Stakeholder Profile 1: Canadian Council of Forestry Ministers

Overview

Canada is a forest nation, with forests covering more than 50 percent of the country's land mass. Large-scale disturbances, such as fire and pest outbreaks, affect 5 percent of the forested area annually. Climate determines forest distribution (location), composition (type of trees), productivity (the amount of timber and wood fibre), dynamics (interactions) and disturbances. As such, climate change is projected to have far-reaching consequences for Canada's forest sector.

In addition to the direct economic benefits from the harvest of timber and fibre, forests provide recreational and cultural value, as well as non-timber forest products such as mushrooms and berries. Ecosystem services provided by forests, such as clean air and water, carbon storage, and soil nutrients, also have social and economic value, although this is difficult to quantify.

Climate change presents challenges to Canada's forest managers. Decisions made today will impact the forest for more than 100 years, given the long generation times of trees. Trees can cope with a certain amount of change in their environment through physiological or genetic adaptation; but the rate of future climate change is likely to exceed the ability of forests to adapt enough to maintain the level of goods and services they now provide. The Canadian forest industry has been facing significant economic challenges, resulting in lost jobs, mill closures, and a general downturn in the forest sector. Effective adaptation must address all of these drivers of change in the forest sector.

Impacts of climate change

Due to their northern location, Canada's forests are exposed to greater increases in temperature than the global average. These impacts are more significant in some parts of the country than others. Past assessments suggest these key findings:

- Increases in disturbances (e.g., forest fires, pest and disease outbreaks) are already evident and will become more pronounced in future.
- Forest composition (types of trees) will change due to changing disturbances and changing climate.
- Access to forests will be impacted by these disturbances, shifting infrastructure costs, and shorter winter harvesting seasons (due to reduced periods of frozen ground).
- Forest-based communities in some regions will face significant social and economic impacts (e.g., safety and security costs, forest sector jobs, and tourism may be affected). Forest fires threaten human health, safety, and security. The 2011 fire in Slave Lake, Alberta, resulted in an estimated $742 million in insurance claims. There will be extra costs for protection and community evacuations.
- Forests provide important ecological services such as water conservation and purification, habitat for biodiversity, and carbon storage. Tree death due to drought, infestation, and fire will reduce carbon storage capability; and will result in a significant release of carbon into the atmosphere. (By 2020, trees killed by the mountain pine beetle in Western Canada will have released nearly one billion tonnes of carbon dioxide into the atmosphere — roughly equivalent to five years of emissions from Canada's transportation sector.)

Possible outcomes

- Forest productivity could increase with warmer temperatures, longer growing seasons, and increasing carbon dioxide levels when other factors such as soil, water, or nutrients are not an issue.
- Productivity will be negatively impacted by increased drought and more frequent and severe disturbances and extreme weather events.

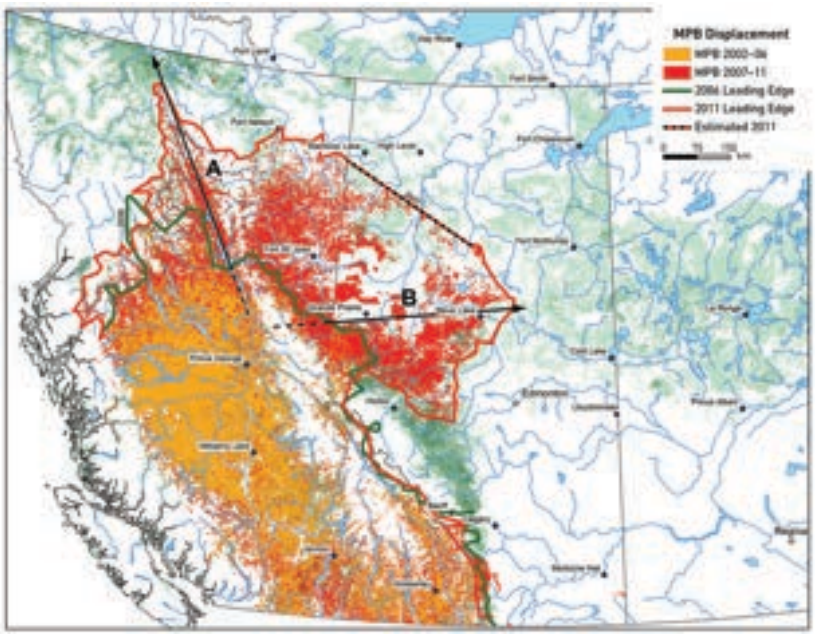
Existing research

Many papers and reports explore options for forest sector adaptation, and there are several examples of specific measures being implemented.

Research needs

- A better understanding of forest sector vulnerabilities is needed to help future work on adaptation. In general, the concept of adaptation is not yet well understood.
- Integration of on-the-ground measurements with remote sensing data (satellites) greatly increases Canada's ability to monitor forest changes and whether they are directly related to climate change.
- Sharing data across disciplines (biology, physics, geology, meteorology, etc.) will also help build a big picture of the vulnerabilities we face.
- Significant uncertainty remains about:
    - future climate conditions,
    - the multiple, interacting impacts of climate change on complex forest ecosystems, and
    - forest response to those changes.
- Scientific understanding of past and future climate change impacts on Canada's forests has increased substantively over the past decade, but this information is not always available, accessible, and/or applicable to prospective end-users. In fact, some in the Canadian forestry industry have identified a lack of knowledge about prospective adaptation options as a barrier to action.

The information in this profile can be found in the "Forestry" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 70.



Map of mountain pine beetle distribution, showing change over the 2002–06 (orange) and 2007–11 (red) periods. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 72.

Stakeholder Profile 2: Canadian Hydropower Association

Overview

Canada is the world's third-largest producer of hydroelectricity. Hydroelectricity accounts for 59 percent of Canada's electricity generation (Statistics Canada, 2013). In the provinces of Quebec, British Columbia, Manitoba, and Newfoundland and Labrador, more than 90 percent of electricity production comes from hydro. Ontario, Alberta, and New Brunswick also produce significant quantities of hydroelectricity, while the Yukon and Northwest Territories rely on hydro to help meet local energy demand.
The majority of Canada's hydro production comes from large reservoir systems. Some capacity is provided by small runoff-river power stations. Transboundary electricity markets, both inter-provincial and the US market, are large. Because hydropower is abundant here, Canada is able to support industries that are big energy consumers, like aluminum smelters.
Climate change impacts hydroelectricity production by making the amount of water available more difficult to predict and control.

