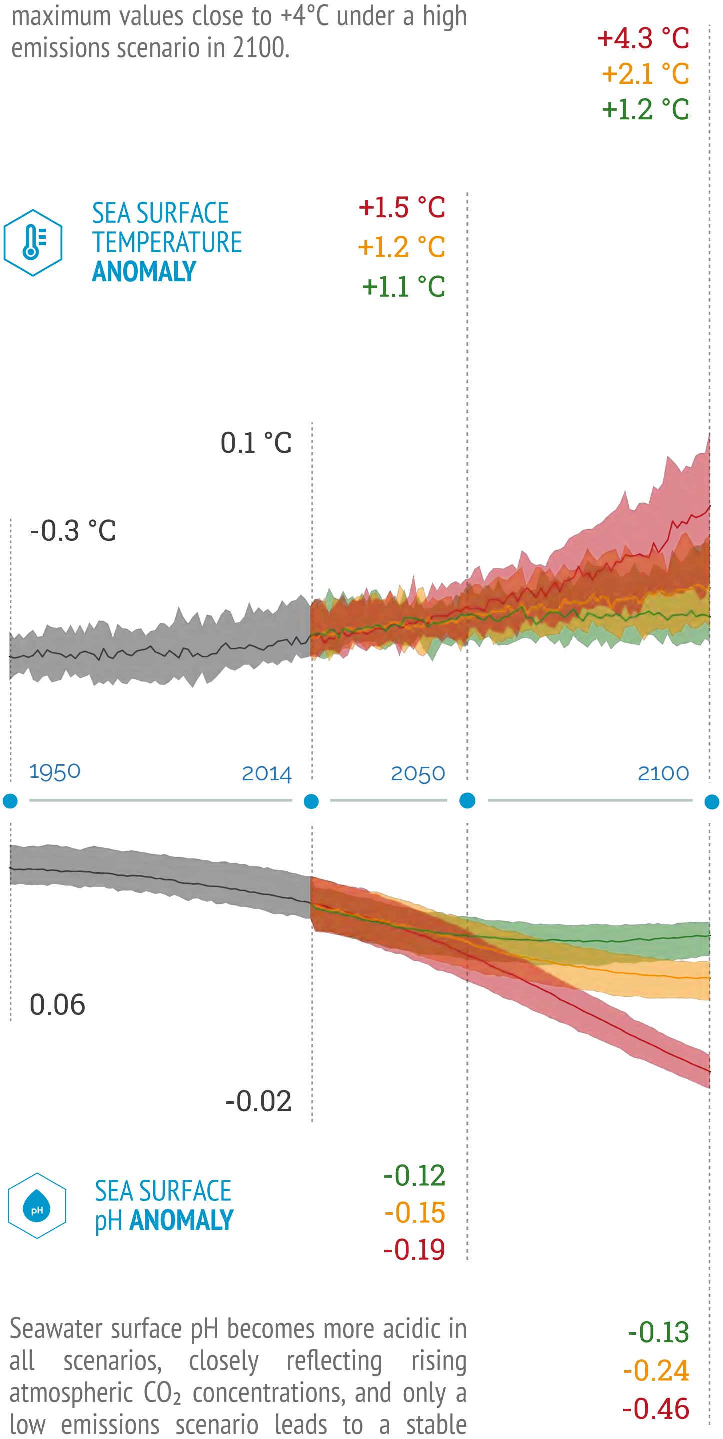


Surface temperature trends indicate a general warming of 0.2°C per decade in all marine areas, with increased gains in the southeastern regions.

FUTURE PROJECTIONS

Projected annual changes within the marine EEZ for the two most significant marine indicators of climate change: sea surface water temperatures and pH.

Seawater temperature changes are in line with the definitions of each scenario, with maximum values close to +4°C under a high emissions scenario in 2100.



Seawater surface pH becomes more acidic in all scenarios, closely reflecting rising atmospheric CO_2 concentrations, and only a low emissions scenario leads to a stable condition by 2100.

ECOSYSTEM INDICATORS AT 2050

Regional changes in key marine ecosystem indicators under projected future scenarios by mid-century (2036-2065) with respect to present climate conditions (1985-2014).

Temperature regulates the metabolism of marine organisms determining which habitats remain suitable. Excessive warming will likely push ecosystems beyond tolerance thresholds.

pH represents the acid/base status of marine waters, where a decreasing pH reflects the acidification of the ocean due to increased absorption of atmospheric CO_2.

Oxygen is fundamental to sustain marine life and its reduction can have a large impact on coastal ecosystem services including fisheries and aquaculture.

Chlorophyll is an indicator of the biomass available at the base of the marine food web supporting all ecosystem productivity.

Indicator		Arctic	Atlantic	Pacific
Temperature	Present	-0.29°C	7.48°C	10.64°C
		+1.22 °C	+1.82 °C	+2.35 °C
		+0.89 °C	+1.75 °C	+1.83 °C
		+0.79 °C	+1.59 °C	+2 °C
pH	Present	8.09	8.1	8.07
		-0.2	-0.18	-0.17
		-0.16	-0.14	-0.13
		-0.13	-0.11	-0.1
Oxygen	Present	368.55 mmol/m³	309.34 mmol/m³	287.77 mmol/m³
		-2.37 %	-3.66 %	-4.53 %
		-1.21 %	-2.87 %	-3.45 %
		-0.83 %	-2.4 %	-3.17 %
Chlorophyll	Present	0.26 mg/m³	0.48 mg/m³	0.48 mg/m³
		-5.7 %	-10.21 %	-6.72 %
		-4.94 %	-3.12 %	-5.25 %
		-14.07 %	-17.29 %	-8.61 %

FISH CATCH POTENTIAL

Fish catch potential is an estimate of the maximum fish catch achievable given the marine resources available over a sustained period. It is linked to the concept of maximum sustainable yield, meaning the maximum amount of fish that can be extracted from a system without causing a collapse in fish populations.

It is a characteristic of the natural system, which is substantially different from realized catch, and a direct result of the fishery policy in place.

Fish catch percentage change

2050

0.0%

-1.6%

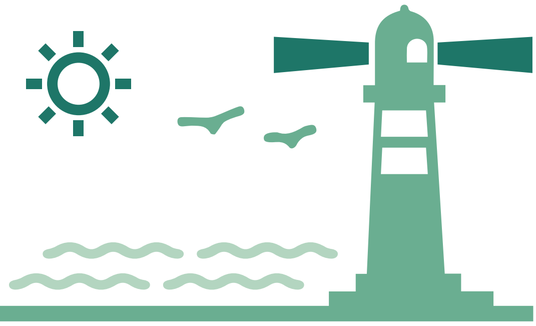
ANALYSIS DETAILS

All datasets were analysed using only data from within the marine EEZ and therefore excluding overseas territories, detached islands and any disputed or joint territories with other nations. In the assessment of current climate conditions, seawater surface tempereature data was obtained using satellite observations distributed in the framework of ESA Climate Change Initiative.

Future projections of marine indicators are represented by the combined analysis of results from 15 different Earth System models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6). These models include new and better representations of physical and biogeochemical processes, compared to previous IPCC assessment reports.

Fish catch potential data was obtained using the FAO's technical report and refers to the best and worst case climate scenarios from the Fifth IPCC Assessment Report. These mean estimates are subject to substantial uncertainties as discussed in the original work.

CANADA COASTS



OVERVIEW

With approximately 265,000 kilometres of shoreline, Canada has the longest coastline in the world. It ranges from resistant bedrock to gravel, sand, and mud. Permafrost (perennially frozen ground) is a significant component of much of the northern coastline. The coast is the focus of major economic activity, with most of the coastal population concentrated in the city of Vancouver, on the west coast, and smaller coastal populations on the east coast around Quebec City, Halifax and St Johns.

Shoreline Length — 265,523 km

Sandy Coast Retreat at 2050 — -25.8 m

CLIMATE CHANGE HAZARDS

Coastal hazards such as erosion, storm tide inundation and permanent flooding, can have strong adverse impacts on coastal regions, with loss of sandy shores, damage to settlements, infrastructure and ecosystems. Climate change can exacerbate these impacts due to rising sea levels and increasing impacts of waves and storms. With a range of shoreline types, Canada's coastal zones have varying sensitivities to projected future climates. Rising sea levels will increasingly erode beaches and flood unprotected low lying areas. Increasing temperatures may also lead to rising land levels due gravitational adjustments in parts of the country covered in permanent or semipermanent ice frost. Some parts of Canada will also experience increasing exposure to extreme weather (on the west coast) or extra-tropical hurricanes (on the Atlantic Coast).

SEA LEVEL RISE

Relative sea level rise has been observed over the past century around the coast of Canada, with a yearly average increase of approximately 1.82 millimetres per year since the 1990s. The latest IPCC projections indicate that, by 2050, global sea levels may rise between 0.18 metres, under a low emissions scenario, and 0.23 metres, under a high emissions scenario.

Observed and projected sea level rise at 2050 — 1.81 mm/year — 0.23 m — 0.18 m

EXTREME SEA LEVEL

On average, one in 100 extreme sea level events are expected to rise from 2.82 metres at present day to 3.09 metres by 2050 under a medium emissions scenario.

Current and projected extreme sea level at 2050 — 2.82 m — 3.16 m — 3.09 m

OBSERVED STORMS

Canada's coasts are exposed to both the Atlantic and Pacific wave climates. Atlantic hurricanes commonly reach Canada's coasts during the summer season, and large pacific storms, particularly in winter, drive storm surges and shoreline impacts on the Pacific coast, which, on average, experiences larger waves than the Atlantic coast.

