UNIT TWO

A resource for building climate resilience in Alberta

2 Make the case

What this unit will help you do

You have been directed to this unit because:

- You need to explain and rationalize why your community should proactively take steps to adapt to our changing climate and manage risks and opportunities that may arise.

This unit contains four sections, each considering a linked theme around which you can collectively develop a business case for adaptation:

Section 1: The climate is already changing.

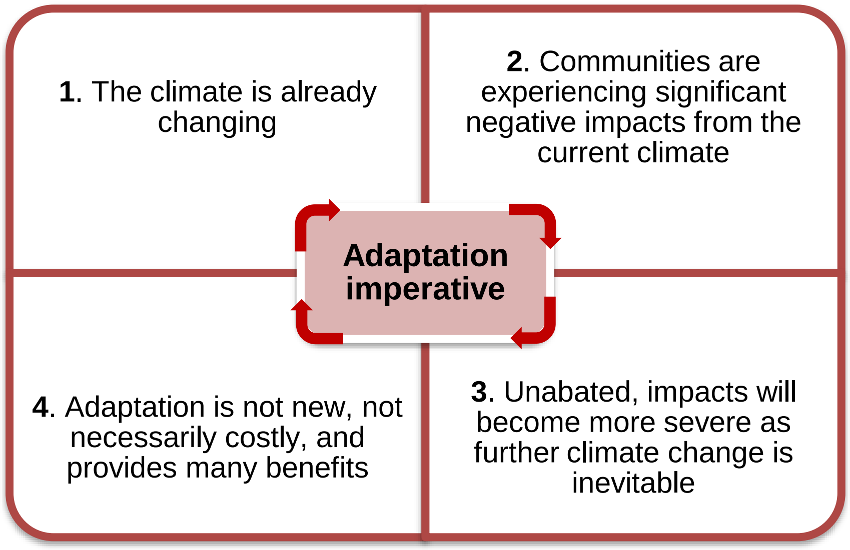
Section 2: Communities are experiencing significant negative impacts from the current climate.

Section 3: Unabated, impacts will become more severe as further climate change is inevitable.

Section 4: Adaptation is not new, not necessarily costly, and provides many benefits.

All local governments face the challenge of constrained operational resources, such as staffing and funding, together with competing priorities within their diverse portfolio of responsibilities. Moreover, these challenges are likely to be more significant in smaller, isolated communities.

To address these concerns, this unit provides information to help you construct and communicate a business case for enhancing climate resilience in your community. The case to act can be developed around the following four linked themes:



Each theme is considered in turn below. One or more "facts" are presented under each theme, which you can draw upon to construct a case for adaptation that will resonate with senior-level management and elected officials. Use the information herein to build consensus among these decision-makers of a shared understanding of the seriousness of climate change impacts and the need to act.

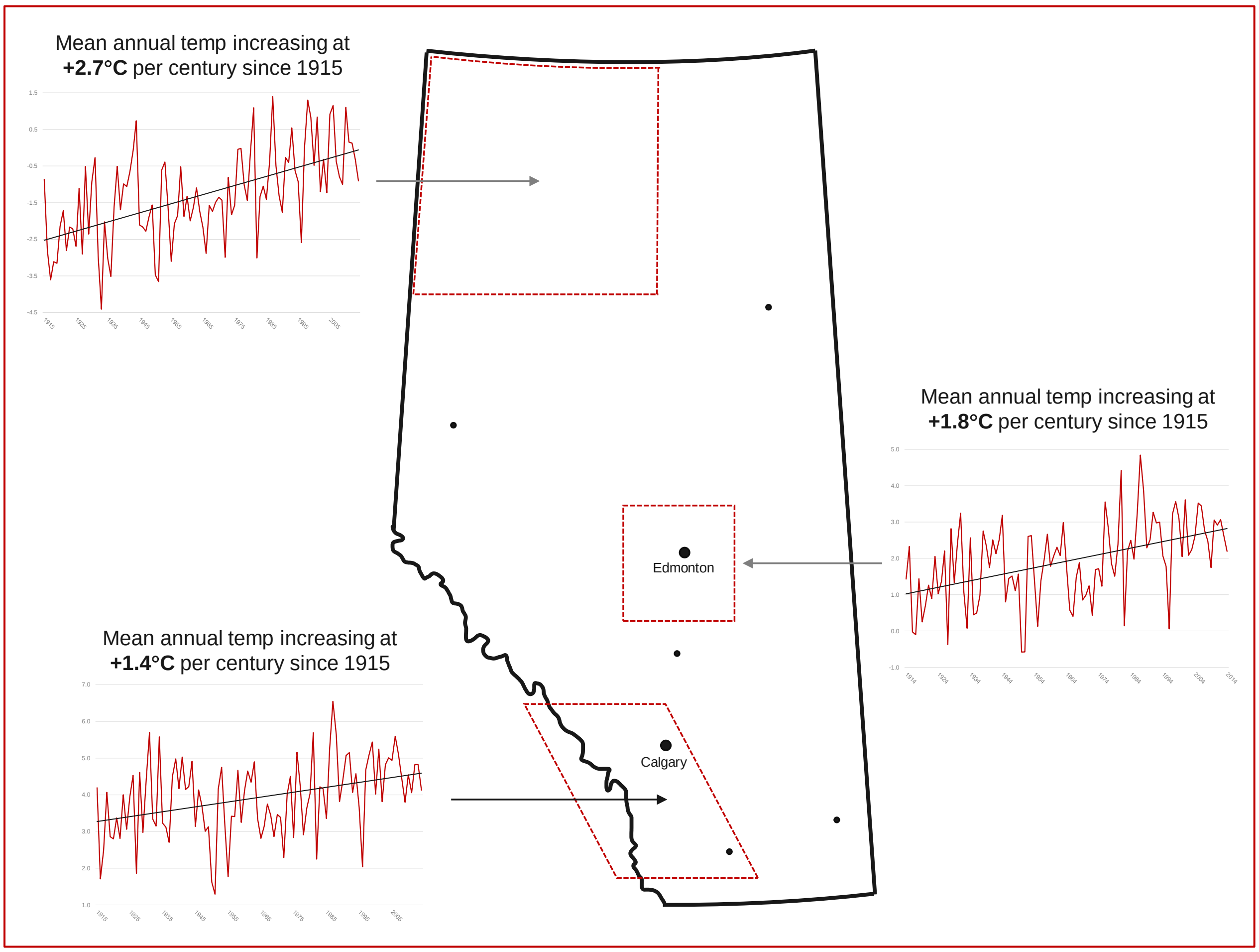
Section 1: The climate is already changing

Fact: Climate change is already being observed in Alberta.