Impacts of climate change

In Canada, climate change means less demand for heating during the winter and more demand for air conditioning during the summer.
Adapting to climate-related changes in energy demand and supply is a challenge for the energy sector across Canada, where the main source of heating is natural gas and oil, and the main source of cooling is electricity.
Specific vulnerabilities depend on geographic setting, primary energy sources, and projected changes in climate.

- Peak summer demand for cooling may coincide with decreased hydroelectric potential in some areas, resulting in short supply.
- Hydroelectricity generation may be affected by seasonal reductions in water supply, particularly in glacier-fed systems. Such changes in timing of flow and peak events will likely require adjustments in reservoir management practices.
- Transmission of electricity is sensitive to weather: higher temperature means greater energy losses; and extreme weather can cause infrastructure damage, leading to distribution problems.

Possible outcomes

- Changes in the distribution of the flow throughout the year could present structural problems with dams and reservoirs and result in floods.
- Improvement in the efficiency of appliances and equipment could reduce the demand for electricity.
- Warmer summers could increase the use of air conditioning units.
- Canada may have the opportunity to export more electricity to the US in the summer, but this would have to be weighed against the higher domestic demand.

Existing research

In the energy sector, climate change and hydroelectricity have received a lot of attention from industry and researchers.

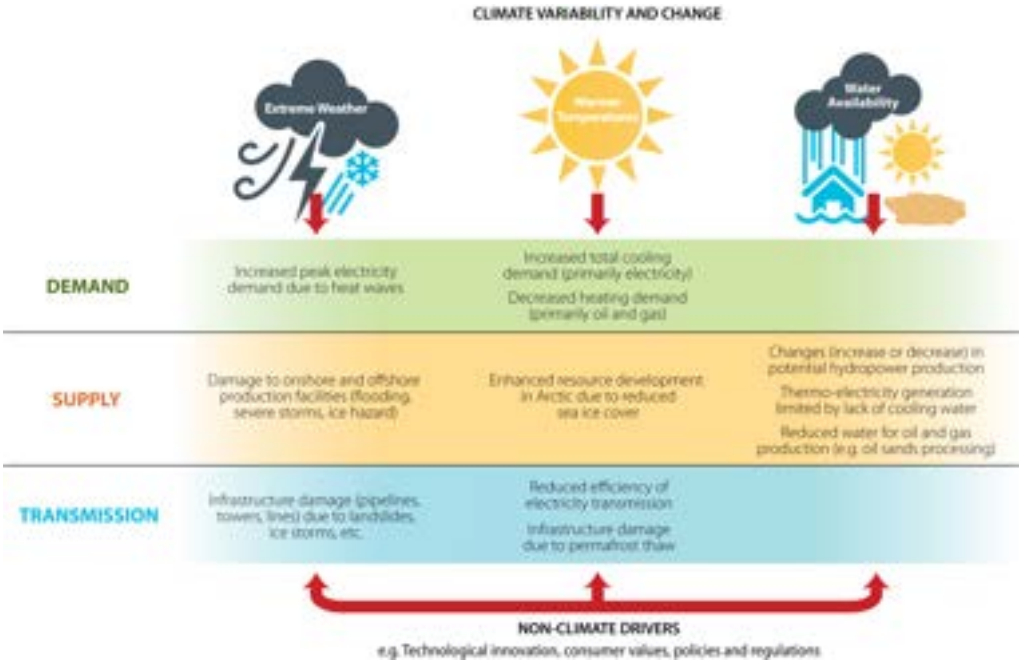
- Most Canadian research has focused on the hydrological consequences of a changing climate, such as shift in the timing and amount of river flows. This will vary significantly between regions and within drainage basins.
- Recent research has expanded to multi-criteria analysis (considering many aspects at once), which involves considering economic, political, social, and environmental aspects in the analysis of potential adaptation measures and their costs and benefits.

Research needs

- Quantitative analyses on whether Canadian utilities will be able to respond to the export opportunity of higher summer electricity demand in the US
- Adaptation strategies to integrate perspectives of different water users (e.g. industry, government, and residential) and changing resource demands
- Studies taking into account the uncertainty of future hydrological projections
- Research on natural adaptation measures, e.g., the restoration of wetlands to regulate flow during times of low and peak flows

Collaboration among companies, regulators, scientists and other stakeholders will increase the likelihood of adaptation to climate change.

The information in this profile can be found in the "Energy" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 81.



Key climate change impacts in the energy sector. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 79.

Stakeholder Profile 3: Canadian Agriculture and Food Industry Association

Overview

Food production is a major economic driver in Canada, with the agriculture sector contributing billions of dollars to our economy. In two provinces, Prince Edward Island and Saskatchewan, agriculture provides more employment than any other sector.

Canada's food system is as varied as its geography. Food production from agriculture relies mostly on intensive culture and harvest practices. However, non-commercial fishing, hunting, gathering, and gardening are also important sources of food.

Impact of climate change

Climate affects crop productivity; animal production, virility, and diseases; pollinator health; and water availability and quality. While all of Canada will be affected by changes in temperature and precipitation, the impacts will not be uniform across the different agricultural landscapes. There will be distinct issues for four regions.

1. Eastern and central Canada
    - Flooding from increased spring runoff may require building systems like wetlands for water retention.
    - Increased temperature will lengthen the growing season but will also increase weeds and agricultural pests and diseases.
    - Livestock will need less heating but more air conditioning. Heat waves can negatively impact animal health, but warmer winters can help fatten livestock.
2. Northern and remote communities
    - Climate change is affecting the availability and quality of wild food such as berries, wild rice, and game animals.
    - Ice conditions are changing (changes hunting patterns).
    - Storms are more intense (affecting wild food gathering).
3. Prairies
    - Water issues represent the greatest concern for the Prairies. Reduced summer rainfall and more frequent droughts might require more irrigation for crops and livestock; however, other pressures may limit the ability to expand irrigated agriculture.
4. British Columbia
    - Management of water resources will be a challenge because of reduced summer stream flows, reduced groundwater recharge, and increasing demands for water from other sectors.