FUTURE STORMS

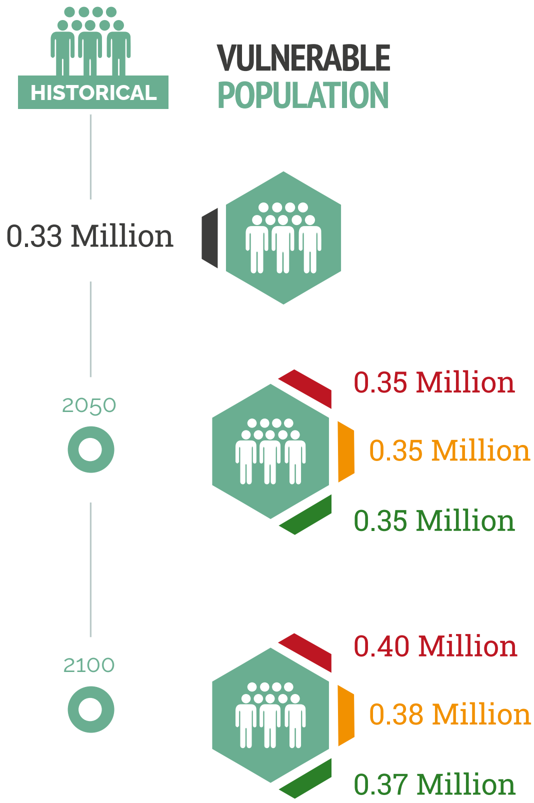
The impacts of climate change on storms and waves are quite uncertain. In general, models suggest that warmer sea temperatures will cause more intense hurricanes on Canada's Atlantic coast, with a poleward shift of the areas affected. Changes in storms affecting Canada's pacific coast are also quite uncertain, with a possible decrease in the size of waves.

VULNERABILITY AND RISK

Most of the coastal population in Canada is concentrated in Vancouver, on the West Coast, and a few cities on the east coast including Quebec City, Halifax and St Johns. Smaller coastal towns and communities are exposed to the impacts of storms and sea level rise around the country. In Vancouver, parts of the city's low lying areas are already impacted by storm surges, effects which may be exacerbated by future sea level rise.

The risks posed by relative sea-level change vary across Canada and are concentrated in populated areas. Sea level rise and and storm surges could cost Canada in the range 53.7 and 108.7 billion USD, with significant variations in costs and impacts across coastal provinces.

Some provinces, such as Newfoundland and Labrador, may experience marginal impacts, whereas others such as British Columbia could be burdened with the highest costs. Under a medium emissions scenario, the population exposed to the annual coastal flood level is expected to increase from 330,000 to 350,000 people by 2050.



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

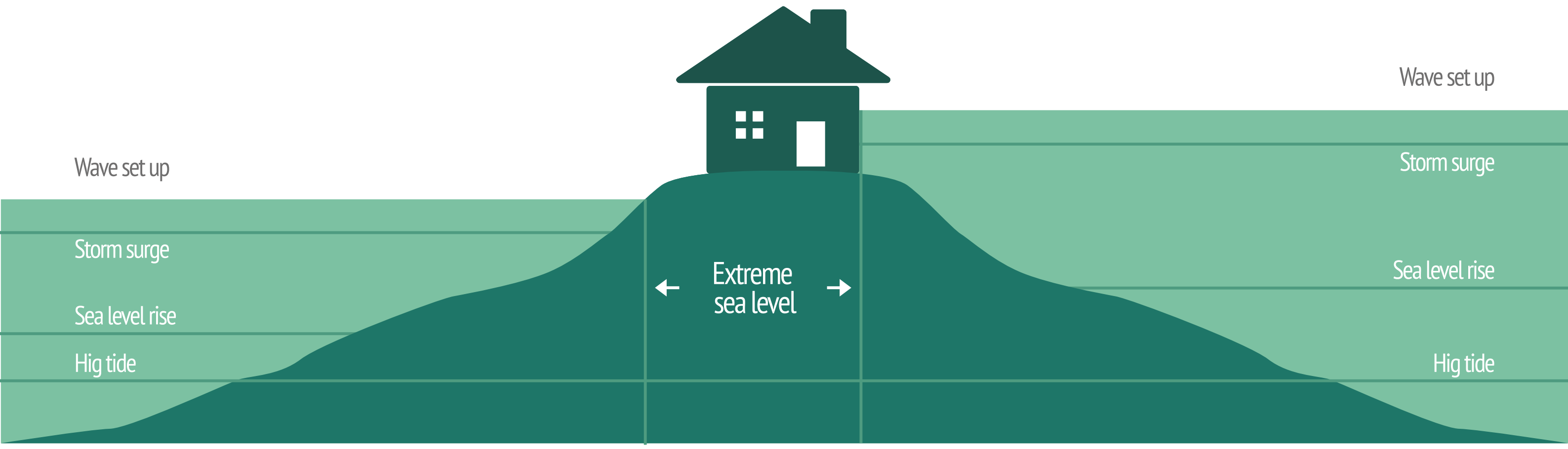
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

The extreme sea levels reported here are based on the 100-year storm surge + wave set up + sea level rise + high tide indicators. The first two parameters (storm surge + wave set up) are based on the 100-year value for the event; sea level rise is its projected value at 2050; and high tide is the absolute value of the highest tide calculated for a given locality, which won't be influenced by climate change.

+ **Wave set up** refers to the accumulation of water near the shore due to the presence of breaking waves.

+ **Storm surge** is an occasional increase in sea level driven by shoreward wind-driven water circulation and atmospheric pressure.

+ **High tide** is usually the highest tide reached in a given location based on tide records.



Present sea levels have risen globally by approximately 20 centimetres over the past century.

Future sea level rise is a projection based on different global warming scenarios, at approximately 100 centimetres by the end of 2100, with consequent inundation during extreme sea level events.

CANADA WATER

OVERVIEW

Canada's fresh water supply is stored in rivers and lakes, which account for almost 12% of the total area of the country, as well as groundwater, ice, and snow.

Although the annual discharge of Canadian rivers amounts to 7% of the world's renewable water supply, aggregate measures show that approximately 60% drains in the north, where less Canadians live.

In fact, 85% of the population live within 300 kilometres of the Canada-USA border and many populated areas have restricted water supplies. Water availability is a major concern when considering water management in Canada.

Renewable internal freshwater resources
2,850 billion m^3

Renewable internal freshwater resources per capita
77,985 m^3

Even in the Great Lakes basin, the world's largest freshwater lake system, some off-lake areas in southern Ontario experience periodic and even chronic water shortage, and groundwater "mining" takes place, whereby more water is taken out of the aquifer than is being recharged.

CLIMATE CHANGE HAZARDS

Climate change can affect water resources through increasing temperatures, higher rates of evapotranspiration and altered rainfall patterns. This leads to changes in the water cycle, including decrease of snow and ice coverage, alterations of surface runoff and groundwater storage, as well as drought and flood occurrence. Climate change impacts on water resources in Canada vary regionally including shortages (droughts), excesses (floods) and associated water quality issues, depending on the season. Since 1948, snowfall has increased in the north, and decreased in southwestern Canada, whereas glacial retreat has been widespread since the late 1800s in Western Canada and since the 1920s in the Arctic, with faster rates of retreat over the past 50 years.

KEY POINT RUNOFF

Runoff is a key indicator for evaluating changes in surface water. At the national level, changes in surface runoff are varied, with significant declines occurring at 11% of localities and significant increases at 4% of localities for the 1967-1996 period, with most decreases concentrated in southern Canada.

In general, an increase in surface runoff is expected across Canada. At a country scale, an average increase in surface runoff by approximately 25% and 7% is expected respectively under a low and high emissions scenarios for the 2045-2055 period, compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C or 4°C, 14%, 26.7% or 45.0% of the area of the country will likely experience an increase in runoff, while 0%, 0.9% and 9% of the surface of the country will likely experience a respective decrease in runoff.

2050

Changes in annual runoff
% of change

+7.3%

+25.2%

2050

Runoff increase
% of area

+45.0%

+14.0%

KEY POINT DROUGHTS

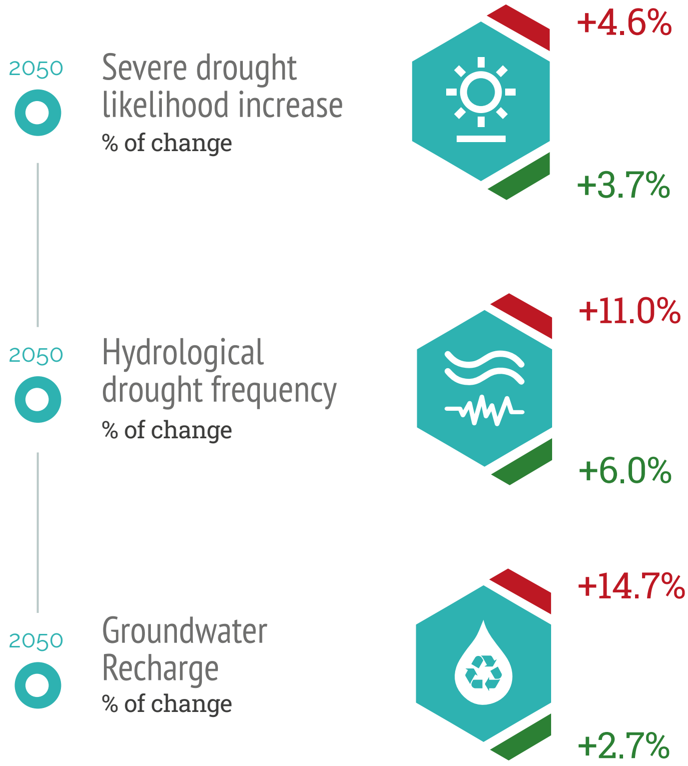
For the Canadian boreal zone as a whole, several regions experienced significant drying between 1951 and 2010, but there were also some areas with significant wetting. The Prairies is the one with the greatest frequency of drought in the country: due to a severe drought that occurred in 2017, crops were affected with poor germination, stunted growth and early maturation. Drought resulted in poor pasture production and unreliable water supplies. In 2021 severe droughts have impacted numerous areas of southwestern Canada.