Evidence suggests climate change is already happening in Alberta, with observable changes in temperature, precipitation, and extreme weather events over the last century. Average annual temperature across the province has increased by about +1.4°C since the early 1900s—that is two times the rate of temperature increase observed globally. Northern regions of the province have witnessed greater warming than southern regions (see **Note**: Graphs show the observed annual mean temperature (red line) for each region from 1915-2015, along with the long-term trend (black line). More details can be found in Unit 5.

Figure 1). The greatest rate of warming has been observed in the winter months of December, January and February.

Over the same period, the amount and timing of precipitation across the province have also changed, with observed reductions in the total volume of precipitation falling as snow.



Note: Graphs show the observed annual mean temperature (red line) for each region from 1915-2015, along with the long-term trend (black line). More details can be found in Unit 5.

Figure 1: Observed rate of warming (degrees Celsius per century) in three regions of Alberta over the last century

We cannot say that a specific extreme weather-related event that has impacted the province is caused by climate change. Nonetheless, over the same period that we have observed changing climate conditions in Alberta, we have also witnessed an increasing trend in losses from more intense and frequent storms, floods, heat waves, and wildfires. Put another way, we are basically under-adapted to the relatively small amount of climate change we have experienced to date. This brings us to a second major theme of the business case for adaptation.

Section 2: Communities are experiencing significant negative impacts from the current climate

"*Severe weather in Alberta is not an anomaly—it is just the way things are now—it has become a trend*."

[Heather Mack, Insurance Bureau of Canada, 2014]

Fact: Weather and climate impact all aspects of the community.

Weather and climate influence the quality of life in our communities, and challenge our capacity to achieve desirable outcomes in the following areas:[1]

- **Public health and safety**: to safeguard the health and safety of individuals and groups in the community, and minimize illness, injuries and fatalities, the loss of habitation and social isolation, and the loss of lifeline (power, gas, water) services.
- **Infrastructure**: to maximize the capabilities of essential facilities, critical infrastructure, transportation and utility systems to withstand, respond to and recover from shocks, and continue to provide essential services that meet community needs.
- **Economy**: to maximize community wealth—measured by investments in building stock and contents, infrastructure and lifeline services, and social institutions that promote local economic vitality, as well as aspects of cultural and heritage assets of value to residents and visitors.
- **Environment**: to maximize the capabilities of the natural environment to withstand, respond to and recover from shocks, and continue to provide essential goods and services of value to the community.

Examples of how weather today impacts living, working and moving in our communities are provided in Table 1; the list of impacts is not meant to be exhaustive and some impacts may not be relevant to all communities. Clearly, the impacts of weather are wide-ranging, and all

[1] These outcomes were adapted from criteria that communities can use to evaluate the efficacy of actions taken to mitigate natural disaster risks (Journeay, J.M., et al, "Disaster resilience by design: a framework for integrated assessment and risk-based planning in Canada", Geological Survey of Canada Open File 7551, Natural Resources Canada, Ottawa, p. 336, 2015.)

community goals—relating to public health and safety, infrastructure, the economy and the environment—are, to varying degrees, susceptible to these impacts.

	Living	Working	Moving
Heat	Discomfort Health risks Increased cooling demand Decreased heating demand	Health risks Reduced labour productivity Increased cooling demand Decreased heating demand	Discomfort Rail buckling Deform roads Increased cooling demand Decreased heating demand
Water scarcity	Health risks Inconvenience / nusiance Environmental degradation Loss of amenities	Reduced productivity or loss of output in agriculture and water-intensive sectors Power outages	Subsidence and damage to transport infrastructure
Wildfires	Health & safety risks Damage to property Evacuations Environmental degradation Loss of amenities	Health & safety risks Disruption to economic activity / reduced access Damage to productive assets	Damage to vehicles and infrastructure Disruption to work and leisure travel Disruption to freight transport
Storms	Health & safety risks Damage to property Inconvenience / nusiance Loss of power, gas, water	Health & safety risks Disruption to economic activity / reduced access Damage to productive assets Loss of power, gas, water	Damage to vehicles and infrastructure Disruption to work and leisure travel Disruption to freight transport
Floods	Health & safety risks Damage to property Evacuations Environmental degradation Loss of amenities	Health & safety risks Disruption to economic activity / reduced access Damage to productive assets Loss of power, gas, water	Damage to vehicles and infrastructure Disruption to work and leisure travel Disruption to freight transport

→ **PUBLIC HEALTH AND SAFETY GOALS**

→ **INFRASTRUCTURE GOALS**

→ **ECONOMIC GOALS**

→ **ENVIRONMENTAL GOALS**

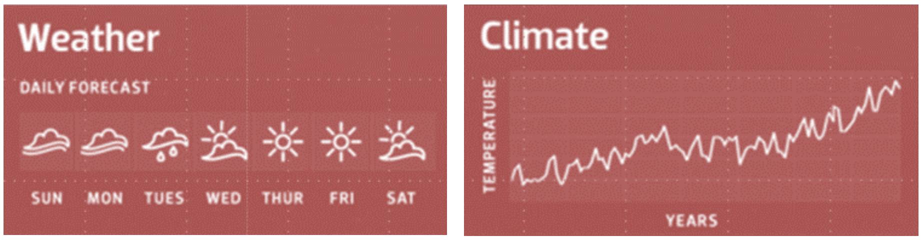
Source: Presentation is adapted from Table 2.1 in "Urban adaptation to climate change in Europe 2016: transforming cities in a changing climate ", European Environment Agency, EEA Report | No 12/2016.

Table 1: Examples of how weather today can affect community goals

The difference between weather and climate is a matter of time.

Weather describes conditions in the atmosphere over the short-term (hours, days, weeks). Weather is often thought of as what is happening outside now, in terms of temperature, precipitation, cloudiness, wind, etc. It can change rapidly—from hour-to-hour, day-to-day.

Climate describes conditions in the atmosphere over the long-term (decades, centuries). Climate is thought of as the average pattern or trend of weather conditions in a region over time. The climate changes more gradually.