Possible outcomes

- A modest increase in agricultural food production
- Changes in crop management practices

- Expansion of maple syrup industry northward
- Shorter ice-road season in northern communities, posing a challenge to food transport to isolated areas
- Longer marine transport season in northern areas, to the benefit of coastal communities with port facilities
- Sea level rise in coastal regions of British Columbia could cause flooding of farmland and affect drinking and irrigation water
- Impact on B.C. wineries, orchards, and agri-tourism due to higher risk of pests, fires, and summer drought

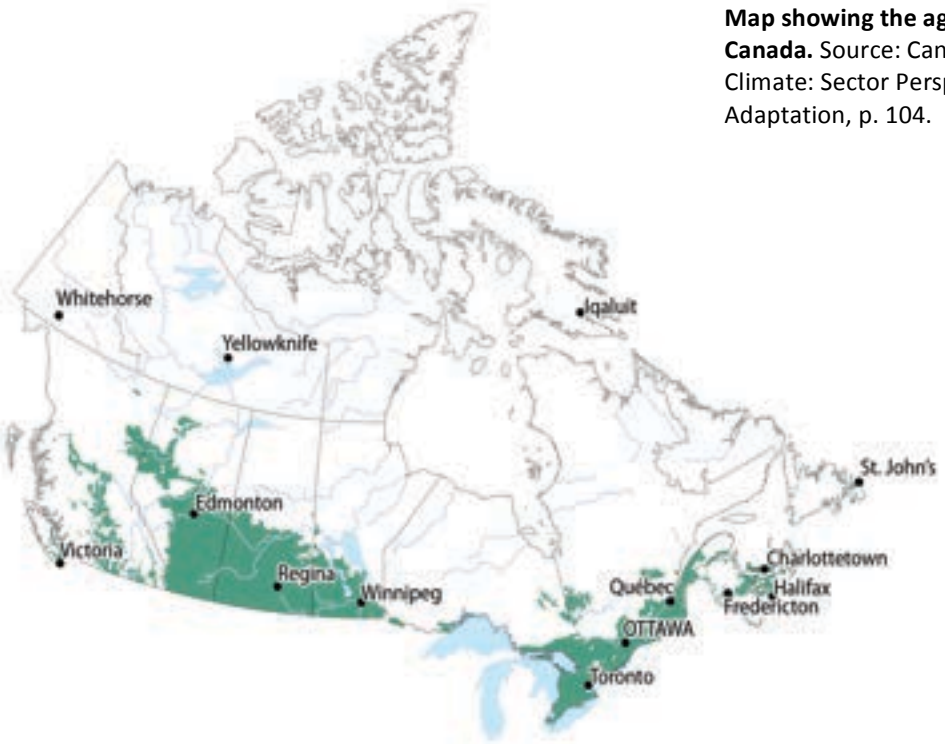
Existing research

Studies have demonstrated that changes in temperature and precipitation will have important effects on agriculture in Canada, intensifying existing risks and presenting new ones. These changes will also create new opportunities for each geographical region.

Research needs

- More studies in yield predictions (assuming that crop productivity could either increase or decrease in a changing climate)
- Studies to develop our understanding of current climate variability
- Studies that link scientific and local knowledge to inform water management decisions
- Rearch and development in irrigation technology

The information in this profile can be found in the "Agriculture" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 104.



Map showing the agricultural extent of Canada. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 104.

Stakeholder Profile 4: Mining Association of Canada

Overview

Mining contributes to the economies of all provinces and territories, in small communities and large cities. That said, this economic contribution fluctuates, depending on the number of mines operating and the value of the commodity produced.

The Canadian mining sector employs people in mineral extraction, in smelting, in fabrication, and in manufacturing.

According to the Mining Association of Canada, the industry plans to invest heavily in projects over the next few years; this may be an opportunity to make climate change adaptation part of mining activities like mineral exploration, mine construction, operations, transportation, and mine closure.

Impacts of climate change

Climate change affects all stages in the mining cycle, including planning, current and future operations, and closing mines. Studies have identified several aspects of mining operations that are currently affected by changing climatic conditions, including: a) built infrastructure; b) transportation infrastructure; c) extraction and processing; and d) daily operations.

- Extreme climate events (e.g., torrential rains) have already exceeded the ability of some mines to operate as they were designed to.
- Warmer winters have rendered seasonal ice roads in the Northwest Territories less reliable than in the past.
- Warm, dry conditions increase dust emissions, requiring mine operators to employ dust control measures like water spraying and covered storage areas.
- Daily operations at mine sites are sensitive to extreme weather conditions, including intense rain and snowfall, flooding, drought, changing ice conditions, extreme cold, and forest fires — all of which can reduce operational capacity.

Possible outcomes

- Reductions in Arctic sea ice could lead to new opportunities for mining exploration and development in the North, related in part to lower shipping costs.
- Decreased viability of winter roads could affect access to many northern mine sites.
- Increased precipitation associated with climate change in some area could benefit some minerals mining operations by helping to control dust emissions.
- Too much precipitation impedes the drying of mined materials, which then requires more energy, resulting in higher costs.

Existing research

The majority of available research on climate change impacts and adaptation in the mining sector focuses on northern regions, on issues including the following:

- Permafrost integrity
- Winter transportation networks
- Water management
- The potential for Arctic seaways as sea ice melts

Research needs

More research is needed on climate change impacts and adaptation with regard to mining operations in southern Canada.

- Studies are needed on abandoned mining infrastructure that was not designed for the full range of changing climatic conditions. Some of these sites could pose serious risks to the environment and the health of surrounding communities.

- Decision-makers responsible for designing, building, maintaining, and retiring mining infrastructure need a better understanding of the likely impacts of future climate changes at mine sites; and how engineering techniques can be adopted to manage these changes. Available climate scenarios are not adequate to help decision-making by mine operators.

The information in this profile can be found in the "Mining" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 76.