With expected increases in average temperature across all seasons according to climate models, drought risk is expected to increase in many regions of the country. Current climate models suggest that the southern Canadian Prairies and the interior of British Columbia will be at a higher risk of drought in the future and as temperatures rise, the threat of drought will increase across many regions of Canada.

KEY POINT GROUNDWATER

The amount and availability of surface water influences groundwater. At the same time, groundwater plays an important role in sustaining base flow for many Canadian rivers. There are marked regional differences in groundwater recharge estimates across the Canadian landmass, with the potential for recharge concentrated on the wast and west coasts, where rainfall is also more prevalent.

Groundwater recharge is directly influenced by the amount of future rainfall, which is expected to decrease mainly in western Canada. Saline intrusion from sea level rise is expected to threaten groundwater reserves near the coast in numerous areas. At the country level, a



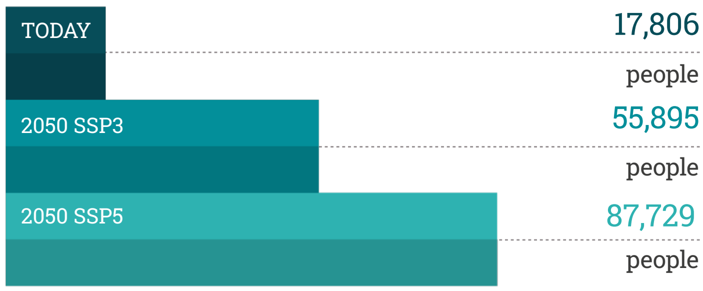
+2.7%, +12.4% and +14.7% change of the annual groundwater recharge for the period 2045-2055 compared to the timeframe 2015-2025 is expected respectively under low, medium and high emissions scenarios.

KEY POINT FLOODS

Flash floods can be extremely dangerous and several notable events have occurred in Canada. In the spring of 2013, flooding affected the southern quarter of the state of Alberta, including the city of Calgary. As many as 100,000 people had to be evacuated from the area when the Bow River watershed experienced above-average spring runoff and rainfall, with four people drowning. In Calgary alone, 3,000 buildings were flooded with infrastructure severely damaged.

Severe thunderstorms over the prairies have produced some of the highest rainfall rates and largest local floods in Canada (such as in Calgary, Edmonton and Lethbridge, and Alberta in 2014). Canada may experience an increase in the risk of flooding in many regions in winter due to less ice cover, more precipitation events, and more

POPULATION AFFECTED BY RIVER FLOODS



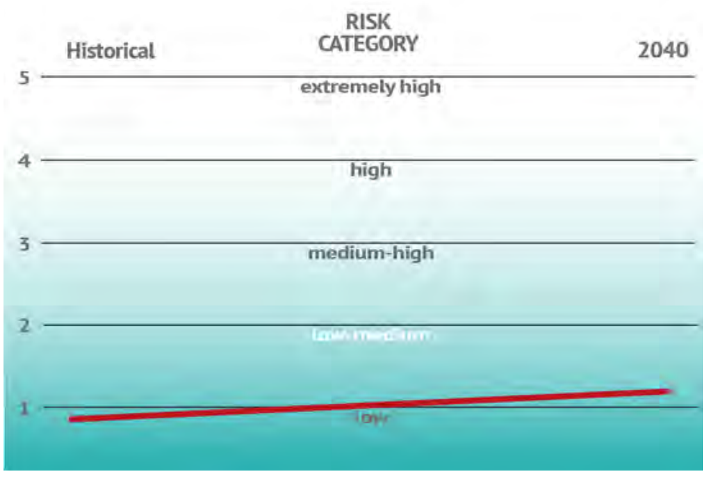
frequent winter thaw. Changes in the population exposed to floods are expected, with an increase from around 18,000 in the present day to 56,000 under SSP3 and 88,000 under SSP5 by 2050.

RISK INDICATORS

The water stress index summarises current and future water related vulnerabilities and risks at the global level. Scores are based on the ratio of total water withdrawals, including agriculture, industrial and human consumption, to available renewable surface and groundwater supplies.

WATER STRESS

Canada's water stress level is considered low for the recent past (1960-2014 average), but it is expected to increase in the near future (2030-2050) based on climate change projections.



CANADA

AGRICULTURE

OVERVIEW

Canada is one of the largest agricultural producers and exporters in the world. As with other developed nations, the proportion of the population employed and economic contribution of this sector compared to national GDP fell considerably over the 20th century. However, it still remains an important part of the economy.

Canada is among the top global producers for canola, oats, milling wheat, flaxseed, dry peas, lentils, and maple syrup, among others. One in eight Canadians works in the agriculture and agri-food sector, which employs over 2 million people between farms, processing plants, boardrooms, laboratories and beyond. A wide range of agricultural practices are used in Canada, from the sprawling wheat fields of the prairies to the summer produce of the Okanagan valley. Only a small fraction (7%) of Canada's land area is suitable for farming; most of which is found in Western Canada.

32.2 Mt
Wheat

13.9 Mt
Maize

20.3 Mt
Rapeseed

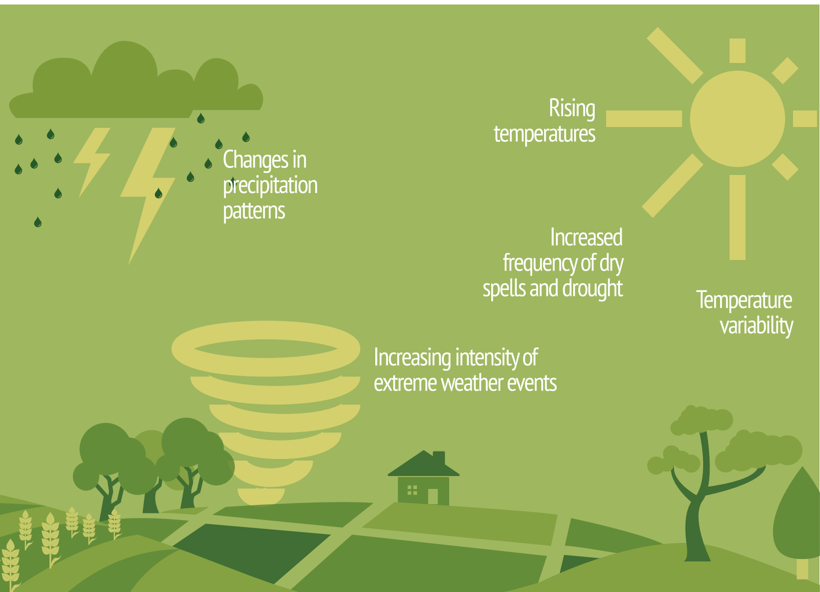
7.4 Mt
Soybeans

0.4 Mt
Apples

	Added Value of Agriculture, Forestry and Fishing	Share of Agriculture Value added in Total GDP	Agricultural land	Area Equipped for Irrigation
2000	22,476 USD Million	1.9 %	41,138 Thousand HA	1,145 Thousand HA
2018	31,293 USD Million	1.9 %	38,857 Thousand HA	1,378 Thousand HA

EXPECTED IMPACTS ON AGRICULTURE PRODUCTIVITY

Rising temperatures, reduction in average annual precipitation, and intensification of extreme events such as heat waves and drought, affect production variability with a tendency towards yield reduction for many cultivated species, accompanied by a probable decrease in food quality. Crops respond to increases in temperatures with changes in duration of the growing season, early appearance of phenological phases and potential shifts of cultivation areas toward higher latitudes and altitudes for better growing conditions. However, impacts vary significantly depending on the geographical area and specific crops in question.

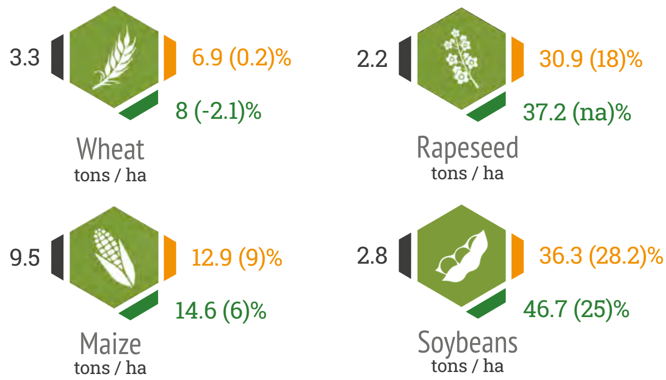


CROP PRODUCTIVITY

Crop productivity refers to the harvested yield of a crop per unit of land area. It is strongly influenced by climate and other environmental and management factors.

Climate change is expected to have an impact on the productivity of several major crops, although this may in part be offset by the fertilizing effect of higher CO_2.

Impacts are estimated using a range of model projections based on low to high emission scenarios and reported as percentage changes between the 30-year average around the historical period and the 30-year average around 2050.

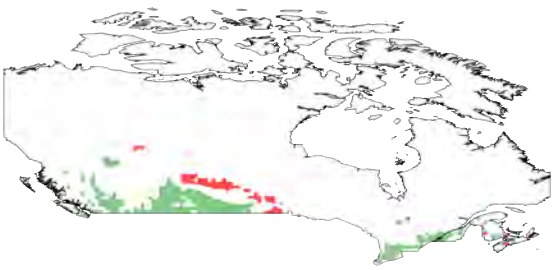


2050

Productivity change with (without) the CO_2 fertilization effect. Estimates assume sufficient water and nutrient supplies, and do not include impacts of pests, diseases, or extreme events.

