EXECUTIVE SUMMARY

Infrastructure—our entire built environment—underpins life in Canada. When this infrastructure is damaged or doesn't function properly, people's health, safety, and livelihoods, and the strength of the economy are put at risk. Climate change is increasing the risk of damage and service disruption to infrastructure across Canada—infrastructure whose repair and maintenance costs are already a major national challenge.

Until now, the scale of risk to Canada's infrastructure has been poorly understood. This report looks at how a warming and increasingly volatile climate could damage infrastructure across Canada and what Canadian governments can do to prepare and to reduce damage, disruption, and costs.

We project impacts for some of the country's most important infrastructure—including homes and buildings, roads and railways, and electricity systems—and assess how various adaptation choices could influence future costs. Our findings suggest that to ensure new and existing infrastructure is "future proofed," investment must dramatically shift toward making infrastructure more resilient. Policy changes drive that shift: Canada must rapidly update the policies, codes, regulations, and funding decisions that determine what gets built and how it is maintained.

This is easier said than done. Even without considering the added stress of a warming climate, Canada already faces significant threats to the integrity of our roads, bridges, buildings, communications systems, water and sewer systems, electricity grids, and homes. Deteriorating roads and electrical grids and slow progress in modernizing transportation corridors and public transit systems are hampering business performance, trade and economic growth. And access to clean drinking water and safe housing remains a critical need for tens of thousands of people—and Indigenous communities in particular—eroding health, safety, and prosperity. Necessary repairs and upgrades are already overdue and underfunded—some estimates peg the money required to address this gap at over $250 billion. And in some places, like in many

majority First Nation, Métis, and Inuit communities, essential infrastructure has never been built. The added pressure of climate change will make it even more difficult to rectify this inequality.

What's more, Canada's transition to net zero will require major infrastructure investments in low-carbon buildings, transportation, and electricity infrastructure. If these new investments are done right, they can help address infrastructure gaps and make infrastructure systems across the country more resilient to climate change. If they are done poorly, they will add to our stock of infrastructure at risk of damage and disruption from climate change and deepen gaps.

Canada has a clear opportunity to address existing infrastructure needs while also building climate resilience into infrastructure from the ground up. Failing to consider climate risks and the benefits of resilience will only increase costs and exacerbate Canada's existing infrastructure challenges.

FINDINGS

▶ The costs of damage and disruption from climate change to Canada's infrastructure, which is vulnerable from decades of underinvestment, could be massive.

Canada's warming climate will accelerate climate- and weather-related damage to some of the country's most important infrastructure. As sea levels rise and rainfall increases, flood damage to homes and buildings could increase fivefold in the next few decades and by a factor of ten by the end of the century, with costs as high as $13.6 billion annually. Temperature- and rainfall- related damage to roads and railways could increase by up to $5.4 billion annually by mid century and by as much as $12.8 billion annually by end of century. Heat and rainfall damage to electrical transmission and distribution infrastructure could more than double by mid-century and triple by end of century, costing utilities and ratepayers up to $4.1 billion annually.

Governments, utilities, businesses, and homeowners across Canada are already struggling to keep existing infrastructure in good condition and build the infrastructure needed for the future. Growing levels of damage and disruption as a result of climate change could make this even more difficult—and costly.

▶ Proactive investment in infrastructure adaptation is the most cost-effective way to protect the services that people, businesses, and the economy depend on.

Early investment in adaptation can substantially reduce the impacts and costs to infrastructure of a hotter and increasingly volatile climate. Building and moving homes out of high-risk areas can reduce the costs of coastal flooding by 2100 up to 90 per cent or up to $1 billion every year. When repaving roads, using asphalt mixes and base materials selected to withstand the climate two or three decades into the future can reduce costs by over 90 per cent, saving as much as

$4.1 billion annually by the 2050s. And during regular maintenance for electricity transmission and distribution infrastructure, replacing components with new ones designed to withstand increases in heat and rainfall for several decades to come can reduce damage costs by 80 percent by the end of the century, or up to $3.1 billion each year.