Province/Territory	Value of mineral production by province and territory, 2000 and 2010 ($M)	
	2000	2010
Newfoundland and Labrador	967.1	4584.0
Prince Edward Island	5.5	3.4
Nova Scotia	295.2	294.2
New Brunswick	772.5	1154.6
Quebec	3653.2	6770.5
Ontario	5711.4	7691.7
Manitoba	1268.8	1663.5
Saskatchewan	2282.6	7084.0
Alberta	1064.4	2347.3
British Columbia	2891.5	7073.8
Yukon	56.2	284.1
Northwest Territories	681.7	2032.7
Nunavut	384.6	305.1
TOTAL	20 034.7	41 288.9

Value (millions of dollars) of mineral production by province and territory, 2000 and 2010. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 77.

FIGURE 4: Canadian mining industry clusters (modified from Stothart, 2011).

Stakeholder Profile 5: Tourism Industry Association of Canada

Overview

The World Travel and Tourism Council forecasts steady growth in Canada's tourism sector between 2012 and 2022 (an average of 2.9 percent per year). Our tourism industry and our federal and provincial governments feel that major tourism growth is possible, as international arrivals are projected to increase to 1.8 billion by 2030.

Tourism is closely linked to weather and the natural environment. Because of this, climate change is anticipated to have extensive impacts on the sustainability and competitiveness of tourism destinations and major tourism market segments around the world. Recent rankings of the impacts of climate change on tourism worldwide have consistently identified Canada as a country with the potential to improve its competitive position as an international destination

While tourism is an important economic driver in every region of Canada, it has even greater importance for small communities like park gateway communities, "cottaging" districts, and many other destinations. It represents a key economic revitalization strategy where traditional resource-based economies have declined.

Impacts of climate change

A longer "summer" tourism season, and reduced "sunshine destination" travel in winter would benefit the Canadian tourism sector.

- **Park systems:** National and provincial parks are among Canada's most renowned tourism attractions. With climate change, visits to these parks could increase across the country. If current demand patterns remain, increases will be greatest in Atlantic Canada, Ontario, and Quebec.
- **Warm-weather recreation:** With effective adaptation, major warm-weather tourism markets in Canada could benefit from projected climate change. The projection of longer golf seasons could reasonably be extended to things like water parks, theme parks, zoos, boating, fishing, and beach recreation.
- **Winter recreation:** A degraded and shortened winter tourism season, on the other hand, represents a risk to tourism in many parts of Canada. The ski industry will depend more on snowmaking, and snowmobiling could be largely decreased in the future.
- **Nature-based tourism:** In Canada's north, changing ice conditions are lengthening the Arctic cruise season and allowing access to previously inaccessible locations. The polar bear tourism market in Churchill, Manitoba, will be threatened over the next 20 years by declining sea-ice conditions on Hudson Bay. Changes in biodiversity and wildlife reproduction will likely impact sport fishing (e.g., increased recreational fishing in northern Ontario due to increased walleye productivity) and hunting (e.g., moose hunting will shift northward).
- **"Last chance tourism":** Climate-induced environmental change has given rise to this new market, where tourists visit a destination or an attraction before it is lost to climate change.

Possible outcomes

- The tourism industry appears to be well positioned to benefit from climate change over the short term.
- A longer cruising season in Arctic Canada could benefit local residents through increased seasonal employment. Increased tourism could also generate more interest in Inuit art, culture and traditions.
- Changes in the frequency and magnitude of extreme events (wind storms, floods, forest fires, etc.) will pose a challenge to park agencies in terms of infrastructure damage, visitor safety, and business interruptions.
- Maintaining water quality will be challenging (swimming areas) and increased irrigation (golf courses for example) will be difficult in regions with limited or declining water resources.

Current research

There are a lot of studies on the effects of climate change on the tourism sector. Tourism operators have implemented a wide range of adaptations to allow them to operate in every climatic zone in Canada. But these strategies have been almost exclusively to manage the impacts of current climate changes.

Research needs

- Studies on the whether current adaptation strategies will be sustainable in the long term, both financially and environmentally
- Studies on tourists' responses to climate-related changes in tourism landscapes in order to create effective adaptation strategies
- Studies on how tourism will be affected by the interaction between climate change and factors like fuel prices and transportation costs, border restrictions, currency fluctuations, international reputation, demographic and market trends, etc.

The information in this profile can be found in the "Industry" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 135; and in Chapter 5 of Canada's Marine Coasts in a Changing Climate, p. 181.

Province and territory	2011 gross domestic product (2002 constant $)	2011 tourism employment (jobs)
Newfoundland and Labrador	$316 million	8 136
Prince Edward Island	$121 million	2 866
Nova Scotia	$683 million	16 636
New Brunswick	$438 million	12 090
Quebec	$5 357 million	130 018
British Columbia	$4 913 million	96 877
Yukon–Northwest Territories–Nunavut	$147 million	Data not available
Total	**$11.975 billion**	**266 623**

Economic contribution of tourism in Canadian coastal provinces and territories. Source: Canada's Marine Coasts in a Changing Climate, p. 79. (Adapted from Tourism Industry Association of Canada, 2012.)

Stakeholder Profile 6: Canadian Construction Association

Overview

The residential construction industry involves both new houses and renovations. The sector accounts for approximately 6 percent of Canada's gross domestic product. Growth is driven by low levels of unemployment, low interest rates, and immigration. The Canadian Home Builder's Association expects new home starts to be steady over the next few years, but to increase in response to immigration and demographic pressures.

When new residential homes are built, there is an assumption that the climate will remain static. But extreme weather linked with climate change can easily exceed the design threshold of these structures and cause damage.

The latest Intergovernmental Panel on Climate Change report on extreme weather concludes that "small increases in climate extremes above thresholds or regional infrastructure tipping points have the potential to result in large increases in damages to all forms of existing infrastructure nationally and to increase disaster risks."

Impacts of climate change

Analysis of the impact of climate change on the housing sector largely focuses on the risks linked with direct climate impacts, specifically an increase in property damage caused by more intense and frequent extreme weather:

- Increase in water damage caused by sewer backups and basement flooding after intense rainfall
- Increase in building damage caused by increase in wind speed
- Increase in the weathering process caused by gradual increases in temperature and precipitation

Possible outcomes

Potential indirect impacts from climate change on residential housing could include the following:

- Changes in the attitudes of homebuyers (e.g., increased demand for resilient housing)
- Increased regulatory pressure (e.g., changes to building codes)
- Increased financial liability (e.g., more stringent lending or insurance conditions)
- Increased costs of building a home if new technologies or design practices are incorporated

These indirect impacts could help create commercial incentives for homebuilders to implement adaptation measures.