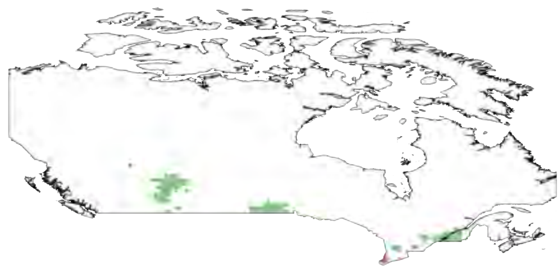
CHANGE IN WHEAT

− = +



CHANGE IN MAIZE

− = +



Longer frost-free seasons, increases in growing degree days, and even increased atmospheric CO_2 can, in theory, lead to better crop yields and productivity. However, an increase in climate variability and the frequency of extreme events would adversely affect the agricultural industry. More pronounced summer droughts may limit a growth in productivity in Canada's prairie provinces.

Rapeseed, soybean, maize and even wheat production are expected to undergo increases in productivity under future scenarios. However, these benefits may decline with warming above 2.5 °C. Spring wheat may replace winter wheat throughout most of the prairies and soybean may replace canola in southern areas.

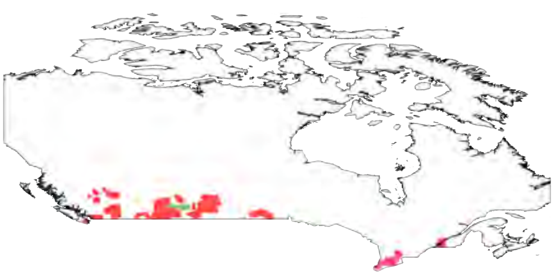
ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Canada's agricultural regions will likely see both drier summers and increased winter and spring precipitation. Projections show that although much of southern Canada will be drier overall in the summer, it could also face an increase in short-lived but very intense rainfall events. Farmers may have to deal with both too much water during the seeding season and too little water during the growing season.

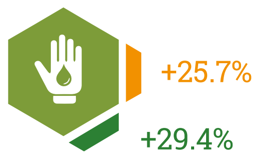
Climate change may induce an increase of 25 to 30% of water requirements for crops. Semi-arid regions may require supplemental irrigation during summers. Although availability of water supplies is extremely consistent and covers agricultural needs, irrigation development can cause increases in relevant energy costs and lead to further emissions by the agricultural sector.

CHANGE IN WATER DEMAND

− = +



Agriculture
Water Demand
% of change



2050

The use of high-efficiency irrigation systems can effectively reduce additional energy demand and costs for pumping and distribution of water in agriculture.

CANADA FORESTS

FORESTS IN CANADA

Canada is one of the most forested countries in the world and Canadian forests contain huge economic, cultural, and environmental value.

Boreal hardwood forests are largely distributed, and over 40% of primary forests are still intact, acting as a very precious source of biodiversity.

FORESTED AREA AND CARBON STORAGE

Nearly 40% of Canada is covered in forests with a stable trend over recent decades. Canadian forests store an enormous amount of carbon in living systems and soil, playing a key role in the country's emissions balance. According to the Canadian Forest Service, although managed forests used to act as a crucial carbon sink, recent natural disturbances have reversed this condition making them a carbon source: releasing more carbon than they accumulate on a yearly basis.

1990

348 Mln ha
Million hectares
Forested area

210 Tons/ha
Tons of Carbon per hectare
Carbon stock

2020

347 Mln ha
Million hectares
Forested area

208 Tons/ha
Tons of Carbon per hectare
Carbon stock

2050

Productivity anomaly
Tons of Carbon per hectare per year

+0.56

+0.45

FOREST PRODUCTIVITY

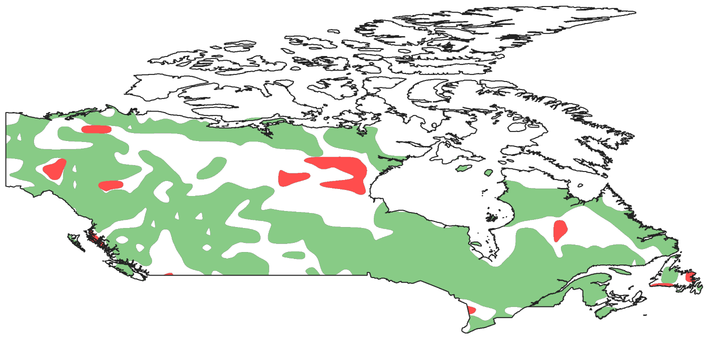
Forest productivity, or Net Primary Production, is the net carbon captu- red by plants. It is the difference between the carbon gained by Gross Primary Production - net photosynthesis measured at the ecosystem scale - and carbon released by plants' respiration. It is expressed per unit land area.

Weak increase expected in most of the country. Strong in the northwest.

+ Fertilizing effect of increasing atmospheric CO_2
+ Melting permafrost
+ Lengthening of growing period

Decrease expected on the northern boundary of the distribution ranges (Nunavut), and in large areas of residual boreal primary forest.

+ Spread of dangerous insect outbreaks



KEY SPECIES UNDER CLIMATE CHANGE

SHIFTING
BOREAL
Boreal forests are moving northwards too fast

DECREASING PRODUCTION
CONIFERS
Strong decrease in biomass production of dominant boreal species (mid to late successional conifers)

DIEBACK
ASPEN
Increased aspen dieback in the Prairies

INCREASING
COLONIZER SPECIES
Increasing abundance of colonizer temperate species

FIRES IN CANADA

Fire is a structural ecological process that provides several types of ecosystem services and impacts on socio-ecological systems, including human health, carbon budgets, and climate change. Changes in global fire activity are influenced by multiple factors such as land-cover change, policies, and climatic conditions. Fire also releases large quantities of greenhouse gases into the atmosphere, contributing to a vicious cycle.

During the last two decades, the total forest area affected by fire was approximately 41.8 million hectares.

BURNING
41.8 MILLION HECTARES OF FOREST

EMITTING
56.7 TERAGRAMMES OF CARBON PER YEAR

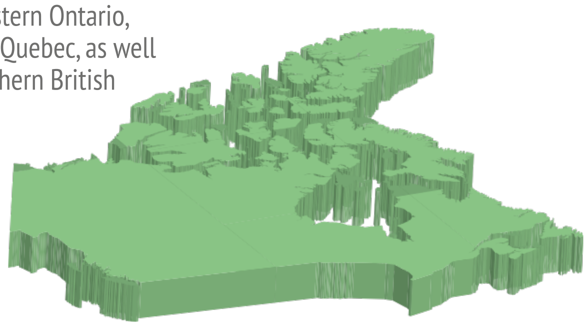
FOREST FIRE EMISSIONS CONTRIBUTED TO 90% OF TOTAL FIRE RELATED CARBON EMISSIONS

COSTING
417 MILLION USD IN ANNUAL SUPPRESSION COSTS (1970-2009)

WHERE DO FIRES OCCUR?

Lightning-caused fires are more common in British Columbia, Ontario and Alberta.

Fire occurrence is mainly human-caused in high population density areas such as central and eastern Ontario, south-western Quebec, as well as central-southern British Columbia.



The most affected areas are the Taiga plains and the Taiga Shield down through the Boreal eco-zones.

FUTURE BURNED AREA

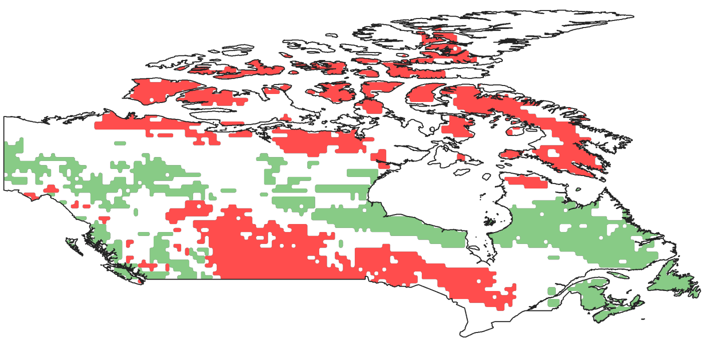
Under a low emissions scenario, models project a generalized increase in burned area over the Artic tundra and mid boreal forests and prairies. This trend is emphasized under a medium emissions scenario, particularly over boreal plains and the western shield. Burned areas may decrease in some taiga forest areas around Hudson bay and in eastern regions.

Burned Area
km^2 per year

2050

+1,238

+943



Decrease in burned areas for a low emissions scenario

Increase in burned areas for a low emissions scenario
+ Prolonged fire season due to rising temperatures and fuel dryness
+ Increase in the proportion of days with unmanageable fires across northern and eastern boreal forests.

VARIATION OF SPECIFIC FIRE INDICATORS

% of change
Crown fire days in Eastern Canada

2090

+47%

+9%

% of change
Crown fire days in Western Canada

2090

+45%

+24%

% of change
Average annual fire suppression cost

2041-2070

+58%

+39%

FUTURE FIRE EMISSIONS

Fire emissions follow a similar spatial pattern to burned area with important changes over eastern and western parts of the country under both low and medium emissions scenarios.

Fire Carbon emission
Teragrams of Carbon per year

2050

+44.2

+33.9

CANADA URBAN

OVERVIEW

A 20% growth in Canada's population is expected by 2050, with the country becoming increasingly more urbanized.

Over half the urban population live in cities with more than 1 million residents, whereas 25% live in cities with fewer than 300,000. The number of big cities and percentage of urban populations residing there are not projected to change much by 2035.

Built up areas cover 0.16% of Canada (15,717.89 square kilometers).

Population in Urban Areas

2020: 30,670,064

2050: 39,233,850

Graphs refer to data provided by United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization

Urbanization Rate

2020: 81.6%

2050: 87.3%

OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

With climate change, Canadian cities will face more frequent and intense heat events; increased incidences of poor air quality; short-duration, high-intensity rainfall events; wind storms; wildland-urban interface fires; coastal erosion; storm surge flooding; and decreased water quality.