Source: NASA – What's the Difference Between Weather and Climate [https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html]

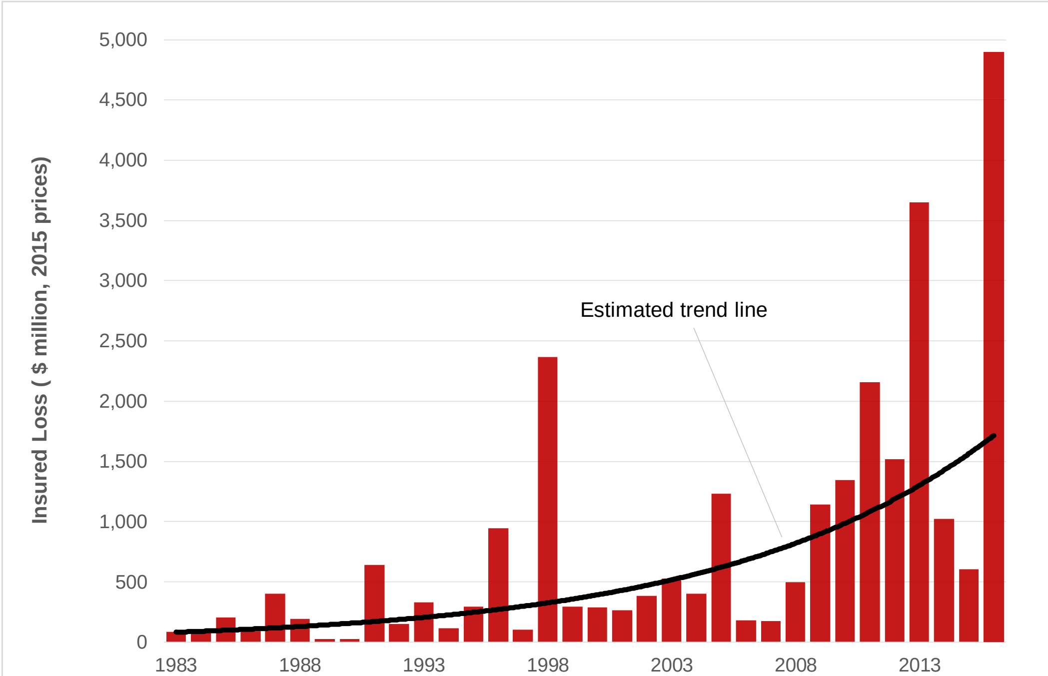
Box 1: In case you are wondering what the difference is between weather and climate

Fact: Since the early 1980s insured losses from severe weather have doubled every 7-8 years.

Insured losses from extreme weather events in Canada have been on a long-term upward trend since the 1980s (see Figure 2)—growing at nearly 10 per cent per year in real terms[2]. Over the last five years annual insured losses have averaged $2.3 billion (2015 prices), largely due to two of the largest weather-related natural disasters on record in Canada: the $1.9 billion flooding event in Calgary and southern Alberta in 2013, and the $3.7 billion wildfire in Fort McMurray and area in 2016. In contrast, over the preceding 25-year period, losses averaged about $0.4 billion per year.

In the last decade, we have also experienced many more large loss events (with seven disasters exceeding $1 billion in losses) than in the previous 20 years (with only one disaster exceeding $1 billion in losses).

[2] Strictly speaking, Figure 2 shows what the insurance industry defines as "catastrophic losses"—insured losses from a natural disaster that amount to $25 million or more. So, Figure 2 is understating the problem, as it does not capture many smaller events where total insured losses are less than $25 million.



Source: IBC 2016 Facts of the Property and Casualty Insurance Industry in Canada (for 1983-2015); Property Claim Services' More Than 50 Cats: PCS Full-Year 2016 Catastrophe Review (for 2016)

Figure 2: Catastrophic insured losses (plus adjustment expenses) in Canada (1983-2016)

ABC

Catastrophic losses: The Insurance Bureau of Canada defines catastrophic losses as insured losses from natural disasters (e.g., storms, wind, tornado, hail, flooding, wildfires, etc.) that total $25 million or more.

Insured losses: Economic or total losses covered by insurance.

Uninsured losses: Economic or total losses in excess of insurance coverage.

"*Alberta has become the place where bad weather pays a visit more often*."

[Don Forgeron, President and CEO, Insurance Bureau of Canada, 2014]

Fact: Seven of the ten largest insured losses from weather-related natural disasters in Canada have occurred in Alberta.

Alberta has experienced seven of the ten most costly weather-related natural disasters in Canada since 1983. These seven events, which include severe thunderstorms and wind, hail, wildfires, and heavy rains and flooding, resulted in total *insured losses* of about $8.9 billion (in 2015 prices). To put this amount in context:

- At the household level: $8.9 billion amounts to about $2,100 per Albertan as of 2016, which is roughly what a household spends annually on all utilities and fuel for personal vehicles, or about half of what each household spends annually on food.

- At the provincial level: $8.9 billion is 15 per cent *more* than the total amount allocated over four years to support capital investment in municipal infrastructure in Budget 2017.

The number of natural disasters in Alberta since 1983 is also disproportionate relative to the rest Canada. Of the nearly 170 catastrophic losses in Canada over the period 1983-2016, just over 25 per cent occurred in Alberta. This seems disproportionate when you consider that Alberta accounts for only 10 per cent of the total building stock (residential and non-residential) and 10 per cent of total population at risk to natural disasters in Canada over the same period.

Rank	Date	Affected area	Event type	Insured Loss
1	May, 2016	Fort McMurray	Wildfires	$3.7 billion
2	Jan, 1998	Southern Quebec	Ice storm	$1.9 billion
3	Jun, 2013	Calgary and southern Alberta	Heavy rains, flooding	$1.9 billion
4	Jul, 2013	Toronto and southern Ontario	Heavy rains, flooding	$1.0 billion
5	May, 2011	Slave Lake	Wildfire	$783 million
6	Aug, 2005	Ontario	Wind, thunderstorm, hail	$740 million
7	Aug, 2012	Calgary and area	Wind, thunderstorm, hail	$585 million
8	Jul, 2010	Calgary and southern Alberta	Wind, thunderstorm, hail	$576 million
9	Aug, 2014	Calgary and southern Alberta	Wind, thunderstorm, hail	$575 million
10	Aug, 2009	Alberta	Wind, thunderstorm, hail	$416 million

Source: IBC 2016 Facts of the Property and Casualty Insurance Industry in Canada (for all events 1983-2015); Property Claim Services' More Than 50 Cats: PCS Full-Year 2016 Catastrophe Review (for Fort McMurray wildfires in 2016)

Table 2: Top 10 most costly insured losses in Canada (1983-2016) ($ billion, 2015 prices)

Fact: Insured losses significantly understate total losses.