For most stakeholders in the housing sector, climate change adaptation is a new concern. Mitigation measures like improving energy efficiency are still the main focus of research and policy.

In order to promote climate change adaptation, multiple stakeholders including homebuilders, regulators, consumers, and the financial services sector should support the use of a number of tools and practices:

- Building codes: update these based on future weather trends
- Land-use planning: build homes in areas protected from the hazards of extreme weather events (e.g., avoid flood plains)
- Retrofits for existing homes: improve the resiliency of existing homes to extreme weather
- Financing adaptation (homebuilders): expand construction budgets and warranty program

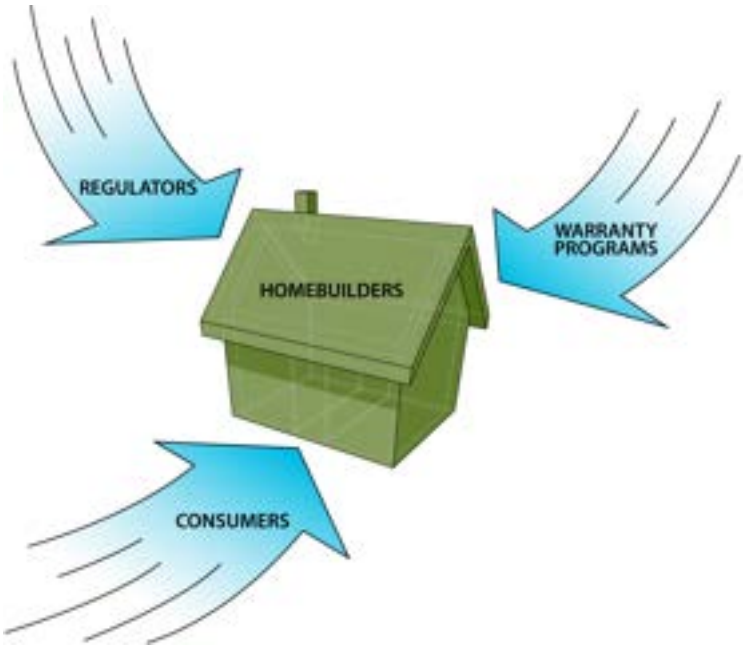
Existing research

Existing studies make a distinction between "direct" climate impacts, such as extreme weather, and "indirect" impacts, such as changes in consumer demands. Most research to date focuses on direct impacts, with only limited information available on indirect impacts.

Research needs

- Research on indirect impacts of climate change
- More information for homebuilders about the local climate change risks so they are motivated to implement adaptive actions
- Research on the costs and benefits of retrofits and building code changes
- Research on the costs and benefits of changing designs to improve resilience to climate risks
- Capacity to develop appropriate adaptation solutions, such as new design techniques and technologies
- Collaboration between building scientists, the insurance industry, and homebuilders

The information in this profile can be found in the "Residential Construction" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 149.



External stakeholders' role in promoting adaptation in residential housing market. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 150.

Stakeholder Profile 7: Insurance Bureau of Canada

Overview

Insurance companies have the ninth-largest income of Canada's 22 industries (Statistics Canada, 2012a). Insurance includes a number of different sub-sectors including life insurance, health insurance, and property insurance. Some insurance sectors, such as life insurance, do not currently appear sensitive to variation in the weather. However, property insurance, and to a lesser extent auto insurance, experience significant swings in costs and earnings with weather variation. In fact, weather damage claims have recently emerged as the largest expense for property insurance companies in Canada. Damage to homes and businesses caused by severe weather has been increasing for several decades in Canada and elsewhere around the globe (in 2011, the Canadian insurance industry paid out a record $1.7 billion for property damage claims linked to weather events). In fact, loss and damage due to intense rainfall, hurricanes, tornadoes, wildfires, and winter storms have recently grown to surpass fire and theft. The increase primarily involves basement flood damage claims.

Impacts of climate change

Climate change and the potential increase in the frequency of severe weather have emerged as a significant priority for property insurers.

- Intense rain can overwhelm Canada's aging urban sewer systems and cause damages to homes and businesses.
- Warming may increase the severity of Atlantic hurricanes, resulting in more claims for damage from wind and heavy rain.
- An increase in the severity of summer storms (e.g., tornadoes, hail storms, lightning events) could increase damages and losses.
- More large wildfires would add to the risk of fire damage in communities on the edge of forestland.

Possible outcomes

- Insurers could use adaptive actions (e.g., adjusting what they cover, raising prices) to protect themselves against costs caused by extreme weather.
- Insurance price increases could make rates unaffordable, and regulatory interventions may force reductions.
- Insurers could offer lower rates to industries and property owners who invest in climate change adaptation.
- Adaptive measures could result from collaboration between insurers and stakeholders with influence over infrastructure and building codes.