Despite the clear benefits of early, proactive investment in adapting Canada's infrastructure for climate change, progress has been limited. Public and private infrastructure owners have been more concerned with short-term budgets and balance sheets than long-term planning, leaving long-term risks like climate change unaddressed. The unprecedented investments in infrastructure over the next several decades to support the net zero transition are a key opportunity to build the climate resilience of virtually all infrastructure in Canada. However, if current short-term thinking around infrastructure continues, those investments will only increase the amount of infrastructure vulnerable to climate change impacts.

▶ Not all impacts and costs of climate change for infrastructure can be quantified—the loss of services and reliability will have far-reaching social and economic consequences.

Our analysis shows that the cost of climate change-induced damage to key infrastructure could be massive, yet our projections of costs are only a low-end estimate. Climate science cannot yet predict how climate change might affect many types of extreme weather events not included in our analysis—such as ice storms, tornadoes, hurricanes, and hail—that could cause much additional damage. Other types of critical infrastructure that we did not study, including telecommunications infrastructure, drinking water systems, healthcare facilities, and marine ports and seaways, are also at risk from climate change.

The costs of climate change impacts on infrastructure also go beyond the price of physical damage and repair. When infrastructure is put out of commission or made less reliable by more frequent damage, the services that it provides—transportation, power, healthcare, communications, and shelter, to name a few—are also interrupted. We show that the costs of delays from climate-induced damage to roads and railways borne by transportation operators alone could be in the billions annually. In reality, however, these effects will reverberate through supply chains and industries, multiplying costs and reducing economic productivity. Further, damage from climate change, or the threat thereof, could have far-reaching implications for the stability of the financial system and the availability of capital and insurance.

▶ A lack of climate risk information, transparency, and regulation is leading to bad infrastructure decisions.

In Canada, very little information is available regarding current or future climate risks to infrastructure. For example, we estimate that at least a half million buildings at risk of flooding in Canada are not identified by government-produced flood maps. The flood maps that are available

are 20 years out of date on average and only show existing flood risk—virtually none of them show how climate change may affect the future risk of flooding. Even bigger information gaps exist for other major climate hazards, including wildfire. In the absence of this information, few infrastructure owners or investors are able to assess and manage existing climate risks, let alone future risks associated with climate change.

The codes and standards that dictate how infrastructure in Canada is built and managed largely do not account for climate change, and updates to reflect climate change risk are many years from being implemented. As a result, infrastructure is being built and operated based on the climate of the past, not the hotter and more extreme climate that is emerging. And regulations for financial decision making in Canada do not yet require owners and investors to assess and disclose climate change risks to physical assets and infrastructure. Markets are therefore not pricing this risk, allowing capital to continue to flow into risky investments.

BALANCE SHEETS ARE LITTERED WITH UNDISCLOSED CLIMATE INFRASTRUCTURE RISKS

The economic implications of climate change impacts on infrastructure in Canada extend well beyond the costs of repairing potholes or flooded homes. The accumulated costs of damage and disruption from flooding and extreme weather and from additional wear and tear from a warming climate, as well as from the impact of this damage on property and asset values, mortgages, and insurance rates, can also ricochet through the economy. Yet very few of these costs are being factored into financial systems and economic decisions today. Both public and private infrastructure owners risk big write-downs in the value of their assets, as well as challenges in obtaining credit and capital once it becomes clear that they face increased risk of flooding or other hazards in a changing climate. And stakeholders and investors in both government-owned and privately owned infrastructure are unknowingly buying into those risks.

