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SUMMARY RECOMMENDATIONS

CLIMATE CHANGE ADAPTATION AND EXTREME WEATHER

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SUMMARY REPORT

CLIMATE CHANGE ADAPTATION AND EXTREME WEATHER

MAKING CANADA'S COMMUNITIES MORE RESILIENT TO THE IMPACTS OF CLIMATE CHANGE AND EXTREME WEATHER: SUMMARY RECOMMENDATIONS

Prepared by: Dan Henstra and Gordon McBean

September 9, 2009

ACKNOWLEDGEMENTS

Gordon McBean, lead policy author for ACT's second set of findings, has a long involvement in climate change studies as a scientist, professor and manager. A lead author for the first and second IPCC Assessments and a review editor for the fourth, Gordon is currently Professor of Geography and Political Science at The University of Western Ontario, Director of Policy Studies of the Institute of Catastrophic Loss Reduction and Chair of the international Science Committee for the Integrated Research on Disaster Risk of the International Council for Science, the International Social Sciences Council and UN's International Strategy for Disaster Reduction. He is also Chair of the Board of the Canadian Foundation for Climate and Atmospheric Sciences, President of START International, and member of several advisory groups on climate change adaptation. Former appointments include Chair, UN Agencies International Scientific Committee for the World Climate Research Programme (1988-94), Professor of Atmospheric and Oceanographic Sciences at the University of British Columbia, and Assistant Deputy Minister, Meteorological Service of Environment Canada responsible for climate, weather, water and ice science and services. Gordon is a Member of the Order of Canada, shares in the Nobel Peace Prize for his role in IPCC, a Fellow of the Royal Society of Canada and was awarded the 1989 Patterson Medal for distinguished contributions to meteorology.

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ACT would like to thank **BC Ministry of Environment** experts Cathy LeBlanc, Intergovernmental Relations and Planning, Ministry of Community Development and Ben Kangasniemi, Acting Manager, Science and Adaptation, Climate Action Secretariat, for kindly providing a technical review of this document.

ACT (the Adaptation to Climate Change Team) is a five-year series of six-month sessions that bring leading experts together with decision-makers and experts from industry, community, academia, and government, to explore the risks posed by climate change and generate policy recommendations for sustainable adaptation. This second set of findings is partly based on information gathered during ACT's three conferences – Municipalities Adapting to Climate Change held June 2-3, 2008, Adapting Infrastructure to Climate Change held October 17, 2008, and Climate Impacts and Public Safety held November 21, 2008 – as part of the six-month session on Extreme Weather Events and adaptation to climate change.

EXTREME WEATHER SESSION PARTNERS

Zurich Canada was a key sponsor for this six-month research session and conference series. It behooves our industry to examine the role of insurance in climate adaptation for extreme weather events, and map out solutions to the challenges insurers face in developing products to support climate adaptation.

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INTRODUCTION

Both the current impacts and future risks associated with extreme weather events demand climate adaptation policies.

Extreme weather events such as severe thunderstorms, ice storms, blizzards, windstorms, tornadoes and hail are part of life in Canada, but these hazards are becoming increasingly frequent and intense as a result of climate change. Both the current impacts and future risks associated with extreme weather events demand **climate adaptation policies**, courses of action designed to reduce the vulnerability of communities and strengthen their capacity to cope with weather-related impacts. At the end of this report, we outline major recommendations to support the development of Canadian climate adaptation policies at the community level, and identify ways in which the federal and provincial governments can facilitate and support these local actions. A central focus is disaster risk reduction, meaning reduction and, where possible, prevention of loss associated with extreme events.[1] Specific attention is devoted to two policy fields—emergency management and infrastructure planning—that are particularly sensitive to extreme weather events. The recommendations outlined here are drawn from a more comprehensive companion report, entitled *Climate Change and Extreme Weather: Designing Adaptation Policy*, which is available from Simon Fraser University's Adaptation to Climate Change Team (ACT).