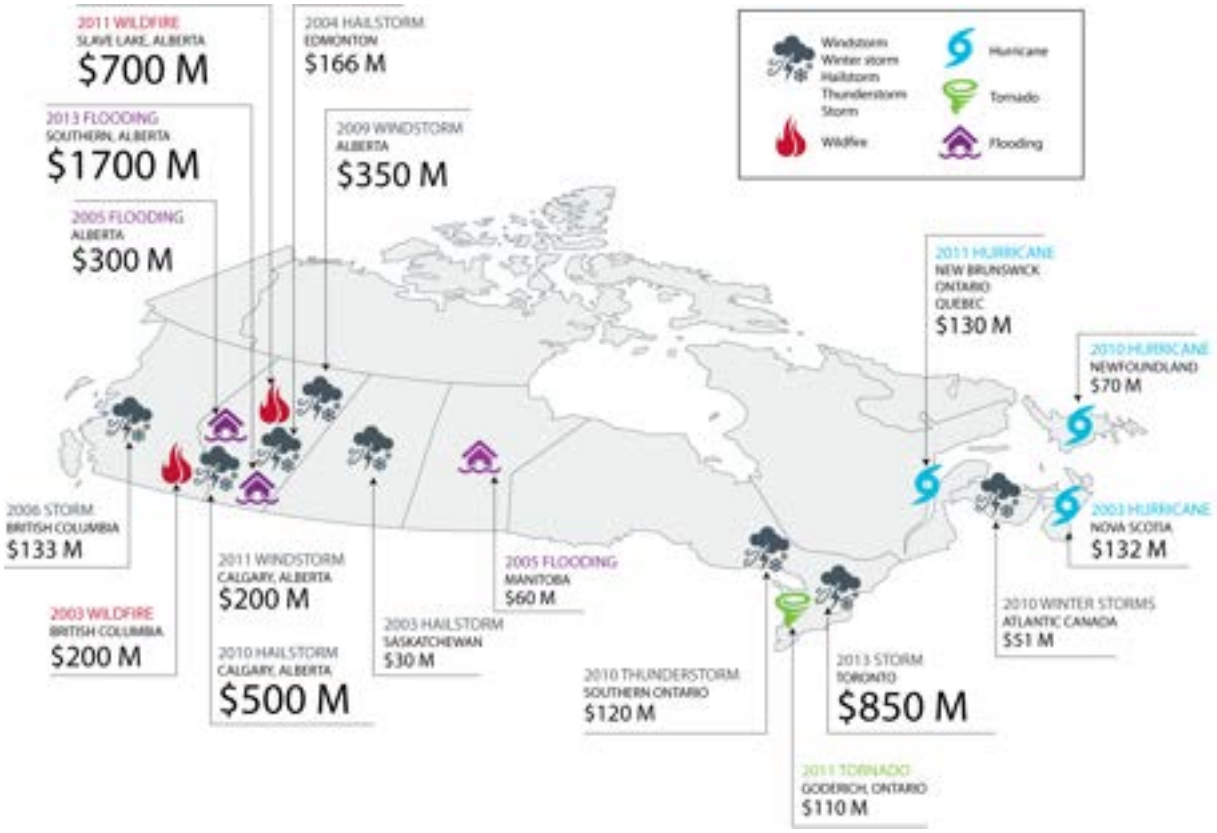
Existing research

Canadian and international studies on developing adaptive actions, like adjustments to coverage and price increases, are available for the insurance sector.

Research needs

- Estimates of the contribution of climate change to the cost of claims that have been paid by insurers in Canada
- Studies on how insurers could partner with universities, governments, homebuilders, and consumers to promote adaptive actions
- Development of demonstration homes with features that go beyond building codes to prevent damage from hurricanes and intense rainfall

The information in this profile can be found in the "Industry" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 135.



Insured losses from extreme weather events in Canada. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 143.

Stakeholder Profile 8: Canadian Association of Importers and Exporters

Overview

Manufacturing is Canada's largest and most diverse industrial sector. Several tens of thousands of companies participate in the sector, including large international companies and many mid-size and smaller ones.

This sector has experienced significant challenges in recent years due to the global economic crisis, the low Canadian dollar, and weakness in export markets. Most manufacturers have experienced some disruptions from severe weather events, such as delays in securing critical supplies, challenges in making deliveries on time, and disruptions from power failures.

Impacts of climate change

Climate change can have a range of physical impacts on the manufacturing sector.

Changes in the environment can limit the availability of certain key manufacturing inputs, such as water or timber, thereby increasing costs for manufacturers.

- Forest fires, pests, diseases, and changing growth patterns could decrease forest productivity, which in turn could increase costs for manufacturing products (e.g., wood products for construction, pulp and paper).
- Water shortages are a risk for industrial processes that use water for cooling, irrigation, cleaning, or refining raw materials.
- Higher temperatures and humidity can decrease workers' productivity and increase health risks.
- Extreme weather can also disrupt operations by damaging infrastructure and interrupting supply chains. For example, an Atlantic hurricane could disrupt vital transportation of materials and shut down supplier plants in southern Ontario.

Possible outcomes

Changes in consumer demands and preferences — due to climate change itself as well as increasing environmental awareness — present indirect opportunities and risks for several areas of manufacturing.

- Milder winters and warmer summers may increase the demand for certain consumer products and decrease it for others.
- Areas of manufacturing that are greenhouse-gas-intensive could face risks as consumers start buying products that are more energy-efficient.

Existing research

Existing studies make a distinction between "direct" climate impacts, such as extreme weather, and "indirect" impacts, such as changes in consumer demand. Most research to date focuses on direct impacts. And studies on climate change and the Canadian manufacturing sector almost exclusively address mitigation actions (actions to reduce energy use or to reduce greenhouse gas emissions).

Research needs

- Studies that document indirect climate impacts (e.g., changes in consumer demand)
- Studies that document climate change impacts, risks, and opportunities
- Studies on the costs and benefits of adaptation as a business strategy (e.g., buying insurance to cover losses and damage, environmental management at manufacturing sites to deal with water issues or weather extremes, using several suppliers or having separate production facilities to reduce disruption in the supply chain, producing surpluses of those goods that frequently get disrupted)
- Accurate cost-benefit analysis of using adaptation strategies to protect supply chains when, for example, extreme weather events disrupt transportation of materials

The information in this profile can be found in the "Industry" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 135.

Stakeholder Profile 9: Biodiversity

Overview

Canada is home to major portions of the world's polar regions and tundra, boreal and temperate forests, grasslands, and aquatic ecosystems. The latter include the Great Lakes as well as territorial waters in the Pacific, Arctic, and Atlantic oceans.

These ecosystems contain about 10 percent of the world's forests and 20 percent of the world's freshwater. They provide niche space for more than 70,000 species of mammals, birds, reptiles, amphibians, fish, invertebrates, plants, and other organisms.

Biodiversity means the variety of species and ecosystems, and the ecological processes they are part of. It contributes to cleaner air and water, climate regulation, carbon storage, pollination, and flood regulation. Humans benefit from biodiversity as, for example, a source of food, fibre, materials for clothing, timber, and recreational opportunities. Biodiversity is vital to economic sectors such as agriculture and tourism. And it is vital during periods of rapid environmental change.

Impacts of climate change

Evidence that Canada's biodiversity is under increasing pressure from climate change continues to grow. Some impacts of climate change are already evident.