There is often a wide gap between insured losses and total economic losses from natural disasters, as reported by insurers. The media typically only quote insured losses, which are a subset of total economic losses.[3] To illustrate the gap between insured losses and total economic losses consider the two most costly natural disasters in Alberta, for example:

[3] Insured losses are simply the sum of all insurance claims, and can include: • Payments for the repair or reconstruction of damage to buildings and for replacing damaged contents; • Compensation for interrupted business income; • Payment for the costs of temporary accommodation while the insured's home or place of work is repaired;

- In June 2013, a strong storm system brought six days of torrential rain to southern Alberta, causing extensive flooding in Calgary and triggering many surrounding communities to declare a state of emergency. Damage to infrastructure was particularly severe. Initial damage estimates were put at around $3 to $5 billion, of which only 75 per cent might be insured.[4] Statistics Canada estimated that Alberta lost a net total of 5.1 million work hours over the second half of June due to the floods, which is equivalent to saying 88,000 people did not work over the entire month.[5] This would of course meaningfully impair economic output in the immediate aftermath of the floods; the Royal Bank of Canada estimated the one-time hit to provincial Gross Domestic Product in June at $1.7 to $3.4 billion.[6] Overall, total economic losses have been estimated at over $5 billion—significantly more than reported insured losses of $1.9 billion.

- In May 2016, a wildfire entered Fort McMurray, spreading east through the Regional Municipality of Wood Buffalo to Saskatchewan. In total, 5,890 km^2 of land burned. Nearly 90,000 residents of Wood Buffalo had to leave their homes and seek shelter in other parts of the province. When they returned, they found roughly 2,500 or 8 per cent of all private dwellings destroyed by fire, along with numerous commercial and industrial buildings.[7] Statistics Canada estimated that Alberta lost a net total of 7.6 million work hours in May and June due to the fire. About 47 million barrels of oil production worth $1.4 billion was also lost, and exports of energy products fell by 7.5 per cent. Gross Domestic Product for Alberta declined by 0.4 per cent during the second quarter of 2016. A recent study puts the total economic loss of the fire at $9.5 billion, including the cost of repairing and replacing infrastructure and buildings, evacuation and emergency management costs, lost income, profits and royalties in the forestry and oil and gas industries.[8] Again, this is significantly higher than reported insured losses of $3.7 billion.

• Payments to cover medical costs not covered by government; • Disability payouts for those left with permanent injuries; and • Life payments to the relatives of the deceased.

[4] "Economic and fiscal impacts of flooding in Alberta", TD Economics, Economic Briefing, June 26, 2013.

[5] "Impact of extensive flooding in Southern Alberta on hours worked", Statistics Canada news release, The Daily, Tuesday, August 27, 2013.

[6] "Economic impact of the Alberta Floods", RBC Economics | Research, Current Analysis, June 27, 2013.

[7] "Fort McMurray 2016 wildfire – economic impact", Statistics Canada, Infographic, March 16, 2017.

[8] Alam, R. and Islam, S., "Economic impacts of the Fort McMurray wildfire", Department of Anthropology, Economics and Political Science, MacEwan University, January, 2017.

Swiss Re, one of the world's largest re-insurers, estimates that private insurance has covered, on average, about 60 per cent of total economic losses from climate-related natural disasters in *North America* since the 1990s (Swiss Re, Sigma Database).

Table 3 presents figures for a sub-set of climate-related natural disasters for Canada. For floods, convective summer storms and winter storms, including ice storms, about 47 per cent of total economic losses have been covered by private insurance since 2005. When federal Disaster Financial Assistance Arrangements (DFAA) are considered, coverage rises to about 63 per cent of total economic losses. **That still leaves communities, residents and businesses exposed to roughly 37 per cent of total economic losses.**

As evident from Table 3, the ratio does vary significantly by type of weather event. In general, the gap between insured losses and economic losses will be larger where—among other things:

- Appropriate insurance coverage is not universally available (as is the case with insurance for overland floods);
- The penetration of available insurance products is low;
- Insurance policies include large deductibles, coverage limits and risk retention; or
- Households, businesses or municipalities only insure part of their infrastructure and property.

	Floods	Summer storms	Winter storms	All weather events
DFAA	$3,465	$20	$1,267	$4,752
Insurance paid	$4,982	$5,726	$3,552	$14,260
Total economic losses	$12,505	$7,314	$10,452	$30,271
% covered by				
DFAA	28%	>1%	12%	16%
Private insurance	40%	78%	34%	47%
Total coverage	**68%**	**79%**	**46%**	**63%**
% not covered	32%	21%	54%	37%

Source: Estimate of the Average Annual Cost for Disaster Financial Assistance Arrangements due to Weather Events, Parliamentary Budget Office, Ottawa, February 25, 2016.

Table 3: Cumulative total economic losses, insurance payments and DFAA for select climate-related hazards in Canada (2005-2014) ($ million, 2014 prices)

Box 2: In case you want to know what losses communities have historically been exposed to in Canada

The Insurance Bureau of Canada and Natural Resources Canada (Adaptation Platform Economics Working Group) jointly funded a project to examine the economic costs associated with extreme weather events anticipated to be affected by climate change: "The Economic Impacts of the Weather Effects of Climate Change on Communities" [assets.ibc.ca/Documents/Studies/IBC-The-Economic-Impacts.pdf].

The project used two case studies in Mississauga (Ontario) and Halifax (Nova Scotia) to develop and trial an approach and toolkit to help municipalities assess the economic costs of four extreme weather events—specifically: extreme wind, storm surge, stormwater flooding and freezing rain.

The basic intent is that by providing community-specific estimates of the expected cost of climate change impacts, municipalities will be able to make the business case for investment in climate resilience actions.

Section 3: Unabated, impacts will become more severe as further climate change is inevitable

Fact: Further climate change is inevitable.

Climate change is already happening, and it is already challenging our communities. This is evident from the discussion above. "Let's wait till climate change occurs and its impacts are felt before we do something about it" is no longer a tenable defense for not engaging in planned adaptation.

Still, decades of greenhouse gas (GHG) releases to the atmosphere have already locked the planet into some amount of further warming and change. Even if global GHG emissions were to stop today, the planet would continue to warm at an alarming rate for many decades to come due to inertia in the climate system. There is a time lag between GHG emissions and when we see the impacts, as the planet takes a while to respond. How much the climate will change beyond mid-century depends on how much and how fast global GHG emissions are stabilized and reduced from current levels.

Figure 3 shows projected changes in mean annual temperature for Alberta this century, under three different scenarios for global GHG emissions. (Researchers refer to these scenarios as representative concentration pathways, or RCP for short). Even under the most optimistic of these scenarios, known as RCP 2.6, Albertans are going to need to adapt to at least a 2°C increase in mean annual temperature. To help you contextualize this magnitude of change, consider that by mid-century the mean annual temperature in southwest, central and northwest Alberta will be comparable to the warmest 2-3 per cent of years over the last 100 years.