1 Jörn Birkmann, Gerd Tetzlaff and Karl-Otto Zentel, eds., *Addressing the Challenge: Recommendations and Quality Criteria for Linking Disaster Risk Reduction and Adaptation to Climate Change*, Publication Series 38 (Bonn: DKKV, 2009).

CLIMATE CHANGE AND EXTREME WEATHER IN CANADA

More intense winter storms are anticipated for mid-latitude regions, suggesting that major ice storms could become more common in the future.

Extreme weather events are a hazard for Canadians and their property, and can severely damage the infrastructure systems that support life in communities. The Intergovernmental Panel on Climate Change's *Fourth Assessment Report*, issued in 2007, projects a number of climatic changes for North America that will contribute to more frequent and intense extreme weather events in Canada.

As the climate warms, there will be an overall global increase in precipitation, but for some locations, such as the southern Prairies and the Interior of British Columba, there will be summertime decreases in precipitation. Warmer temperatures will bring more summertime evaporation, resulting in water shortages and a reduction in lake levels. In most areas, extreme precipitation events will occur more frequently than in the past. More rapid and extensive snowmelt associated with rising temperatures, and increasingly intense rainfall associated with summer storms, could heighten the flood risk in many Canadian communities. Warmer surface air temperatures could increase the frequency and extent of wildfires and could lengthen the wildfire season. More intense winter storms are anticipated for mid-latitude regions, suggesting that major ice storms could become more common in the future. Sea level is rising faster than was earlier projected, meaning a greater risk of inundation on low-lying lands, beach erosion, increasing salinity of fresh-water aquifers, and intense coastal flooding resulting from storm surges associated with more intense storms. A number of recent extreme weather events in Canada indicate that climate change is already starting to make its effects felt by Canadian communities. Key examples from the past 12 years include:

- Severe flooding in the Saguenay–Lac-Saint-Jean region in southern Quebec in 1996 destroyed more than 1,000 homes, required the evacuation of 16,000 people and caused damages in excess of $800 million. Manitoba was still recovering from its second worst flood in 1997, which cost $817 million, when in the spring of 2009, it experienced its third worst flood ever. At one point, more than 700 square kilometres were flooded.
- The ice storm that struck eastern Ontario, southern Quebec and parts of the Maritime provinces in January 1998 was responsible for 28 deaths and over 900 injuries, and the estimated total costs associated with the disaster exceeded $5 billion.
- On January 21, 2000, an intense storm passed approximately 55 kilometres east of Charlottetown. High wind speeds created a storm surge 1.36 metres high, which, coincident with high tide, caused a new record water level in Charlottetown of 4.23 metres. Significant flood damage occurred in Charlottetown and other Prince Edward Island communities. Damage was estimated at $20 million for all areas affected by the surge.
- In 2002, a violent rainstorm of a magnitude seen on average once every 100 years drenched Peterborough, Ontario. Two years later, an equally extreme downpour ravaged the town's homes and businesses with what the CBC called "the flood of the century." An unusual cluster of tornadoes caused a third devastating event in August 2005, costing Peterborough and the province upwards of $100 million and having a significant impact on residents.

In summer 2009, BC Premier Gordon Campbell warned that "the wildfire risk is at the highest level in recent memory, with 85 per cent of the province facing a high or extreme fire hazard level."