HEATWAVES AND HEAT STRESS

Cities are subject to higher temperatures because of the Urban Heat Island (UHI) effect. Built up areas absorb solar radiation during the day and release the heat at night, warming the surrounding air. This is a result of several factors including reduced natural landscapes, building material properties, urban geometry and waste heat. Canada is warming at twice the rate of global mean temperature increase. From 1948-2016 the mean annual temperature increased by 1.7°C for all of Canada, and 2.3°C for the northern portion of the country.

Hot days (max temp > 30°C) are uncommon north of 60° latitude, but have increased annually by about 1-3 days at several stations in southern Canada from 1948-2016. Hot nights (min temp > 22°C) have increased at a few stations in southern Ontario and Quebec.

Future scenarios of **+1.5°C**, **+2°C** and **+4°C** mean temperature increse indicate that the frequency and duration of heatwaves will increase for the entire country. This will lead to an increase in the number of cooling degree days.

Cooling Degree Days (% of change) — 2050

+970.7%
+248.1%
+135.4%

Heatwave frequency (% of change) — 2100

+82.7%
+26.5%
+14.0%

Heatwave duration (% of time) — 2050

+1,306%
+181%
+63%

HEAT, HEALTH AND AIR POLLUTION

Heat related health impacts from increasing air temperatures in urban areas are furthermore accentuated by air pollution. Wildfires, which are projected to increase in frequency, contribute to lower air quality at the wildland–urban interface. Particulates (especially PM2.5) from wildfire smoke can affect air quality and health across great distances.

2017

Population exposed to air pollution

0%

COASTAL FLOODING

Canada has the most extensive coastline in the world, fronting on the Atlantic, Arctic and Pacific Oceans. Coastal communities in Canada are facing risks including damage to coastal infrastructure, property, and people from inundation, saltwater intrusion and coastal erosion due to sea level rise and storm surges.

The different landscapes and climates of the west coast, north coast and east coast regions influence their relative vulnerability to sea level rise and coastal flooding. Changes in sea-level will vary significantly in the future, and in the areas where sea levels are rising, the frequency and magnitude of storm-surge flooding will increase.

Projected sea level rise

2050

0.23 m

0.18 m

2100

0.77 m

0.38 m

EXTREME PRECIPITATION EVENTS

The amount of precipitation varies widely across Canada, decreasing from south to north. Recent trends show that annual mean precipitation is increasing, on average, with larger percentage increases in northern Canada.

Annual precipitation and winter precipitation are projected to increase accross the country in the 21st century, with larger percentage changes in northern Canada. Summer precipitation is projected to decrease in southern Canada.

2050

Runoff increase
% of area

+45%

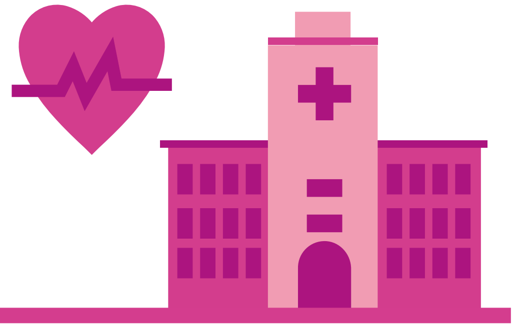
+27%

+14%

SURFACE SEALING AND FLOODS

Heavy precipitation in cities is problematic due to the high level of sealed surfaces. Soil sealing increases run off and reduces the amount of water absorbed by soil. Where there are large amounts of impervious ground cover, short duration extreme rainfall events can lead to increased flooding, even resulting in flash floods.

CANADA HEALTH



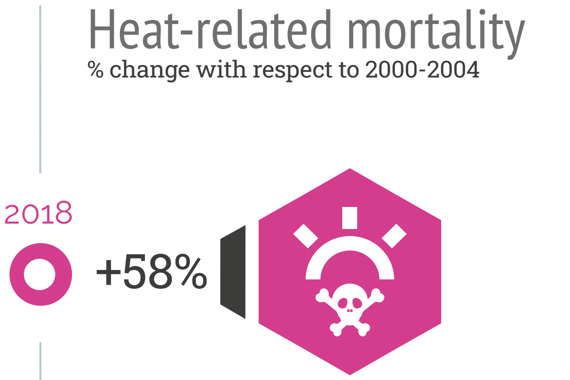
OVERVIEW

Due to its large landmass, the climate-related impacts on the wellbeing of Canadians varies widely from region to region. Future climate change is likely to increase many health risks, including that of infectious diseases. The impacts of climate change on health are increasing rapidly, and at the same time, the health and social systems necessary to mitigate these impacts are often unable to meet the needs of those most vulnerable to climate-related health hazards.

HEAT RELATED MORTALITY

Climate change related health risks in Canada include direct and indirect illnesses and deaths related to poor air quality, water and food borne contamination, changing patterns of diseases spread by animals, ticks and insects. Extreme weather events, including extreme heat events and urban heat islands due to the increase in temperature extremes and the risk of heat-related illness, will increase while exacerbating cardiovascular disease, diabetes, and respiratory diseases. Still, cold exposure in some places will be reduced. Under a high emissions scenario, heatwave-related excess deaths will increase by 455% in Canada.

Under a medium emissions scenario, the increases in heatwave-related excess mortality will be around 293%. In 2018, there was a 58% increase in heat-related deaths in Canada compared to a 2000 to 2004 baseline. 38.5% of heat-related mortality during 1991 to 2015 can be attributed to human-induced climate change.

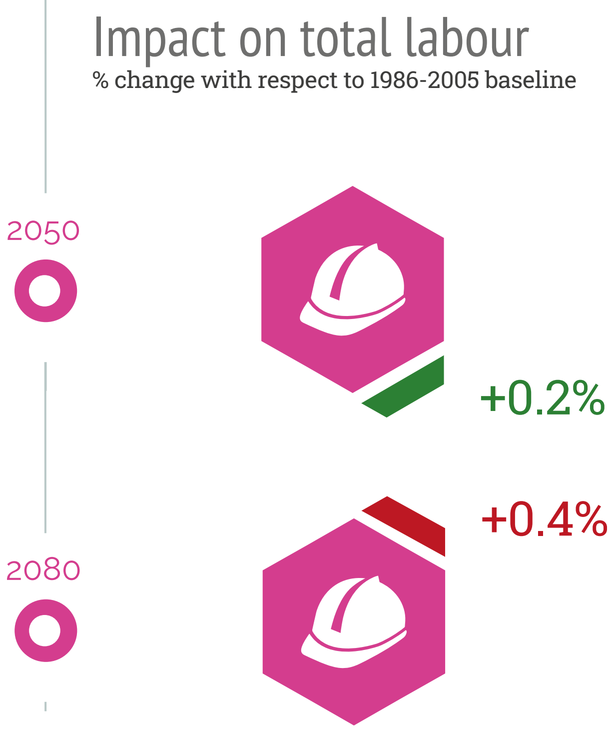


IMPACTS ON LABOUR

Labour is directly affected by changes in environmental conditions. Warming affects both the number of hours worked (labour supply) and on the productivity of workers during their working hours (labour productivity). Both labour supply and productivity are projected to decrease under future climate change in most parts of the world, and particularly in tropical regions.

Parts of sub-Saharan Africa, south Asia, and southeast Asia are at highest risk under future warming scenarios. Future climate change will reduce global total labour in the low-exposure sectors by 18 percentage points and by24.8 percentage points in the high-exposure sectors under a 3.0°C warming scenario

Canada is one of the few countries projected to experience positive impacts on labour productivity due to climate change. In Canada, there was a 4.4% gain in potential hours of labour in the agriculture and construction sectors in 2019, compared to a 1990s baseline. Total labour in Canada is expected to increase by 0.22% under a low emissions scenario and by 0.36% under a medium emissions scenario.



CLIMATE CHANGE AND DENGUE

Dengue has spread throughout the tropical world over the past 60 years and now affects over half the world's population. Globally, vectorial capacity for both dengue vectors (A. aegypti and A. albopictus) has been rising steadily since the 1980s, with nine of the ten highest years occurring since 2000.

Climatic stressors are one important driver of the current distribution and incidence of dengue. Climate change is likely to expand the geographical distribution and suitability of several vector-borne human infectious diseases including dengue. The risk of dengue transmission is increased by warming climates, as the growth and development of mosquitoes are significantly influenced by temperature, precipitation, and humidity.

CLIMATE CHANGE AND ZIKA

Zika virus has spread to at least 49 countries and territories since 2013. Climate change impacts on transmission suitability risk have increased over the years and future warming over 1.3 billion additional people could face suitable transmission temperatures for Zika by 2050.

DENGUE AND ZIKA: POPULATION AT RISK

Canada is currently at low risk of dengue and Zika transmissions. Climate change is likely to have both direct and indirect impacts on the burden of West Nile fever, dengue, chickungunya fever, malaria, leishmaniasis, tick-borne encephalitis, Lyme borreliosis, Crimean Congo haemorrhagic fever, spotted fever rickettsioses, yellow fever, Zika, and Rift Valley fever. However, these risks will increase due to future climate change.

Warming temperatures due to climate change are improving the suitability conditions for the spread of ticks that carry Lyme disease in Canada. Under a low-emissions future, additional cases of Lyme disease will increase to around 8,500 annually by mid-century compared to about 600 cases per year.

CLIMATE CHANGE AND MALARIA

Cases of Malaria are rare in Canada; however, climate change will likely increase the occurrence of temperature conditions suitable for malaria transmission. 6.4% of the Canadian population will be at risk of malaria under a low emissions scenario in 2050, whereas 12.5% will be at risk under a high emissions scenario.