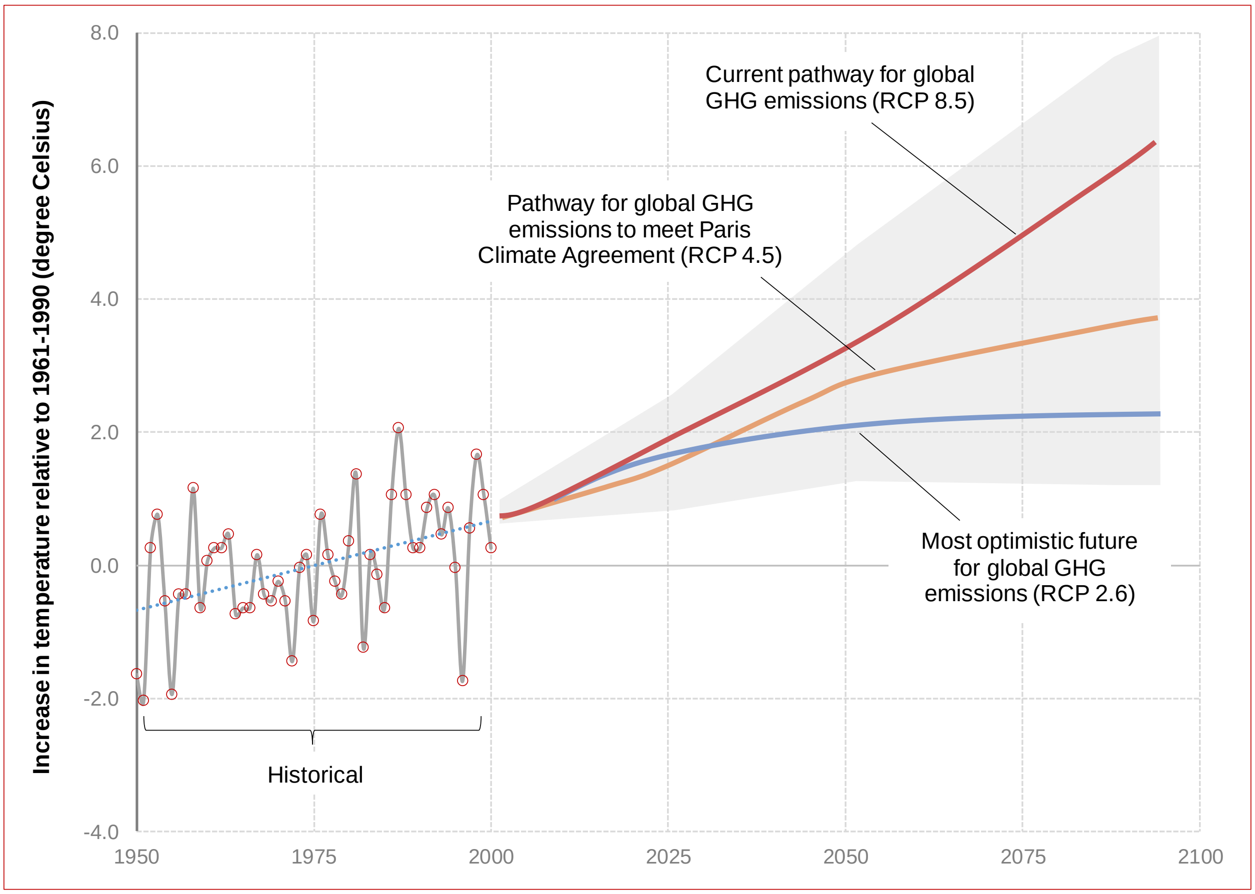
Hence, the appropriate question is not 'will we observe further climate change?' but rather 'just how bad with it be?' It is very unlikely to be less than +2°C anywhere in Alberta.

Descriptions of projected climate changes for three regions of Alberta are displayed in Figure 4 (southwest), Figure 5 (central) and Figure 6 (northwest). The projections are for mid-century; for a future world, somewhere between RCP 8.5 and RCP 4.5 in **Note**: the solid lines represent the median projected change in mean annual temperature relative to 1961-1990; the grey shaded area covers the 10th - 90th percentile range of projected temperature increases in mean annual temperature

Source: data obtained from PCIC's Regional Analysis Tool

Figure 3. Corresponding numerical projections for the same regions are available in, respectively, Appendix C, Appendix E and Appendix F.

The climate changes projected for each region will also lead to a wide variety of changes in the surrounding environment, with potential implications for local economies, municipal infrastructure and services, community health and safety, and residents' quality of life. Projected environmental changes are also provided in Figure 4 through Figure 6.



Note: the solid lines represent the median projected change in mean annual temperature relative to 1961-1990; the grey shaded area covers the 10th - 90th percentile range of projected temperature increases in mean annual temperature

Source: data obtained from PCIC's Regional Analysis Tool

Figure 3: Just how much climate change can we expect in Alberta even under the most optimistic scenario for global GHG emissions

Projected climate changes by mid-century
○ Warmer temperatures, especially in summer
○ Less precipitation in summer
○ More periods of extreme heat, fewer spells of extreme cold
○ Increase in the number of extreme precipitation events
○ Less precipitation as snow
○ Increase in intensity of summer storms
○ Increased precipitation in fall, spring and winter
Projected environmental changes by mid-century
○ Longer growing season
○ Regional shift towards grassland dominated ecosystems
○ Extended wildfire season
○ Fewer, smaller and less permanent wetlands
○ Increased winter streamflow, earlier spring peak flow, decreased flow in summer
○ More favourable conditions for invasive plants
○ Less available moisture