Currently, the risks of climate change for infrastructure owned by individuals or businesses, such as homes and commercial buildings—and for the capital that finances them—are not being widely assessed or disclosed. For example, flood, wildfire, and permafrost risks are very difficult for asset owners in Canada to assess because there are no country-wide maps or data sources, and the local data that exists is frequently dated or obsolete. This means that the amount of climate risk threatening the value of a home or building is equally unknown to the owner, mortgage lender, and mortgage-backed security holder. Indeed, our estimates show that within 30 years, climate change will likely increase annual damages of coastal and inland floods to homes and buildings by $4.5 billion to $5.5 billion annually, three to four times today's costs. Yet the lack of information about flooding and other climate change risks means that not enough infrastructure owners or lenders are taking steps to protect themselves. For example, approximately 45 per cent of homeowners in Canada believe they have insurance that will pay for repairs and rebuilding after overland flooding,

only about 10 to 15 per cent of households actually have this coverage. And mortgage lenders typically don't require purchasers of homes in flood zones to have overland flood insurance.

Risks to public and large-scale infrastructure like railways and electricity systems are also a concern. Governments and other major infrastructure owners continue to design and build for yesterday's environment without factoring in climate change risk. Stakeholders—users, taxpayers, ratepayers, lenders, and investors—are largely unaware of how the impacts of climate change to these major infrastructure systems will impact them. For example, our projections indicate that by around 2050, climate change-induced damage to roads could require governments across Canada to spend up to $3.1 billion more annually on road maintenance and repair—or almost 20 per cent more than what they currently spend. These costs will hurt the bottom line of municipal governments—which are responsible for most roads in Canada—and will ultimately impact residents through higher taxes, poor road conditions, and delays.

In addition to financial risks for individual owners, businesses, and governments, damage and disruption to infrastructure from climate change could have major systemic consequences. Cumulatively, the costs of infrastructure damage and loss of asset value could affect the stability of Canada's financial system. Lenders and investors will be less willing to provide capital—or will demand higher rates—to areas and industries where climate-related risks are clearly increasing. Similarly, insurance will become more expensive or even unavailable, meaning that more losses will be borne directly by owners or creditors. More frequent and severe damage means that infrastructure will more frequently be out of service or in poor condition, reducing the function that it performs in supporting people, communities, and businesses. For example, traffic congestion in the Greater Toronto and Hamilton area alone is already estimated to cost up to $11 billion per year in lost productivity—an amount that will only grow with roads in worse condition or more frequently closed for repair. Loss of vital infrastructure services will also affect productivity, mobility, trade, communications, and food and water security, among other things, with implications for economic growth and the health and well-being of people across Canada.

Quite simply, when it comes to forecasting the true scale of damage and disruption of infrastructure in a warming climate, we don't know what we don't know. The scale and extent of climate-related risks to Canada's infrastructure are only now coming into focus as climate models are updated, and the complex consequences of increasing infrastructure damage and loss of service for the financial system and the broader economy are beginning to come to light. It is therefore impossible to fully gauge the extent of the economic impact of future climate risk. However, without starting to act now to minimize future loss and damage based on the information today, Canada could find itself swamped by the pace of climate change and its impacts on our infrastructure.

CLIMATE CHANGE MUST FACTOR MORE PROMINENTLY INTO INFRASTRUCTURE DECISIONS

Decisions about where and how public and private infrastructure are driven by a complex web of government policies and market forces. In governments, infrastructure departments play an important role in deciding what gets built where, but other departments also influence infrastructure planning, design, financing, and operations through other levers, including building codes and standards, macroprudential decisions, financial system oversight, regulation of utilities, and land-use planning. And alongside government decisions, the practices of financial system actors, including banks, insurers, stock exchanges, investment companies, institutional investors, accounting firms, credit rating agencies, and real estate professionals, have a powerful influence over how and when markets finance infrastructure with private capital.

To date, the combined actions of governments and markets have not been enough to prepare Canada's built environment for the warmer and more volatile climate that lies ahead. The climate information developed by governments does not provide individuals and businesses the information they need to understand and prepare for climate risks. Building codes and standards have not kept up with the increased stresses of a warming world. Governments are also enabling risky decisions and bad investments by funding at-risk infrastructure and repeatedly providing financial assistance in response to climate-related infrastructure failures and disaster losses. And markets are failing to account for the true value of climate change risk because owners, lenders, and investors are not able or not willing to disclose how climate change will affect their infrastructure assets.