- The Canadian Wheat Board estimated that the 2002 drought resulted in production losses for grains and oilseeds of nearly $2.8 billion. Crop insurance payments hit a record level of $803 million in the first nine months of 2002, an increase of more than 300% when compared to the five-year average.
- In August and September 2003, disastrous fires caused by drought and extended hot weather in the Kelowna region of British Columbia forced the evacuation of 45,000 people and destroyed more than 300 homes, with a total cost of $700 million. The summer of 2009 was even hotter, and the risk of forest fire was again extremely elevated with evacuation alerts affecting over 17,000 people. At one point, Premier Gordon Campbell warned that "the wildfire risk is at the highest level in recent memory, with 85 per cent of the province facing a high or extreme fire hazard level."[2]
- In August 2005, an intense rain event in Toronto washed out a major street and also flooded many basements. Insurance payments to homeowners totalled about $500 million, the largest insured loss event in Ontario's history. In August, 2009, several tornadoes wreaked havoc across Southern Ontario and led to the death of an 11-year-old boy, prompting premier Dalton McGuinty to call for better extreme weather warning systems. Environment Canada did issue a call one-half hour before the tornado struck Durham, but the warning failed to reached area emergency services.
- In 2006, a severe windstorm ripped through Vancouver's world-famous Stanley Park, damaging 40% of the forest, flattening 3,000 trees and costing $9 million to repair. Heavy rains increased turbidity in the city's water supply, prompting a boil-water advisory that lasted more than a week.

The return period of extreme weather events—the estimated interval between occurrences—will be shorter in the future. Damage from climate-related catastrophes like those listed above has cost Canadians billions of dollars in the past few years, and both climate scientists and insurers predict that the toll will increase unless preventive actions are taken.

Climate change is also expected to result in more extreme warm temperatures in all parts of Canada. For example, the Canadian climate model projects that by 2050 the number of days with a maximum temperature above 30°C will increase in Victoria from one to about five; in Calgary from five to almost 20; in Winnipeg from 14 to nearly 50; in Toronto from 12 to 35; and in Fredericton from eight to about 25.[3] In the summer of 2009, Vancouver experienced two of the hottest days in recorded history, at 34°C and 34.4°C.

2 British Columbia, Office of the Premier, *Wildfire Risk Critical Across the Province*, news release 2009PREM0020-000181, July 31, 2009, http://www2.news.gov.bc.ca/news_releases_2009-2013/2009PREM0020-000181.pdf (accessed August 11, 2009).

3 Henry Hengeveld, Bob Whitewood and Angus Fergusson, *An Introduction to Climate Change: A Canadian Perspective* (Downsview, ON: Environment Canada, 2005), 44.

CLIMATE ADAPTATION POLICY

Canada's governments, from local to federal, are beginning to grapple with the challenges posed by a changing climate and are awakening to the need to systematically plan and develop adaptation policy to reduce adverse impacts on their populations and infrastructure. The challenges are many, and include a broad lack of awareness among the public, most of the private sector, and government decision-makers of the risks posed by climate change and what preventive actions they might take; lack of coordination across levels of government for information flows, policy levers and funding instruments; limited resources (monetary and human) at the local government level, where the most immediate impacts of climate change are felt; and either inadequate regulation to enhance climate adaptation, or enduring policies that are inimical to adaptation. This report focuses on immediate actions that governments must take to begin to reduce the harm to people and property in our communities from climate change, and to save our economy billions of dollars in damages that need not occur.

Although extreme weather events have the potential to harm people and property, the extent of the damages they cause depends to a great extent on a community's ***vulnerability***, which is a function of its **exposure** to extreme weather events, its **sensitivity** to the stresses they impose, and its **capacity to adapt** to these stresses. Since our ability to prevent extreme weather events is limited, the central objective of climate adaptation policy is to reduce vulnerability.

Exposure refers here to the degree to which a community is subject to stress associated with extreme weather events. Exposure is partly determined by geography: for example, a town located adjacent to a river has a greater exposure to the risk of flooding. Similarly, communities that contain a large number of high-value assets exposed to extreme weather events are more vulnerable to these climate hazards. For instance, a city with an extensive, complex power grid has a greater exposure to an ice storm and thus may be more vulnerable than a neighbouring rural community with a simpler network. A central goal of climate adaptation policy is to reduce the exposure of people and systems to extreme weather events.