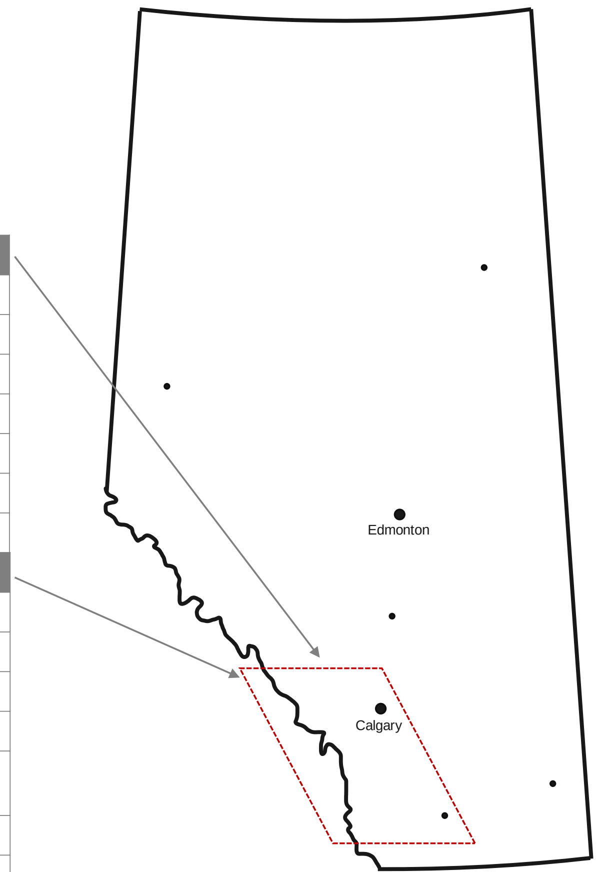
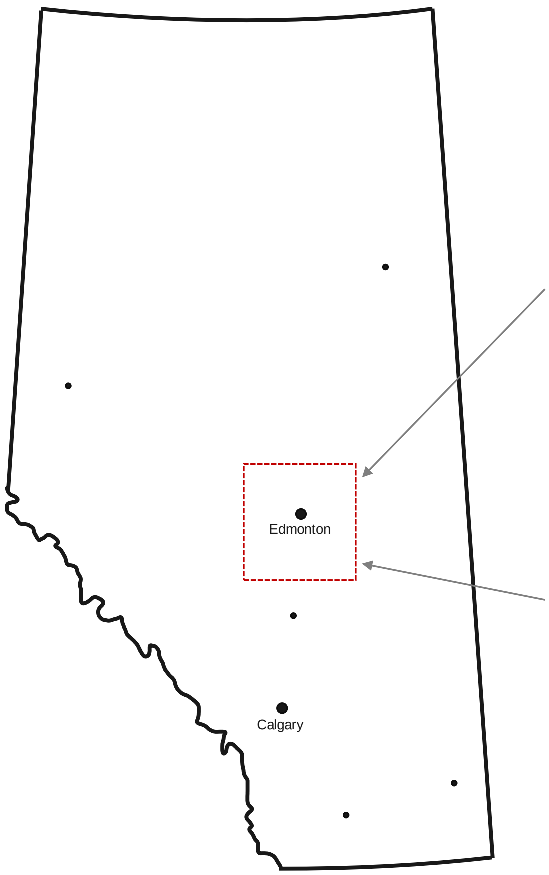


Figure 4 Summary of projected climate changes and environmental changes for a region of southwest Alberta by mid-century



Projected climate change by mid-century
○ Warmer temperatures, especially in winter
○ More precipitation in fall, spring and winter
○ More periods of extreme heat, fewer spells of extreme cold
○ Increase in the number of extreme precipitation events
○ Less precipitation as snow
○ Increase in intensity of summer storms
○ Increased frequency, intensity and duration of drought
Projected environmental changes by mid-century
○ Longer growing season
○ Reduced soil moisture for plant growth
○ Ecosystem shift from boreal / parkland to parkland / grassland
○ Fewer, smaller and less permanent wetlands
○ Increased winter streamflow, earlier spring peak flow, decreased flow in summer

Figure 5 Summary of projected climate changes and environmental changes for a region of central Alberta by mid-century

Projected climate changes by mid-century
○ Warmer temperatures, especially in winter
○ More precipitation, especially in winter
○ More periods of extreme heat, fewer spells of extreme cold
○ Increase in the number of extreme precipitation events
○ Less precipitation as snow
○ Increase in intensity of summer storms
Projected environmental changes by mid-century
○ Longer growing season
○ Regional shift towards deciduous forest and parkland ecosystem
○ Extended wildfire season
○ Decreased streamflow in summer
○ Increased winter streamflow, earlier spring peak flow
○ Shorter ice-covered period on rivers
○ Degradation of permafrost

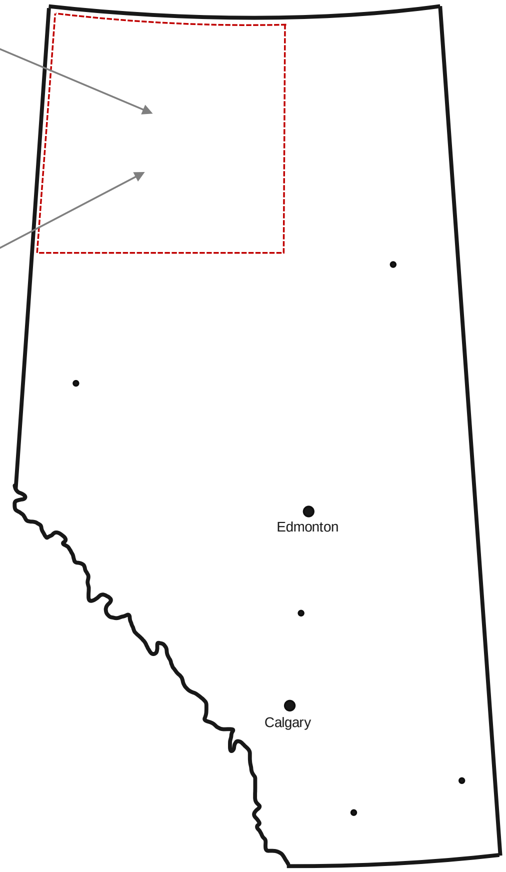


Figure 6 Summary of projected climate changes and environmental changes for a region of northwest Alberta by mid-century

Fact: Climate change will exacerbate current weather- and climate-related impacts on your community.

We are experiencing significant adverse impacts from current climate conditions (recall Table 2). It is fair to say that exposure to weather and climate is already challenging communities in Alberta. Projected climate and environmental changes, like those presented in in Figure 4 through Figure 6 will make many potential exposures and resulting impacts more severe. These changes may also present communities with economic benefits (e.g., earning more from new or increased tourism or agricultural opportunities).

Examples of both positive and negative impacts due to projected climate and environmental change, that were identified by communities participating in the Climate Resilience Express project, are listed in Table 4.