Governments and the private sector need a new blueprint for how to decide, fund, and insure what gets built. To avoid the costs and social and economic disruption of climate change impacts, infrastructure planning must be forward-looking, strategic, and coordinated across government departments and orders of government, encompassing funding, codes and standards, land-use planning, infrastructure asset management, and more. Government policies should also encourage the transparent disclosure and valuation of risk and stop financially backstopping risky public and private investments. And private sector lenders, investors and firms need to play their part in making better long-term decisions that incorporate climate change risk.

Canada is at an infrastructure crossroads. Governments, businesses, and communities are beginning to rethink what the roads, railways, homes, buildings, and electricity grids of tomorrow should look like, and how best to prepare for the changes we anticipate. Ultimately, continuing to build infrastructure the way Canada has in the past will cost more than future-proofing the country's built environment.

RECOMMENDATIONS

All orders of government have an important role in building the resilience of Canada's infrastructure in preparation for climate change. The following recommendations, if acted on by federal, provincial, territorial, Indigenous, and municipal governments, will help ensure that Canada starts building today for the climate of tomorrow.

1 Governments should develop and publish accurate and practical information about climate-related infrastructure risks.

To understand and manage current and future climate change risk and make informed investments in adaptation, governments, corporations, investors, and individuals need actionable and up-to-date risk information. However, current information about future climate change impacts and existing climate risks in Canada is inconsistent and incomplete. To ensure that all owners and investors of infrastructure understand climate risk and can account for it in their decisions, governments must develop useful and consistent climate risk information that is universally accessible.

2 Governments and regulators should require owners of existing and proposed infrastructure to disclose climate change risks.

Transparency about climate change risk promotes resilient decisions and discourages risky ones. But if infrastructure owners and investors are not made aware of and accountable for climate risk, that risk will grow dramatically as the climate becomes hotter and more volatile. Governments and regulatory bodies should use their authority to ensure that owners, lenders, investors and other financial system actors are analyzing, disclosing, and managing climate risk.

3 Governments should explicitly evaluate resilience benefits and climate risks for all infrastructure spending and regulatory decisions.

The long lifespan of most infrastructure means governments and others need to start building adaptation and resilience into infrastructure decisions immediately to avoid locking in decades or centuries of additional climate vulnerability. To make this happen, all orders of government should take a long-term, coordinated approach to setting infrastructure standards, funding and planning public infrastructure, regulating infrastructure operation, regulating urban development, evaluating major industrial and resource development projects, and maintaining and operating infrastructure.

4 Governments should create safety nets for the most vulnerable to make climate risk pricing equitable.

More transparency and disclosure of climate change risk will create price signals that have overall, long-term benefits for reducing climate risk. However, uncontrolled climate change risk pricing could create unsustainable costs for the individuals and communities that are already the most economically vulnerable to climate-related damage—for example by raising mortgage rates or insurance premiums. To avoid negatively impacting those who can already least afford to pay, governments should ensure that economically vulnerable individuals, businesses, and communities are made a priority for adaptation investments and for programs to ensure access to insurance and credit.

Northern infrastructure

Canada's infrastructure gaps are perhaps most visible when comparing differences between Northern and Southern Canada. Inadequate housing, unreliable electricity, and deficient roads and airports, among other issues, are major challenges to the health, well-being, and prosperity of communities across the North, and of Indigenous peoples in particular. The climate is also warming more rapidly in Northern Canada than almost anywhere else in the world. The speed of change, as well as the North's unique geography and history, mean that the patterns and consequences of climate change impacts on infrastructure are distinct in Northern communities.

The Canadian Institute for Climate Choices is examining the unique challenges facing northern Canada when it comes to climate-related infrastructure impacts and adaptation. These include the impacts and costs of permafrost thaw on airports, roads, and homes across the North and the impacts of shorter ice road seasons. In collaboration with Firelight, an Indigenous-owned consulting and research firm that works with Indigenous and local communities across Canada, we are also exploring what these infrastructure impacts mean to Inuit and First Nations communities. This analysis will be published in 2022.