A community's ***sensitivity*** refers to the degree to which it will suffer negative impacts associated with more frequent and intense extreme weather events. For example, a community may be particularly sensitive because it houses a large population of "vulnerable groups"—elderly residents, low-income households, homeless people, and so on—who typically lack the financial means and physical capacity to take protective action. A community's sensitivity is also affected by the resilience of its physical infrastructure. Essential local services such as clean water, electricity and communications depend on the continuity of infrastructure systems, which vary considerably in their capacity to withstand or absorb weather-related stress. Reducing the sensitivity of people and systems to extreme weather events is an important goal of climate adaptation policy.

Adaptive capacity means the ability to adjust practices, processes or structures to moderate damages associated with climate change. A community that has a strong adaptive capacity is less vulnerable to extreme weather events, and several key factors contribute to a community's ability to make adaptive adjustments. One of the central goals of climate adaptation policy is to increase the adaptive capacity of communities. First, **information** about the nature of climate hazards and the community's vulnerability to their impacts is needed. This requires, for example, access to historical meteorological data and socioeconomic information to assess exposure and sensitivity to climatic stresses. Second, a community's capacity to adapt depends on whether or not it has the **expertise** to collect information, perform analyses and translate the data into policy. Effective policy design requires, among other things, assessments of the effectiveness, costs and feasibility of measures to reduce vulnerability; stakeholder analyses to identify targets and beneficiaries of adaptation interventions; and analyses of the consequences of inaction. Third, since effective adaptation policy involves some level of public expenditure, a community's adaptive capacity depends in part on its **fiscal capacity** to address adaptation alongside competing demands that must be met regardless of climate change. Finally, a community's capacity to adapt is either strengthened or weakened by the level of **political support** for this priority among elected officials. In summary, the key priorities for increasing adaptive capacity are information, expertise, fiscal capacity and political support.

PRINCIPLES

Designing climate adaptation policy is complex, involving difficult choices and a wide range of stakeholders. Experts have identified a number of key principles associated with effective climate adaptation policy, which serve as a framework to guide policy design. These are outlined below.

INTERGOVERNMENTAL COLLABORATION

Although most adaptation actions are implemented locally, an effective course of action in this area requires a partnership with the federal and provincial governments. For example, though local governments respond initially to emergencies triggered by extreme weather, provincial and federal resources must be deployed when the impacts exceed local coping capacity. If communities are sufficiently resilient to absorb the stresses associated with extreme weather events, they are less likely to need operational assistance from higher-level governments. Similarly, resilient communities are less likely to need financial support from provincial or federal disaster recovery programs.

The Government of Canada is uniquely positioned to support community adaptation planning in all parts of the country. The federal government produces important resources, such as climate and weather data, which can support vulnerability and risk assessments, and these must be accessible to community adaptation planners. Moreover, a recent federal initiative to create "Regional Adaptation Collaboratives"—networks of local stakeholders organized to integrate climate risks into planning and decision-making—is particularly promising as a means to support local action. These initiatives contribute the information and expertise required to build adaptive capacity. Provincial governments also play a key role in facilitating and supporting community adaptation planning, and should use the instruments at their disposal to ensure that all communities take action to adapt to climate change. Sustained collaboration among officials at all levels of government will be necessary to ensure that efforts are coordinated and resources are allocated effectively.

STAKEHOLDER ENGAGEMENT

An effective adaptation policy design process is participatory and engages stakeholders and the general public. By incorporating stakeholders from the private and non-profit sectors, policy-makers can draw upon a broad range of expertise and can generate political support. Public engagement is important in increasing awareness of climate-related risks, generating political support for policies chosen in response, and legitimizing resources devoted to adaptation.

TARGETING CURRENT VULNERABILITY AND RISK

Designing community adaptation policy must begin with an assessment of current exposure, sensitivity and adaptive capacity, and the ways in which existing policies and practices contribute to or reduce vulnerability. This information is the foundation for a risk assessment, which examines the likelihood of occurrence of extreme weather events and their potential consequences, including sea level rise, in order to estimate the risk posed to the community by climate change. Once equipped with vulnerability and risk assessments, adaptation planners can map out a course of action. However, preparing thorough vulnerability and risk assessments requires access to extensive and accurate information, which communities must seek from higher-level governments.