Climate change	Impact	Consequences identified by community
Increase in the number of extreme precipitation events	Recurring risk of **stormwater system being overwhelmed**, leading to localized flooding	○ Inconvenience for residents from transport disruption ○ Disruption to economic activities with loss of output ○ Transport delays affecting shipping of supplies and products ○ Decrease water quality ○ Increased bank erosion and changes to channel morphology and habitat ○ Damage to property and infrastructure ○ Interruption to lifelines (water, sewer) ○ Increased costs to town
Warmer summer temperatures, more periods of extreme heat, less summer precipitation, and increase in intensity of summer storms (lightning strikes)	Recurring risk of **forest fire**	○ Public safety concerns ○ Smoke inhalation, poor air quality related illnesses ○ Impairment of visual amenity ○ Decline in economic activities with loss of output, due to reduced tourist visitation ○ Impact to, loss of, trees and other wildlife habitat and ecosystems ○ Damage to property and infrastructure ○ Interruption to lifelines (power and communications) ○ Increased costs to town and demands on emergency services
Increase in the number of extreme precipitation events, earlier peak stream flow, and more spring precipitation as rain	Recurring risk of **river flooding**	○ Public health and safety concerns, including longer-term mental health (stress and anxiety) ○ Disruption in, loss of, economic activities with loss of output ○ Bank erosion and damage to (wildlife) habitat and ecosystems ○ Damage to, loss of, property and infrastructure ○ Interruption to lifelines (power, water and sewer) ○ Evacuations, damage to towns reputation ○ Increased costs to town and demands on emergency services
Increase in intensity of summer storms	Recurring risk of **extreme winds**	○ Public safety concerns ○ Disruption to economic activities with loss of output, from fallen trees and transport disruption, and loss of lifelines ○ Damage to, loss of, trees ○ Damage to property and infrastructure ○ Interruption to lifelines (power and communications) ○ Increased costs to town and demands on emergency services
Warmer summer temperatures, less summer precipitation, and reduced extent of glacier feeding rivers	Recurring risk of **water supply shortages**	○ Inconvenience to residents from water use restrictions ○ Deterioration in water-based recreation ○ Decline to economic activities and output for selected businesses ○ Deterioration in water quality with implications for aquatic ecosystems ○ Interruption to lifelines (water supply) ○ Increased costs to town from changes to water treatment to maintain standards
Increase in number of extreme precipitation event	Recurring risk of **sediment loading-turbidity**	○ Deterioration in water quality with implications for aquatic ecosystems ○ Increased costs to town from changes to water treatment to maintain standards
Increase in number of extreme heat events and record temperatures	Recurring risk of **heat stress on vulnerable populations**	○ Public health concerns (sleep disturbance, heat stress and associated morbidity, including stress and anxiety) ○ Reduced productivity of workers, lost output ○ Increased demands on emergency services

Warmer temperatures, and increase in number of extreme heat events and record temperatures	Trending risk toward **increased water demand** by households, businesses, and other consumers	○ Increased competition between users, including in-situ uses in water sources ○ Increased costs to town from changes to water services (abstraction, treatment, provision, sewer)
Increased in extreme precipitation events in winter	Recurring risk of **heavy snowfall events, blizzards**	○ Public safety concerns ○ Inconvenience – snow clearing and getting about ○ Disruption to economic activity, mainly from transport disruption and people staying at home ○ Stress to wildlife ○ Interruption of lifelines (power) ○ Property damage from excess snow loading ○ Costs to town from snow clearing, sanding, and clean up ○ Increased demands on emergency services, also with costs implications for town
Increased variability of temperatures in winter, early spring and late autumn	Recurring risk of increased frequency of **freeze-thaw cycles**	○ Public safety concerns relating to the potential for injuries ○ Reduction in recreation opportunities, like skating ○ Disruption to economic activity, mainly from transport disruption ○ Costs to town from increased road maintenance, sanding, and clean up, as well as repairs to, and replacement of, underground infrastructure
Less periods of extreme cold spells, warmer temperatures	Trending risk towards **increased incidence of vector-borne diseases**	○ Public health concerns, primarily related to morbidity (illnesses and disease) ○ Loss of economic activity and output, if tourists opt to stay away to reduce exposure to insects (ticks, mosquitos) carrying vectors ○ Stress to, or loss of, pets and wildlife ○ Adverse impact on Town's image
Less periods of extreme cold spells, warmer temperatures	Trending risk towards **increase prevalence of invasive species**	○ Loss of visual amenity (e.g., from pine beetle tree loss) ○ Loss of economic activity and output, if tourist visitation or experience impacted ○ Native species displacement ○ Forest loss, loss of habitat
Less precipitation falling as snow, warmer spring and fall temperatures, and reduced winter snowpack	Trending opportunity towards **increase in summer season recreation activities** for residents and tourists	○ Increased amenity for residents who favour summer recreation activities ○ Increase in economic activity and output for selected businesses, with job benefits
Warmer temperatures	Trending opportunity towards **reduced heating demand**	○ Energy bill savings to residents, businesses and town ○ Reduction in fossil fuel combustion with associated reductions in emissions of GHG and other air pollutants
Warmer temperatures in shoulder seasons	Trending opportunity towards **extended construction season**	○ Less transport disruptions, with less disruption to economic and recreation activities ○ Increase in development, growth (projects completed sooner) ○ Cost savings to town, and lower procurement prices

Table 4: Examples of projected climate-related impacts and consequences identified by communities participating in the Climate Resilience Express

Section 4: Adaptation is not new, not necessarily costly, and provides many benefits

"*The costs of action pale in comparison to the costs of inaction*."

[Mark Lowery, New York State Office of Climate Change, 2014]

Fact: Building climate resilience does not necessarily require additional time and budget, and can yield benefits today.

There are a range of actions that communities could take to manage climate-related risks and opportunities—examples are provided in Table 5. You may be surprised to see that your community is already doing several of these things. Indeed, many communities already have strategies, plans, programs and projects that somewhat manage climate-related impacts; they are just not labelled as "climate adaptations". For example, your community may now be monitoring leakage in the water supply system, have a water conservation and efficiency program, a stormwater management plan, an emergency response plan, etc. These common community initiatives already support adaptation to climate-related impacts today, and with some strengthening, can help manage projected future impacts. Recall, many projected climate change impacts are simply more extreme, more frequent versions of what we are observing today. For communities that presently experience climate-related impacts, it is thus fair to say: **planning for the future can benefit the present**. Communities in southern Alberta periodically experience drought conditions, for example. By resourcing a robust water conservation and efficiency plan, these communities not only reduce their vulnerability to future water scarcity risks, but also reduce the consequences of drought conditions today.

There are many other community plans and policy documents which could include components that support adaptation to projected climate change impacts. When these plans and documents are developed, or updated, it provides an opportunity to consider potential future climate change impacts, and to integrate actions to manage them. In this way, climate change adaptation becomes 'mainstreamed' into the day-to-day operations of local government. Importantly, **doing so does not necessarily entail large additional costs**.