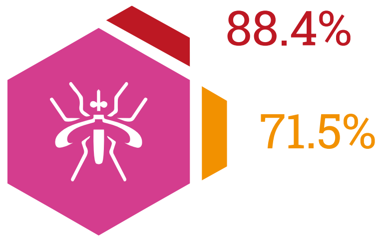
POLLUTION AND PREMATURE MORTALITY

In 2019, 14,600 premature deaths were associated with ambient air pollution exposure in 2015.

2050

Dengue suitability

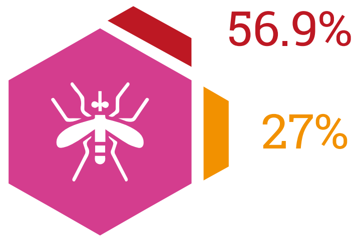
% of population at risk



2050

Zika suitability

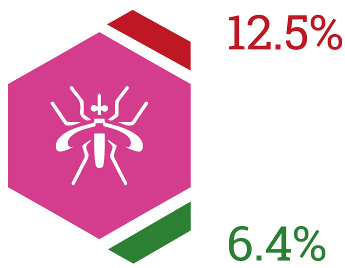
% of population at risk



2050

Malaria suitability

% of population at risk



CANADA ENERGY

ENERGY SYSTEM IN A NUTSHELL

With over 75% of electricity generated from non-emitting sources the Canadian electricity system has one of the lowest carbon contents in the world, although fossil fuels dominate the overall energy mix.

In 2019 a carbon tax of was introduced, with plans to increase it gradually. Canada is one of the top world energy producers, with the highest energy supply per capita. Most fossil fuels produced are exported.

0.17
ktoe/US$
Energy intensity

5.2%
AC Share in electricity consumption

CLIMATE CHANGE TODAY

HYDROPOWER

Changes in temperatures and rainfall have impacted surface water levels in Canada, which can have a direct impact on the capacity of hydroelectric power generation.

STORMS

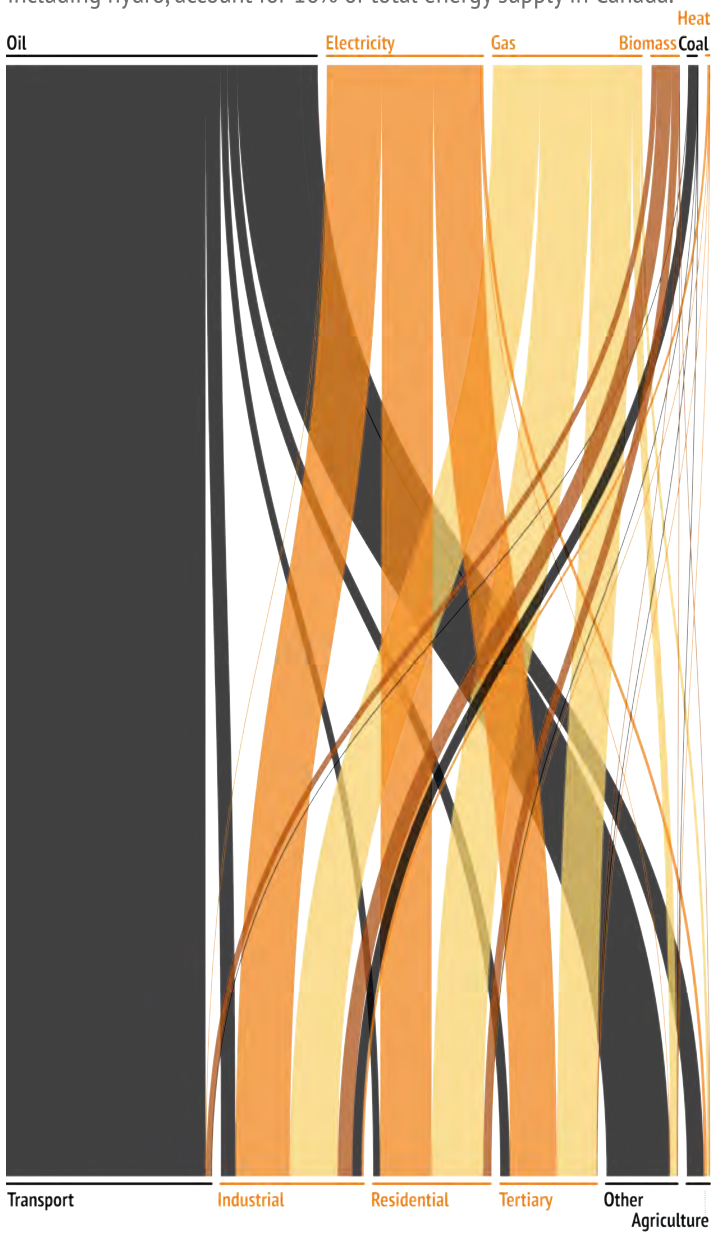
Severe storms, hurricanes and floods have caused major power outages and substantial damage to energy infrastructure, for example Post Tropical Storm Arthur in 2014, the USA Canada ice storm of 2013 and the 2013 flash flood in Toronto.

VULNERABILITY

The energy infrastructure in Canada is ageing and a large proportion will need replacement or updating by 2050. Much of the infrastructure is highly vulnerable to climate risks, as it was designed based on outdated weather-related assumptions.

ENERGY SUPPLY

Canada's total primary energy supply energy mix is dominated by natural gas and oil (both 35% in 2019), followed by hydropower (nearly 11%, and historically a steady and major contributor). Nuclear is also relevant (8% of total primary energy supply in 2019). Coal use is declining, accounting for only 5% in 2019. Renewable sources, including hydro, account for 16% of total energy supply in Canada.



ENERGY DEMAND

Energy demand in Canada is driven mainly by transport (33%), the majority of which for road transport, followed by residential (22%) and tertiary (13%). The agricultural and forestry sector demand is negligible. Industry is also responsible for most of the non-energy use of fuels (9%). Air conditioning accounts for approximately 10% of final residential electricity consumption.

FUTURE ENERGY DEMAND

In Canada, hotter summers will increase peak demand, particularly in large cities due to the urban heat island effect. Increasing energy demand in the USA could also result in an increase in Canadian electricity exports.
Overall, total energy demand is projected to decrease, as the decrease in heating needs more than outweighs the increase in cooling needs, resulting in a net decrease in energy demand slightly in excess of 281 PJ (78 billion KWh) by 2050 under a medium emissions scenario.

Net change in energy demand due to changes in HDD/CDD
Billion KWh

2050

- 78.10

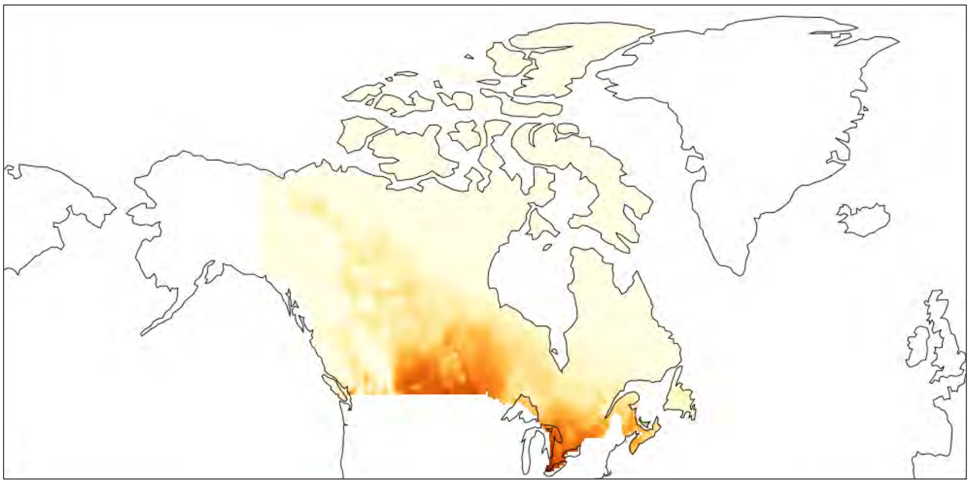
COOLING NEEDS

Cooling needs will increase summer demand in many regions. The effects will be most severe in the south eastern and Prairie regions, while northern regions remain mostly unchanged.

The increase in cooling needs is expected to be less than the decrease in heating needs across the country, resulting in a net decline in energy demand.

COOLING DEGREE DAYS

0 281

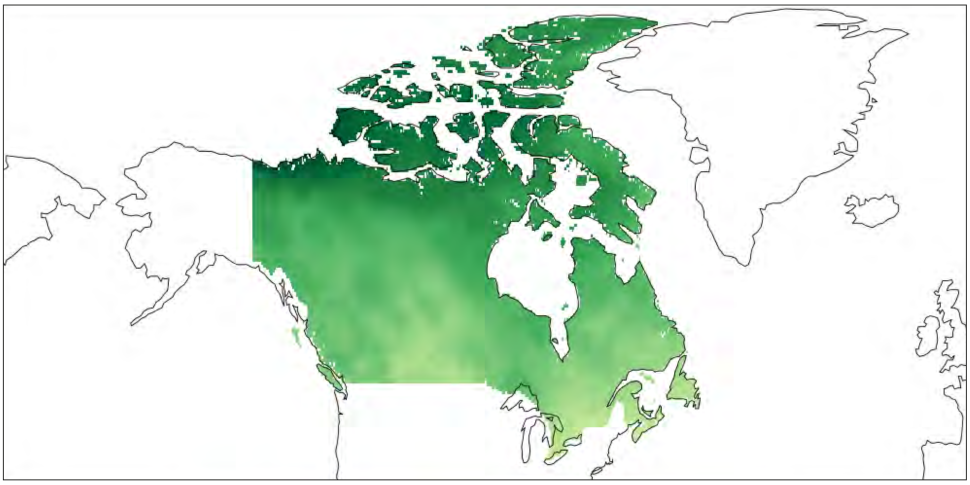


HEATING NEEDS

Heating needs are expected to decline drastically all over the country and in particular in the northern regions, outweighing the increases in summer cooling needs expected in the south, along the border with the USA.