ACTING STRATEGICALLY

Early work on adaptation is best devoted to formulating an adaptation strategy, which prioritizes short- and long-term adaptation actions, assigns responsibility to specific community actors and sets out performance targets for implementation. However, developing strategic priorities can be challenging, as it involves many stakeholders and requires difficult choices about how scarce resources should be allocated. For this reason, experts recommend using risk management—a systematic methodology widely used by government and industry to identify, assess, communicate and manage risks—as

a framework to prioritize adaptation actions. Risk management requires analysts to consider alternative scenarios and assess benefits and costs of different responses. Moreover, it emphasizes continuous communication with stakeholders, and incorporates a broad range of interests to ensure that proposed solutions are publicly and politically acceptable.

MAINSTREAMING

Climate adaptation policy is most effective when it is "mainstreamed" into everyday decisions and actions. For example, local development decisions—choices about land use, the location of structures, and so on—are long-term, and could contribute to the vulnerability of a community unless exposure and sensitivity to future extreme weather events are considered. Successful mainstreaming techniques used by local governments include designating an internal steering committee to integrate adaptation into existing policies and programs, and incorporating adaptation principles into official community plans. Equally important is the need to mainstream climate adaptation into federal and provincial policies and programs, which can have a significant impact on community resilience.

INSTRUMENTS

Designing climate adaptation policy involves selecting specific tools to achieve policy goals. Table 1 identifies generic adaptation measures and illustrates how these could be implemented to address extreme weather events. Three particularly promising instruments—planning, insurance, and codes and standards—are profiled on the next page.

TABLE 1. ADAPTATION MEASURES
Adapted from Ian Burton, Robert W. Kates and Gilbert F. White, The Environment as Hazard (New York: Guilford Press, 1993).

Instrument	Action	Examples
Share loss	Spread losses among wider population	Insurance Relief and rehabilitation programs
Modify events	Implement measures to control or contain hazards	Flood protection (dykes; levees)
Prevent effects	Protect people and systems from hazards	Land-use regulation Warning systems
Reduce impacts	Build resilient infrastructure; reduce demands on infrastructure to free up capacity	Increase robustness Plan for swift recovery Water or energy conservation
Change location	Relocate people and property from hazard-prone areas	Incentives to relocate Public acquisition of exposed properties
Research	Invest in research to identify new adaptation methods	Pilot projects Engineering research for code development
Education	Information and public education campaigns to encourage behavioural change	Websites; pamphlets Seminars; workshops

PLANNING

The planning function offers communities a powerful set of tools for building resilience to extreme weather events. If an adaptation lens is incorporated into the planning process, decisions can be made that reduce vulnerability to extreme weather events and increase adaptive capacity and disaster risk reduction. For example, local land-use plans can be used to prohibit or restrict development in hazard-prone areas such as floodplains, thereby limiting the exposure of people and property to hazards. Decisions concerning the location of infrastructure components or transportation routes can limit the exposure of key assets, thus reducing vulnerability to extreme weather events.

INSURANCE

Insurance has long been an effective instrument to manage climate-related risks and will play an important role in adapting communities to climate change. For example, adaptive adjustments implemented during the reconstruction or rehabilitation of insured structures damaged by extreme weather events can increase their resilience to future hazards. Variable, risk-based premium charges for insurance products can offer an economic incentive for individuals and organizations to implement risk reduction measures or relocate from high-risk areas. But although insurance is a means to finance the repair or replacement of structures that suffer infrequent, unforeseeable losses, failing to address the underlying vulnerability of insured assets could lead to chronic, catastrophic losses that would undermine the effectiveness of this adaptation tool. Furthermore, depending on the location and the specific characteristics of an asset, as well as the hazards it is or becomes exposed to, insurance coverage may be limited or unavailable. Insurance must therefore be incorporated into a broader course of action, complementing other measures designed to reduce and manage the risk associated with climate hazards.