- Impacts on Arctic species will involve habitat loss, competition from species migrating northward, and the arrival of new diseases and parasites from the south.
- Impacts on species distribution, abundance, physiology, and life cycle timing will alter ecological relationships and habitats.
- Coastal and estuary ecosystems are at risk from erosion, which could eliminate habitat for some species.
- Drier conditions in prairie ecosystems will likely decrease productivity in natural grasslands.
- As the climate warms, habitats could contract or become increasingly fragmented.
- Climate change impacts on water quantity and quality are a concern for lakes and rivers across Canada.
- In Hudson Bay, the numbers and distribution of seals and polar bears correlate with a shorter sea ice season and higher water temperatures. The same is true for a number of fish species.
- Increases in wildfires, insect outbreaks, and droughts will result in loss of old-growth forests.
- In northern and alpine regions, the rapid melting of glaciers will change river and stream flows. This will affect downstream aquatic ecosystems, as well as water supplies for many towns and cities.

Possible outcomes

Current evidence indicates that the range for many species will likely shift northward in response to warming temperatures. This would have major implications for people who rely on the current configuration of ecosystems.

- Many bird species that currently breed in the northeastern United States are likely to move northward into Canada, increasing bird species richness in Eastern Canada.
- Climate change may increase biodiversity in southern Quebec during this century as species move northward.
- The southern edge of species range is likely to contract in response to shifting climate.
- The West Nile virus and Lyme disease in humans could expand their distributions with changing climate.

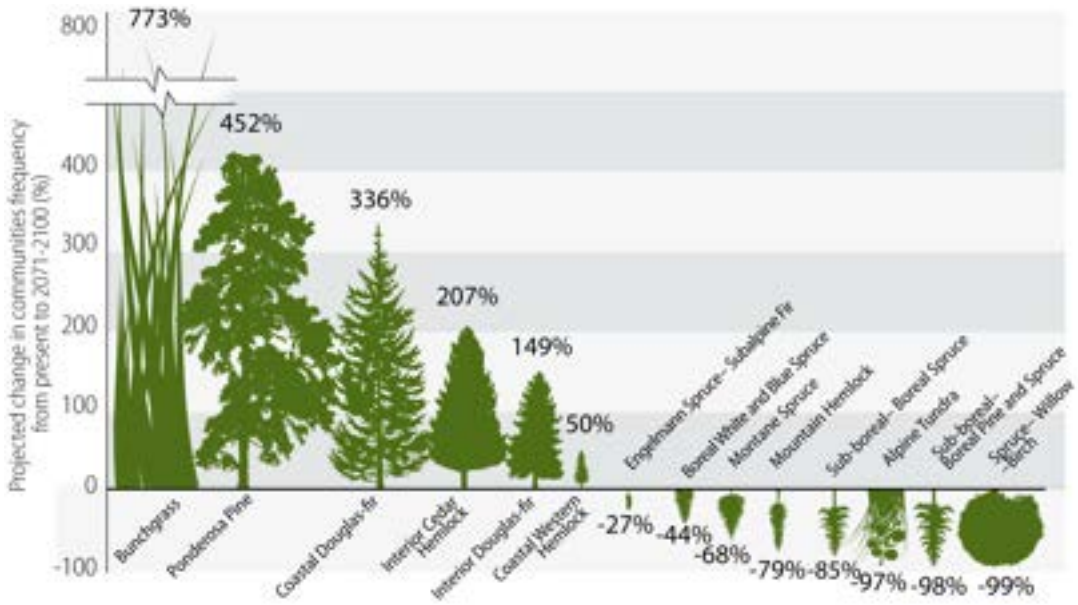
Existing research

Most work to date has focused on the effects of climate change on individual species.
As for the effects of climate change on biodiversity, there has been a range of adaptation recommendations aimed at maintaining or restoring biodiversity. These include improved institutional coordination (e.g., government, universities, industry, and environmental organizations), inclusion of spatial and temporal (set in time) perspectives, and integrated coordination of climate change scenarios into planning and action related to ecosystem management.

Research needs

- Studies of the effects of climate change on species patterns and response of species groups
- Studies of ecological relationships, which will help us understand the impacts of climate change on how ecosystems function
- Studies of the influence of other factors, such as competition and predation, on population distribution and abundance
- Studies of the effect of localized microclimates and extinction risks

The information in this profile can be found in the "Biodiversity" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 159.



Projected change from the present to 2071–2100 in the distributions of British Columbia ecological zones, with bunchgrass communities and ponderosa pine forests becoming more common than today, while alpine tundra may disappear. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 167.

Stakeholder Profile 10: Transportation Association of Canada

Overview

Transportation services account for 4.2 percent of Canada's gross domestic product. Dependable transportation networks are critical to a wide range of economic and social sectors.

Transport is very sensitive to climate, and there are many examples of transportation disruptions related to weather events and seasonal conditions. The climate sensitivity of transportation systems is reflected in design and construction standards, spending, and mobility and safety outcomes.

Well-maintained infrastructure (e.g., roads, railways, bridges) is more resilient to a changing climate. This is especially true when it comes to gradual changes in temperature and precipitation patterns: in many cases, these can be addressed through regular maintenance and normal upgrade cycles or adjustments to the way a system is operated or maintained.

Infrastructure is designed to provide services over its lifetime — anywhere from 10 to 100 years — and must be adapted over time to meet changing circumstances (e.g., changes in technology, society, and business).

Impacts of climate change

Impacts of climate change are associated with extreme weather events (e.g., heat waves, heavy rainfall) as well as more gradual changes (e.g., permafrost thaw, higher temperatures, sea-level rise, and declining water levels in freshwater systems).

Climate change presents a range of challenges for infrastructure design, construction, operation, and maintenance. It is recognized as a factor that needs to be considered as Canada strives to maintain and improve existing infrastructure.

- Disruption from extreme events (e.g., floods, fire, storms) is the main climate concern with respect to transportation.
- More frequent and longer heat waves could result in pavement softening, rail buckling, and cargo overheating.
- Railway systems could be impacted by flooding, erosion, landslides, and fires.
- The northern regions are vulnerable to changing climate in a number of ways. They rely on a combination of ice roads, barge transport, air services, and limited rail access for commercial activities and community supply.
- In coastal communities, transport infrastructure is vulnerable to the intensity and frequency of storm events, which can cause storm-surge flooding and submergence.
- Warmer temperatures could mean lower water levels in the Great Lakes system, affecting the Great Lakes–St. Lawrence Seaway, a major international shipping route.