HEATING DEGREE DAYS

-1,526 0



FUTURE ENERGY SUPPLY

The future configuration of the Canadian energy mix is likely to be determined by the evolution of climate mitigation policies and hence is outside the scope of this report. However, given that Canada has established targets to reduce CO_2 emissions by 30% of 2005 levels and achieve net-zero emissions by 2050, it is likely to result in a reduction in the relevance of fossil fuels and their vulnerabilities, while carbon-free sources and their vulnerabilities will prevail.

Change in Hydropower generation
% of change

2050

-6.41%

-5.79%

EXPECTED IMPACTS OF CLIMATE CHANGE

Studies do not agree about the future of hydropower generation in Canada. They range from average production gains of 7.1% under a low emissions scenario and 4.4% under a high emissions scenario, to decreases by -5.8% and 6.5% under the same two scenarios.

CANADA ECONOMY

OVERVIEW

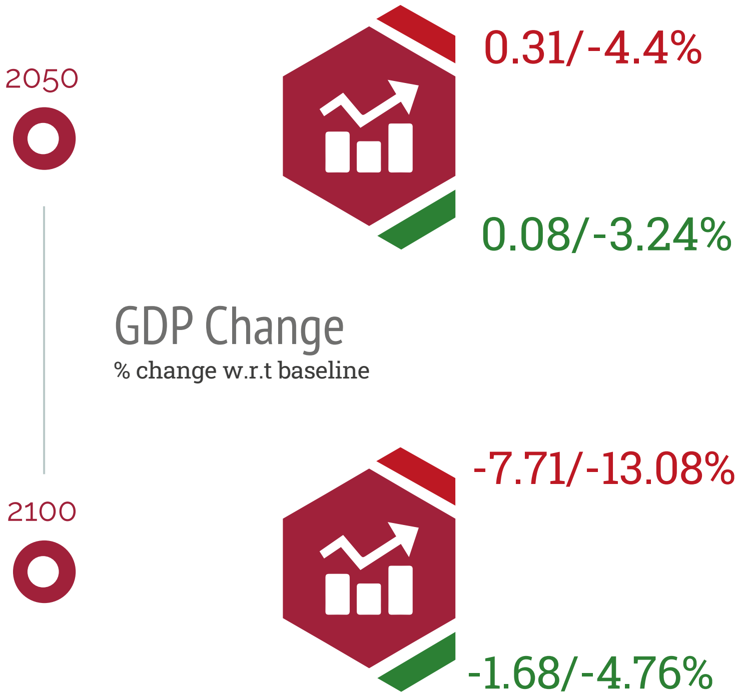
Canada ranks 11th in terms of GDP in the G20 group. The COVID 19 crisis impacted the economy, which registered a 5.4% decline in real GDP in 2020.

IMPACTS ON GDP

Climate change will have an effect on the growth rate and overall systematic economic performance of the country. In the short term and for moderate levels of warming the overall economic impacts of climate change may be slightly positive for Canada.

By mid century, a low emissions scenario is indeed associated with a 33 billion euro loss, but also to possible benefits of 0.8 billion EUR. The high emissions scenario is associated with a loss of 45 billion EUR, but also to potential gains of 3 billion EUR.

By the end of the century, impacts are expected to be unambiguously negative with losses ranging from 18 billion to 49 billion EUR under a low emissions scenario and rising to between 79 billion to 133 billion EUR under a high emissions scenario.



SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

Canada's extensive coastline spreads across three marine coasts and covers 243,000 kilometers. A large majority of the population lives near coastal areas (one in six living within 20 kilometers of a marine coast) leaving them vulnerable to sea level rise and extreme weather events. Climate change is expected to increase the pre-existing risks of flooding and storms.

IMPACTS ON AGRICULTURE

Resource-based industries such as mining, agriculture, forestry, fishing and hunting are a relatively small contributors to Canadian GDP (2.1%). However, they remain an important component of foreign trade and support Canadian wealth. Being a "cold" country, the economic impacts of climate change in the agricultural sector are estimated to be slightly positive for Canada.

Under a medium emissions scenario, Canadian prairie agriculture (where over 80% of Canada's agricultural land is located) could gain between 1.14 billion CAD (0.76 billion EUR) and 1.63 billion CAD (1.08 billion EUR) annually. Relative to the annual value of the Praries' crop and animal production of 11.67 billion CAD (7.7 billion EUR), this is a substantial gain.

Despite these positive predictions, extreme weather events of recent years (2010-2016) in the Canadian Prairies, including flooding, drought and wildfire have been some of the most damaging natural disasters in Canadian history. The 2016 wildfire in Fort McMurray, Alberta cost almost 4 billion CAD (2.65 billion EUR). Climate models predict an increased risk of these events in the future.

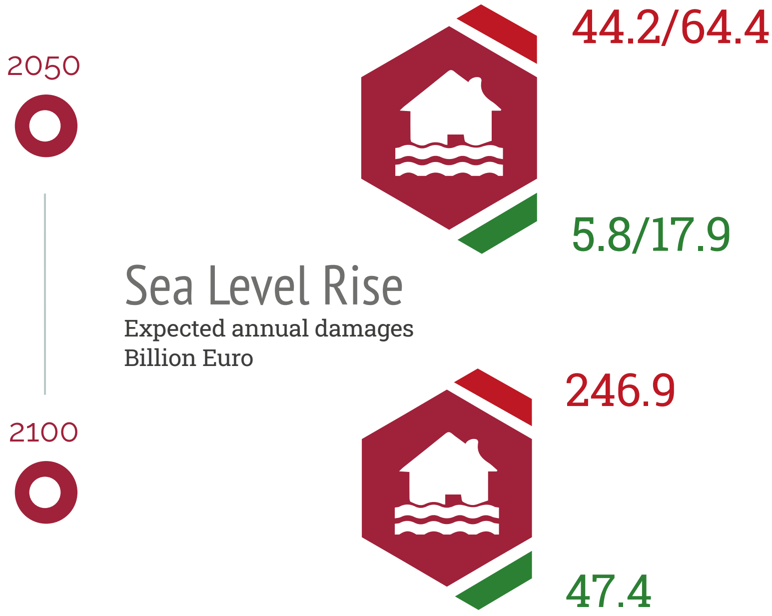
Additionally, drastic economic impacts at a community level can be masked by these aggregate analyses. Certain communities are highly dependent on natural resources for their income and costs will be much larger for these groups, for instance in Aboriginal and Arctic communities, where the subsistence economy makes up between one-quarter and one-half of their total economy.

Overall, climate change will bring both benefits and risks to Canadian agriculture. Achieving the projected benefits will depend on the extent to which farmers adapt and its effectiveness.

SEA LEVEL RISE DAMAGES

Under the current level of coastal protection, by mid century, sea-level rise and coastal flooding may cost the country 5.8 - 17.9 billion EUR and 44.2 billion EUR in terms of expected damage to assets in the low and high emissions scenarios, respectively.

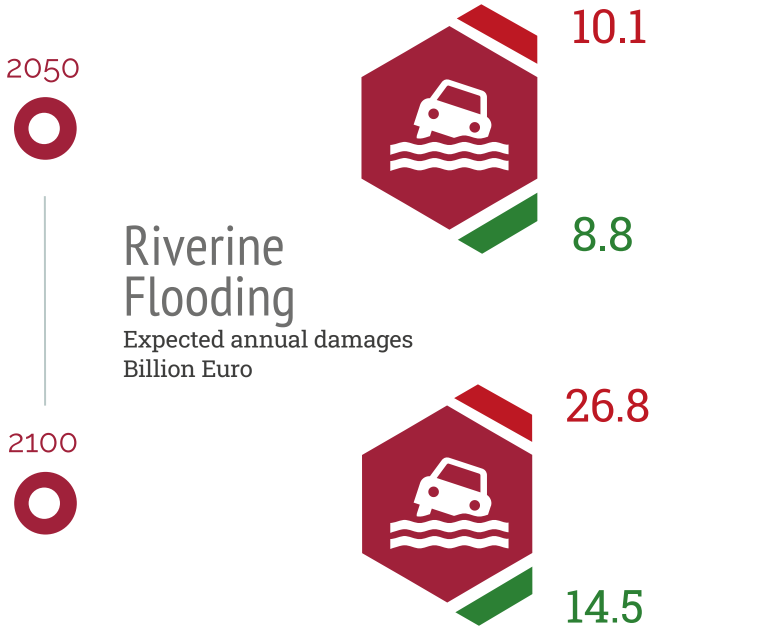
By the end of the century, expected losses can increase to between 47.4 billion and 64.4 billion EUR under a low emissions scenario and to 246.9 billion EUR under a high emissions scenario.



RIVER FLOODING DAMAGES

River flooding is projected to result in significant annual damages. By mid century these are estimated to be 8.8 billion EUR under a low emissions scenario and 10.1 billion EUR under a high emissions scenario.

By the end of the century, damages are projected to be 14.5 billion EUR under a low emissions scenario and 26.8 billion EUR under a high emissions scenario.



IMPACTS ON FORESTRY AND FISHERY

Forestry is another important sector in Canada which makes up 1.7% of national GDP, or 17 billion EUR and where 10% of the world's forest cover resides. Climate change is predicted to increase the risks of wildfires, affecting timber supply and increasing costs of fire management. Climate change could cost Canada between 25 billion CAD (16.6 billion EUR) under a low emissions scenario and 276 billion CAD (183 billion EUR) under a high emissions scenario by 2080 due to reduced timber quantities.