CODES AND STANDARDS

Regulatory instruments, such as codes and standards, are a primary means by which governments can prevent or reduce losses associated with extreme weather events. Building codes, which set out design and performance requirements to guide construction, can be a powerful adaptation tool if climate change is incorporated as a risk factor. Canada has a centralized system of code development based around the National Building Code, and periodic revisions provide a crucial opportunity to mainstream adaptation into the construction process.

EMERGENCY MANAGEMENT

Since extreme weather events pose a current risk to Canadian communities, better emergency planning accrues immediate benefits, regardless of the scope and degree of climate change in the future.

Emergency management, or disaster risk reduction, involves measures to protect people and property from hazards, to minimize losses associated with emergencies, and to ensure a swift and effective recovery from disasters. As a part of community climate adaptation policy, emergency management is clearly a "no-regrets" investment. Since extreme weather events pose a current risk to Canadian communities, better emergency planning accrues immediate benefits, regardless of the scope and degree of climate change in the future. There are many practical measures that communities can take to address current disaster risk and to ensure that plans and procedures are adequately adapted to cope with changing risk into the future.

REDUCING EXPOSURE

For emergency managers, reducing exposure to extreme weather events begins with a hazard and risk assessment, which identifies hazards the community is likely to face in the near future and in the decades to come; assesses physical and social vulnerability to these hazards; and estimates the likely injuries, damages and costs associated with the hazards. In order to perform these assessments, however, communities require detailed information on the climate and weather, which in turn requires a high-quality observation and monitoring network. Although Canada has world-class expertise in the collection and analysis of weather and climate data, as a recent report of the Commissioner of the Environment and Sustainable Development points out, Canada's monitoring network is "nearing the breaking point"[4] due to chronic under-investment. Communities also need information on future weather and climate in order to factor predicted changes into their strategies for reducing exposure.

REDUCING SENSITIVITY

Local emergency managers can reduce the sensitivity of people and systems to extreme weather events in a number of ways. One effective measure is to establish a warning system to inform residents about impending hazards. Communities currently receive hazard warnings from many different sources—federal, provincial and local government agencies, as well as universities, volunteer organizations, and so on—and this fragmentation can impede the ability of emergency personnel to relay hazard warnings in a timely and effective manner. Furthermore, whereas other jurisdictions have established an "All-Channel-Alert" system to interrupt media programming to broadcast hazard warnings, and although

4 Office of the Auditor General of Canada, "Managing Severe Weather Warnings: Environment Canada," in *Report of the Commissioner of the Environment and Sustainable Development* (Ottawa, ON: Minister of Public Works and Government Services Canada, 2008), 9.

Emergency managers can strengthen a community's adaptive capacity by implementing measures that ensure an effective response to extreme weather events and swift recovery from their impacts.

the technology has been available for over a decade, Canada has not yet implemented a system capable of "pushing" warning information to end users. Public Safety Canada, the federal department with primary responsibility for emergency management, is currently tasked with implementing such a system.

STRENGTHENING ADAPTIVE CAPACITY

Emergency managers can strengthen a community's adaptive capacity by implementing measures that ensure an effective response to extreme weather events and swift recovery from their impacts. First, since emergencies lead to increased demand from residents for routine services, such as water, electric power, telecommunications, social services and even waste collection, emergency managers should plan for the continuity of local government operations, which involves identifying critical functions and services and developing strategies to first reduce the likelihood of failure and then to restore them if they are interrupted. The latter might involve, for example, preparing a strategy to relocate services to alternative buildings in the event that their headquarters sustain terminal damage. Second, adaptive capacity can be enhanced by establishing mutual aid agreements with neighbouring communities, whereby equipment and personnel can be called upon if local response resources are insufficient or become depleted. Third, community response capacity can be augmented by training groups of volunteers who can perform response functions, such as providing victims with first aid assistance and conducting light search and rescue. Fourth, emergency managers should plan ahead for important recovery-related activities, such as damage assessment and debris management, to ensure that resources are allocated effectively in the recovery phase.