Possible outcomes

- Freezing rain events — as well as sequences like rain on freezing rain, or rain on snow — are likely to increase in south-central Canada and will pose risks to transportation.
- In light of the warming trend, there will be a need to reconsider road design and to use different materials, especially in trucking corridors.
- For each centimetre decrease in water level in the Great Lakes–St. Lawrence Seaway, ship capacity would decrease by six containers, or 60 tons (Transports Québec, 2012).

Existing research

The work of the Public Infrastructure Engineering Vulnerability Committee (PIEVC) has broadened our understanding of how to adapt Canada's infrastructure to climate change. Using the PIEVC's risk-based assessment protocol, engineers and planners can view and address climate change as one factor among many that affects system resiliency — and plan accordingly.

Research needs

- Further assessment of current and future climate risks to infrastructure systems is required. This would then inform adjustments to design codes and standards to address future climate.

The information in this profile can be found in the "Transportation Infrastructure" section of Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 233.

Summary	Date	Reference
Winter roads in Manitoba turn into quagmires	3-Jan-12	CTV News (2012)
Flights cancelled due to low visibility and fog	17-Jan-12	Ptashnick and Hayes (2012)
Rainfall-induced underground slide creates sinkhole 200 m wide x 5 m deep on Hwy 83 in Manitoba	3-Jul-12	CBC News (2012c)
Ice build-up in E. Arctic damages ship and causes delay in unloading sealifts	29-Jul-12	CBC News (2012d).
Wawa in a state of emergency due to runoff from rain. Total damage > $10 million dollars	27-Oct-12	Metro News (2012)
Hurricane Sandy causes flight cancellations in Atlantic Canada	29-Oct-12	The Telegram (2012)
The Trans-Canada Hwy in Newfoundland closed due to damage from a landslide	19-Nov-12	CBC News (2012e)
Sailings from Vancouver Island cancelled due to winds, wave height and sea conditions	19-Dec-12	Lavoie (2013)
Record snowfall affects transport in southern Quebec	27-Dec-12	Radio Canada (2012)
VIA Rail uses the "snow fighter" to clear the train tracks during snowstorms	24-Jan-13	Pinsonneault (2013)
Roads closed in Northwestern Ontario as drifting and blowing snow impacted highways still affected by freezing rain	30-Jan-13	CBC News (2013a).
Road and marine travel delayed by winter weather	18-Feb-13	National Post (2013a)
Barge supply to western Arctic interrupted by ice	3-Sep-13	CBC News (2013c)

Examples of weather-transportation news stories from 2012–2013. Source: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, p. 244.

Stakeholder Profile 11: Health and Social Well-Being

Overview

Climate change poses significant risks to human health and well-being, with impacts from extreme weather events and natural hazards; from air quality and stratospheric ozone depletion; and from water-, food-, vector-, and rodent-borne diseases.

In recent years, greater efforts have been made to prepare for these health impacts by public health officials, emergency management officials, and non-governmental organizations.

Although all Canadians are at risk from the health impacts of climate change, some groups have been identified as being more vulnerable. These include seniors, children and infants, the socially and economically disadvantaged, those with chronic diseases and compromised immune systems, aboriginal people, and residents of northern and remote communities.

Impacts of climate change

In the past 10 years, stronger evidence has emerged that a wide range of climate-related impacts are of public-health concern in Canada.

1. Air quality
    - Increased air pollution, i.e., higher levels of ground-level ozone and airborne particulate matter, including smoke and particulates from wildfires
    - Increased production of pollens and spores by plants
2. Food and water quality
    - Increased contamination of drinking water and recreational water by runoff from heavy rainfall
    - Changes in marine environments that result in algal blooms and higher levels of toxins in fish and shellfish
    - Behavioural changes due to warmer temperatures resulting in an increased risk of food- and water-borne infections (e.g., through longer barbecue and swimming seasons)
3. Infectious diseases transmitted by insects, ticks, and rodents
    - Changes in the biology and ecology of various disease-carrying insects, ticks, and rodents (including geographical distribution)
    - Faster maturation for the pathogens carried by insects and ticks
    - Longer disease transmission season
4. Stratospheric ozone depletion
    - With a warmer climate, increased human exposure to ultraviolet radiation due to behavioural changes

Possible outcomes

- Heat-related illnesses and deaths
- Possible changed patterns of illness and death due to colder conditions in some regions
- Increased risk of cardiovascular diseases (e.g., heart attacks, ischemic heart disease)
- Respiratory disorders; irritation of eyes, nose and throat; and shortness of breath
- Exacerbation of allergies
- Food- and water-borne illnesses and other diarrheal and intestinal diseases
- Possible emergence of new infectious diseases
- More cases of sunburns, skin cancers, cataracts, and eye damage

- Various immune disorders
- Health and mental-health impacts in aboriginal and northern communities if environmental changes affect their livelihood, relationship with the land, and culture

Existing research

Canada is ahead of many developed countries in efforts to protect health from climate change, according to a comparison listed in the United Nations Framework Convention on Climate Change. Canada is particularly strong on research into the impacts of climate change and adaptation options in the health sector, the comparison shows. It is also one of the few countries to recognize the particular vulnerabilities of indigenous groups and develop specific adaptation options.

Public health officials and researchers are focusing on some new adaptation areas of focus:

- Vulnerability assessments of high-risk populations
- Actions to address psychosocial impacts of climate hazards, and other secondary health effects
- New adaptive technologies that individuals can use (e.g., devices in cars to warn of water depth, landslide early-detection systems)
- Planning measures for health-care facilities to help them manage emergencies
- Preventative measures, like green roofs to reduce the urban heat island

Research needs

- Research on how dampness and temperature affect materials in buildings and thus indoor air quality
- Research on the impacts of climate change on food and water security in the various regions of Canada
- Research on the capacity and preparedness of water utilities to adapt to climate change
- Basic and applied research studies with respect to disease surveillance, prevention, and control
- Longitudinal studies across different demographic groups (children, elderly, urban, rural, outdoor workers) to identify health impacts from slow-developing hazards (e.g., drought) and the cumulative effects of climate change (e.g., extreme heat, drought, wildfires)