IMPACTS ON ENERGY

Changes in water availability will affect the capacity of hydropower generation in Canada, and could lead to substantial economic losses. Economic impacts of shifts in household and firm energy demand (see chapter on energy) are difficult to predict and will mostly lead to redistribution effects. In the case of Canada, an overall decrease in energy bills is expected due to the heavily reduced heating needs, which is expected to largely exceed any increase in cooling needs. By 2050, under a worst case climate scenario, the potential losses to hydropower generation from extremely low water levels in the Great Lakes and St. Lawrence watershed could reach 1.9 billion EUR. Severe weather such as ice storms and coastal storm surges threaten energy infrastructure in Canada, particularly in Charlottetown, PEI, and parts of Nova Scotia. A large amount of energy infrastructure is outdated and will need replacing by 2050 as it was constructed based on older weather related assumptions.

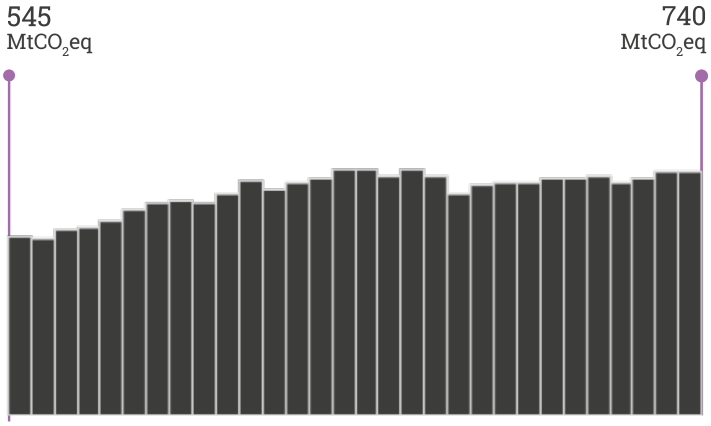
IMPACTS ON TOURISM

No exact figures are available for the economic impact on the Canadian tourism sector as a whole. However, the overall impact is expected to be positive for Canada, where higher temperatures might extend the summer season. However, a high emissions scenario could eliminate over half of the Canadian ski season by the end of the century, resulting in the loss of over 420 million CAD (278.8 million EUR). The 5 billion CAD (3.3 billion EUR) winter tourism industry is also likely to be impacted severely.

CANADA
POLICY

OVERVIEW

Canada is the 2nd largest country in the world, with a population density of 3.9 people per square kilometre. It accounts for 1.6% of global emissions and in 2018 registered one of the highest rates of GHG emissions per capita.



INTERNATIONAL COMMITMENTS

In its 2021 NDC update, Canada strengthened its emissions reduction target from a 30% reduction below 2005 levels by 2030 to at least 40-45%.

CLIMATE POLICY COMMITMENTS CHRONOLOGY

2002 **Kyoto Protocol - 1st period**

6% in yearly average reduction of GHG over the four year period 2008-2012, with respect to 1990 levels

2016 **Paris Agreement - 1st NDC**

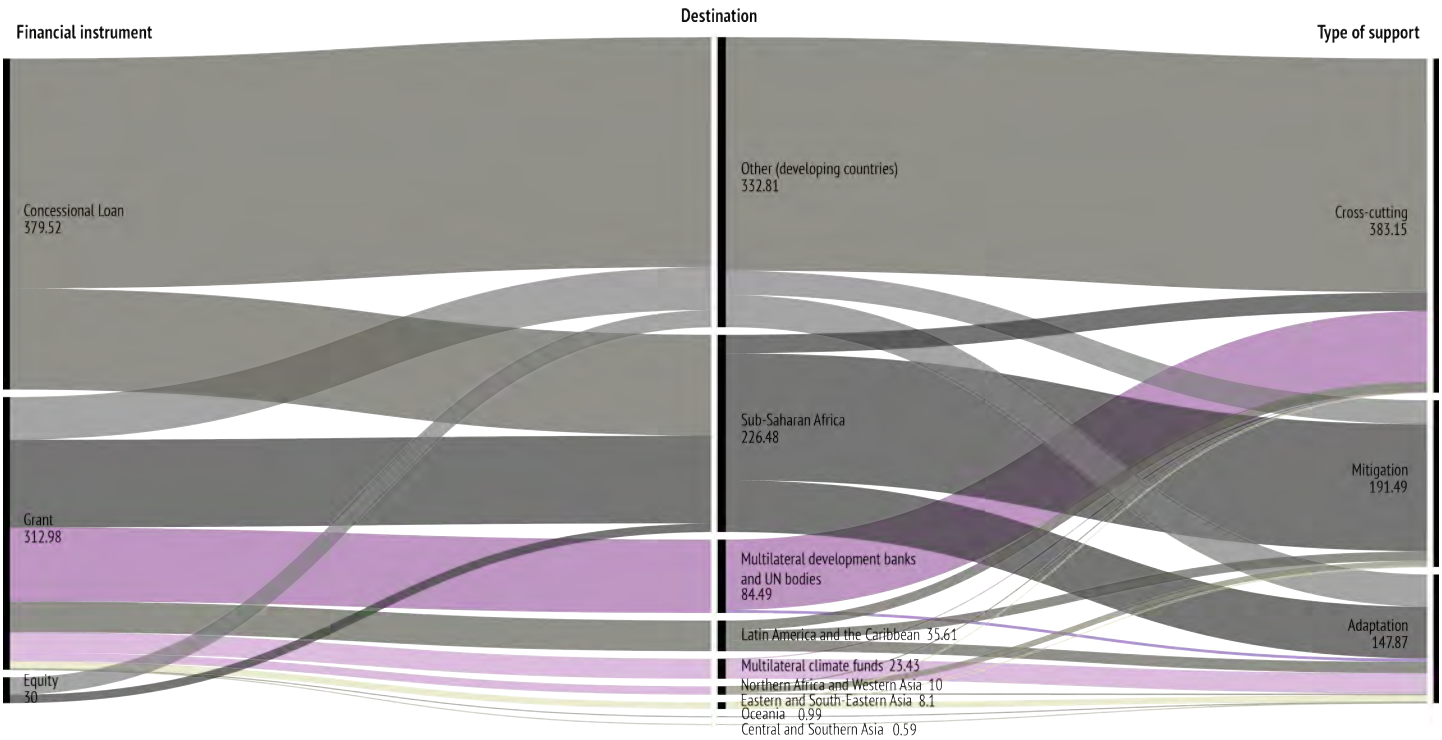
30% GHG reduction by 2030, with respect to 2005 levels

2021 **Paris Agreement - NDC update**

Between 40% and 45% GHG reduction by 2030, with respect to 2005 levels

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

The 4th Biennial Report shows that Canada provided 722.54 million USD in climate-specific development aid in 2017 and 2018, mainly targeting sub-Saharan Africa. More than half of which provided in the form of bilateral concessional loans and equity.



SUSTAINABLE RECOVERY POLICY

According to the Global Recovery Observatory, in 2020 the proportion of green spending out of total recovery spending was 75%, 60% of which was allocated to clean energy infrastructure investments.

249.6 billion $	27.25 billion $	20.31 billion $
Total Spending	Recovery Spending	Green Spending

DOMESTIC ADAPTATION POLICY

The Pan-Canadian Framework on Clean Growth and Climate Change includes actions to advance climate change adaptation and build resilience to climate impacts. In December 2020, Canada's federal government announced its commitment to developing Canada's first-ever national adaptation strategy (NAS).

Domestic Adaptation Policy
- ○ Inclusion of Adaptation in NDCs
- ● Integrated Adaptation & Mitigation Policy
- ○ Dedicated Adaptation Strategy
- ○ Dedicated Adaptation Plan

Subordinate Adaptation Policies
- ○ Sectoral Adaptation Plans
- ● Subnational Adaptation Plans

○ Policy not in place ● Active policy

ADAPTATION POLICY HIGHLIGHTS

TRANSNATIONAL INITIATIVES

International Upper Great Lakes Study (IUGLS)

IUGLS was established to improve to outflow regulation of Lake Superior to better address changing needs and the impacts of future climate on water flows, water levels, and associated resources

Canada-US agreement on weather and climate collaboration

The MoU between Canada and US facilitates bilateral cooperation on activities that promote improved meteorological hydrological and environmental forecasts and information

NATIONAL INITIATIVES

CCGP

The Earth Science Sector's Climate Change Geoscience Program (CCGP) develops geoscience information to help land-use planners, industry and regulators to mitigate the climate risks in northern resource development

Climate Lens

The Climate Lens is an assessment framework developed to help decision-makers understand the climate risks with the design, construction and operation of large infrastructure projects in Canada

SUBNATIONAL INITIATIVES

Atlantic Climate Adaptation Solutions (ACASA)

ACASA is a partnership among the provincial governments and regional stakeholders including NGO, tribal governments, and industry to jointly address regional climate change impacts

First Nation Adapt Program

The program prioritizes First Nation communities most impacted by climate change (sea level rise, flooding, forest fires, drought, fisheries and winter road failures), by providing funds to assess the impacts on infrastructures and to reduce disaster risk

ENERGY TRANSITION

Canada shows an Energy Transition index about 5 points above the G20 average: this is mainly due to an outstanding performance in Renewables penetration (more than twice the average). Emissions, Efficiency and Fossil Fuels indicators also contribute to the transition, being slightly above or below the average.

On the contrary, looking at the Electrification indicator, there is still room for improvement: the ongoing digitalization of the grids could spark energy consumption patterns in both residential and transport sectors.

	G20 Average	Country
Energy Transition	58.7	63.2
Fossil Fuels	45.3	48.1
Renewables	19.7	46.0
Efficiency	84.9	84.5
Electrification	70.8	63.4
Emissions	72.9	73.9

G20 AVERAGE
COUNTRY

Only actively pursuing an energy transition based on decarbonization and electrification – from policy and regulation, to health and education – will enable countries to benefit the most from future opportunities and fight climate change whilst ensuring an equitable distribution of wealth.

The Energy Transition indicators were developed by Enel Foundation in cooperation with SACE, and provide a retrospective analysis based on historical data.