INFRASTRUCTURE

Although infrastructure systems are normally dependable in delivering services, extreme weather events put stress on these systems, with impacts ranging from temporary service interruptions to permanent destruction of exposed facilities.

The reliability of infrastructure systems and the continuity of the services they support are essential for the health and safety of community residents and for the social and economic activities they engage in. Although infrastructure systems are normally dependable in delivering services, extreme weather events put stress on these systems, with impacts ranging from temporary service interruptions to permanent destruction of exposed facilities. For example, a heavy rainstorm in an urban area can quickly overwhelm stormwater drainage infrastructure, causing flooding. Windstorms can cause structural damage to building components, block transportation routes with debris, and sever telephone, television and other communication lines. In light of the risks posed by extreme weather events, reducing the vulnerability of infrastructure systems must be a central objective of community climate adaptation policy. Large-scale projects to build or replace infrastructure in the coming years present a tremendous opportunity to ensure that these physical systems have the resilience to cope with a changing climate.

REDUCING EXPOSURE AND SENSITIVITY

Decisions regarding the location of infrastructure components can significantly affect a community's exposure to extreme weather events. Infrastructure exposure to extreme weather events can be reduced chiefly by locating (or relocating) critical facilities, such as electrical power generation and transmission structures, away from hazard-prone areas like floodplains, low-lying coastal zones, or hillsides. Where relocation is not feasible, measures should be taken to shield infrastructure components from hazard impacts.

Reducing the sensitivity of infrastructure systems to extreme weather events involves implementing measures that enhance their ability to withstand stresses without suffering a loss of function, and to recover quickly in the event that a failure occurs. This requires that new infrastructure be designed and built to cope with stresses associated with more frequent and intense extreme weather events within a changing climate. Given that the construction of new infrastructure projects is often contracted out to private firms, local governments can incorporate resilience into these projects by including climate adaptation criteria in requests for proposals. More broadly, integrating resilience into new infrastructure requires engagement with key actors at the pre-construction stage, such as designers, engineers and contractors.

Action is also required to make existing infrastructure systems more resilient to climate hazards. For example, roof rainwater leaders that currently discharge directly into a community storm water management system could be disconnected, and the water could be allowed to drain onto lawns, into underground cisterns or into rain barrels. Alternatively, berms could be constructed around large open spaces such as parks in order to use the areas for temporary water storage

Regardless of other actions taken to reduce the vulnerability of infrastructure to more frequent and intense extreme weather events, all communities should plan for infrastructure failures and exhort citizens to prepare to be self-sufficient in the recovery period.

during heavy rainfall events. Although adaptation measures might be implemented voluntarily by infrastructure managers or business firms, governments should be prepared to mandate these practices if they will enhance community resilience to extreme weather events.

INCREASING ADAPTIVE CAPACITY

Local governments can strengthen adaptive capacity by undertaking a long-term infrastructure planning exercise in which participants visualize the impacts of climatic changes over several decades, and map out strategies to cope with them. Knowledge generated allows for adaptive management of infrastructure assets in response to actual changes in climatic conditions. The planning team should involve decision-makers, infrastructure managers and operators, climate researchers, and applied scientists such as planners and engineers, who can work with climate scenarios to develop practical adaptation strategies.

Climate-related risks to infrastructure range from gradual changes in temperature and moisture, which can increase weathering effects on structures, to more frequent extreme events, which subject systems to heavy loads and threaten to exceed their design capacity. Interdependence among systems heightens the risk of cascading failures, which can cripple community activities and pose a serious threat to public health and safety. Given the number and diversity of climate-related risks to infrastructure, it is advisable that local governments use risk management as a framework to identify, assess and manage these risks.