Research or monitoring: Includes actions to help improve your understanding of a specific risk and how it might be affected by climate change, such as monitoring your water sources or leakage in your water supply system.
Early warning systems: Includes actions to warn residents and local businesses of potential risks should they occur, such as a wildfire or flood threatening the community.
Hazard information: Includes actions to increase your knowledge of exposure to a specific risk, such as flood or wildfire hazard maps.
Awareness raising: Includes actions to help residents and businesses better understand either the nature of a specific risk or opportunity, or the need for action—e.g., education campaigns, mandatory or voluntary climate risk disclosure in real estate transactions, etc.
Bylaws and plans: Municipal Development Plans, Area Structure Plans and Parks, Open Space and Trails Master Plans could be updated to include climate resilience policies, such as consideration of climate changes in future development decisions.
Technologies: Includes the purchase and use of technologies to manage risks and opportunities, such as smart water meters and leakage detection devices to address water supply shortages, roof sprinkler systems to address wildfire, etc.
Infrastructure: Includes "hard" (structural) and "soft" engineered solutions to manage risks and opportunities—e.g., scaling-up flood protection measures, changing the design of storm-water systems, building more resilient buildings, installing irrigation systems, creating wetlands or using green roofs to manage flood risk.
Economic incentives: Includes insurance products and the use of economic instruments and other financial incentives to encourage the adoption of risk mitigation technologies or practices—e.g., a rebate program to support residents in purchasing water-saving appliances or technologies, or fire-proofing their home and property.
Operations: Includes actions to modify day-to-day operational tasks, such as increasing the frequency of storm-water maintenance and cleaning, or road and sidewalk clearing and salting.

Table 5: Types of adaptation actions

Several smaller communities in Alberta have already developed Action Plans using the Climate Resilience Express, including the Town of Bruderheim, the Towns of Black Diamond and Turner Valley, the Town of Banff, the Town of Canmore, and McKenzie County. These are available at www.allonesky.ca and www.mccac.ca.

The City of Leduc (www.leduc.ca/weather-climate-readiness-plan) and the City of Red Deer (http://www.reddeer.ca/city-government/plans-and-projects/corporate-projects/climate-change-adaptation-plan/) have also developed plans to manage climate change impacts.

Fact: Proactively investing in climate resilience provides value for money.

Several recent studies have reviewed cost-benefit analyses of investments in actions to reduce risks from natural hazards, including climate-related hazards. These studies assessed whether actions to build resilience represent value for money in terms of their benefit-cost ratio:[9]

$$\text{Benefit-cost ratio} = \frac{\text{Current worth of all project benefits}}{\text{Current worth of all project costs}} > 1 \text{ is value for money}$$

If the benefit-cost ratio is greater than one, then the current worth of all benefits exceeds the current worth of all costs, and the resilience action provides value for money. Benefits of resilience actions typically comprise estimates of:

- Reduced direct damage to the (residential and non-residential) building stock and contents;
- Reduced direct damage to essential facilities and critical infrastructure (hospitals, schools, emergency operating centers, fire halls, police stations);
- Reduced direct damage to utility systems (power, gas, water, communications) and transport infrastructure (roads, bridges, tunnels, rail, airports);

[9] For example: Shreve, C. and Kelman, I., "Does mitigation save? Reviewing cost-benefit of disaster risk reduction", International Journal of Disaster Risk Reduction, Vol 10, Part A, December 2014, p. 213-235; Wethli, K., "Benefit-Cost Analysis for Risk Management: Summary of Selected Examples", background paper for the World Development Report 2014, World Bank, Washington, DC, USA, 2014; Kunreuther. H. and Michel-Kerjan, E., "Challenge paper: natural disasters: policy options for reducing losses from natural disasters", Center for Risk Management and Decision Processes, The Wharton School, University of Pennsylvania, Philadelphia, USA, 2012; and MMC, "Natural hazard mitigation saves: an independent study to assess the future savings from mitigation activities", Multi-hazard Mitigation Council (MMC), National Institute of Building Sciences, Washington, DC, USA, 2005.

- Reduced direct business interruption losses (from disruption to the flow of goods and services not produced due to damage to productive assets and economic infrastructure);
- Reduced indirect business interruption losses (due to 'ripple effects' throughout the local economy, as directly affected businesses purchase less materials and labour, and supply less output to customers);
- Reduced human losses (illnesses, injuries, fatalities, homelessness);
- Reduced damage to non-market assets (damage to habitat, ecosystems, parks, wildlife, structures or sites of historical or cultural significance); and
- Reduced cost of emergency response and relief.

Looking at estimates for North America, the benefit-cost ratios of anticipatory resilience actions is, on average, around 4. That is, **every dollar spent of managing the risk of natural hazards saves society an average of $4**. Some risk management investments had much higher ratios; others slightly lower, but still greater than one.

In general, non-structural resilience actions—such as land use planning, early warning systems, awareness raising, etc.—offer greater value for money than investments in structural measures. Non-structural measures are more readily mainstreamed into existing daily activities of local government, which requires less additional time and budget.

Furthermore, anticipatory adaptation, before climate-related impacts are realized, will be more cost-effective than responding reactively to climate change impacts as they happen. For instance, accounting for the impacts of climate change on future stream flows, snow melt and water demands when designing the capacity of a reservoir today—to ensure it can meet future water supply needs—will be less costly than attempting to increase the capacity of the reservoir in the future.

Fact: Both adaptation and mitigation actions are needed to tackle impacts of climate change.

Mitigation targets the causes of climate change and seeks to reduce the amount of greenhouse gases (GHGs) we release to the atmosphere; for example, by reducing energy consumption in our building or vehicles, reducing the GHG-intensity of the energy we use, or enhancing natural carbon sinks.

Climate adaptation and climate mitigation are inextricably linked. We are already committed to a certain amount of climate change over the coming decades, due to past GHG emissions and the inertia of the climate system. Beyond that, how much climate change we see depends on the strength of mitigation efforts to stabilize and reduce concentrations of GHGs in the atmosphere. **Bottom line: adaptation is needed to address the physical impacts of unavoidable climate change, in the short, medium and long-term**. The less effective mitigation efforts are, the more difficult and costly it will be to effectively adapt. Indeed, there is a risk that unfettered releases of GHGs will overwhelm our capacity to adapt in the long-term. Hence, communities need to pursue climate adaptation and climate mitigation simultaneously, while taking advantage of all possible synergies[10] and minimizing conflicts[11].

[10] For example, designing buildings to maximize passive or active cooling of the indoor climate, such as building insulation, white roofs, green roofs or sunscreens, prevents buildings from overheating, and reduces energy consumption for air conditioning and the associated GHG emissions.

[11] For example, densification of developments through land-use planning can reduce energy use, but it can also reduce green space and ventilation that help with adaptation to heat waves.