A high priority for any community climate adaptation strategy is to raise awareness among public- and private-sector officials responsible for infrastructure and to encourage them to integrate climate adaptation into their operations. An awareness campaign is necessary to convey the importance and value of adaptation, but also to communicate to stakeholders that their participation is necessary in order for adaptation to be effective. Furthermore, regardless of other actions taken to reduce the vulnerability of infrastructure to more frequent and intense extreme weather events, all communities should plan for infrastructure failures and exhort citizens to prepare to be self-sufficient in the recovery period.

POLICY RECOMMENDATIONS

Based on the principles and instruments noted in this document, and the research carried out and reported in the accompanying background report, we make the following recommendations:

1. **The Government of Canada should take the lead in addressing the risk of extreme weather associated with climate change by establishing a permanent scientific and technical working group with provincial participation and a mandate to:**
   - 1.1 Share information and coordinate adaptation policies and programs.
   - 1.2 Promote dialogue between government and private-sector infrastructure providers to identify effective and efficient adaptation measures for existing infrastructure, including the risk of more frequent and intense extreme weather events.
   - 1.3 Partner with professional associations to mainstream adaptation principles into the work of practitioners.
   - 1.4 Examine the role of insurance in climate adaptation for extreme weather events, and map out solutions to the challenges insurers face in developing products to support climate adaptation.
   - 1.5 Incorporate climate adaptation into the National Disaster Mitigation Strategy and federal and provincial environmental assessment processes.
   - 1.6 Explore ways in which the principles of climate adaptation can be incorporated into codes and standards to build resilience to future risks.

2. **The Government of Canada should establish a Climate Action Centre, which, through partnerships with provincial and municipal agencies, will focus national attention on climate hazards and promote adaptation planning.**
   - 2.1 Review and adjust current human and financial resources allocated to observation and monitoring to ensure that comprehensive and high-quality climate and weather information and projections of changes over periods of hours, days, seasons, and decades is collected, analyzed and disseminated to provincial agencies and communities. Data analysis should include updating recurrence intervals based on recent observations and rehabilitation of time series, particularly with respect to tide gauge data.
   - 2.2 Establish an integrated, multi-hazard National Public Alerting System and Climate Information Service, to ensure that timely warnings of climate hazards and information on protective actions are delivered to emergency response organizations and individuals.

3. **Provincial and local governments should incorporate climate adaptation principles into infrastructure design and land-use planning decisions in order to reduce exposure and vulnerability to extreme weather events. Local governments should assess both their current vulnerability to extreme weather events and the risks posed by climate change, including sea level rise, and should develop an adaptation strategy, using risk management as a framework to prioritize actions targeted at climate-related risks.**
   - 3.1 Incorporate climate adaptation as a priority in official community plans.
   - 3.2 Ensure that resilience to future risk is anticipated in new development by requiring climate adaptation planning as a precondition for development approvals.
   - 3.3 Prioritize actions to reduce vulnerability of existing infrastructure.
   - 3.4 Undertake an integrated approach to infrastructure and land-use planning, designing within nature's limits; distributing infrastructure such that it is not singularly vulnerable to extreme weather events; and recover-

ing water, energy and other resources rather than relying on new supplies that can be affected by extreme events.

3.5 Plan and test procedures to evacuate people from areas at risk, to minimize the exposure of residents during an emergency.

3.6 Plan for the continuity of municipal services during an emergency and for increased demand from residents.

3.7 Establish a public hazard education program to inform citizens and key stakeholders about extreme weather events and the protective measures they should take to reduce their vulnerability.

CONCLUSION

Communities in all parts of Canada are susceptible to extreme weather events, and it is projected that these hazards will increase in frequency and severity due to climate change. Extreme weather poses a significant risk to public health and safety, and thus demands a purposive and coordinated course of action to reduce the vulnerability of communities and increase their capacity to cope with hazard impacts. Although most instrumental adaptation measures will be implemented at the community level, these must be part of a broader public policy strategy to increase community resilience, which will require coordinated action among all levels of government. The goals, principles and instruments examined here are intended to offer guidance for the development of community climate adaptation policy, and to provide a blueprint for an intergovernmental framework to support local climate adaptation.

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