Climate Resilience and Canadian Water Infrastructure

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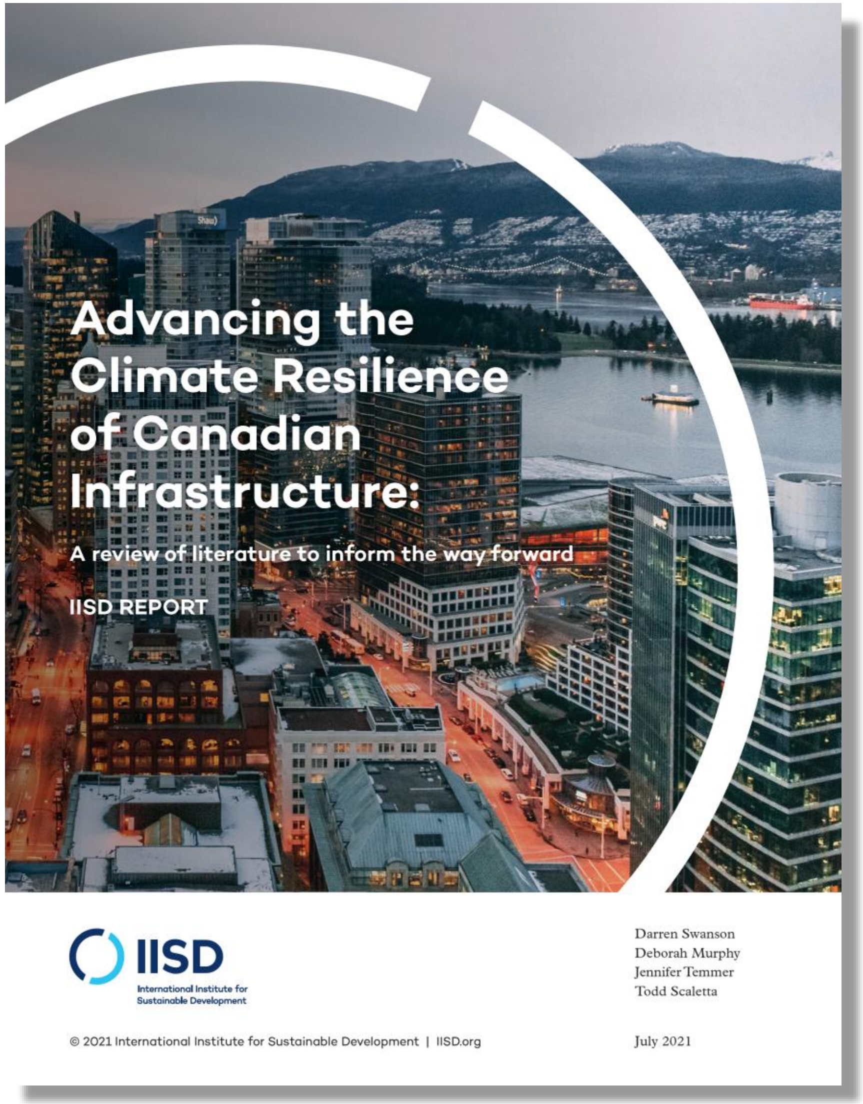
IISD
International Institute for Sustainable Development

Report on Advancing the Climate Resilience of Canadian Infrastructure

- Compile latest information on climate hazards and impacts on Canadian infrastructure;
- Take stock of resilience options for addressing these climate risks; and
- Capture the range of policies, practice guidance, and financing options that have emerged in recent years at the federal level in Canada and internationally.



https://www.iisd.org/publications/climate-resilience-canadian-infrastructure

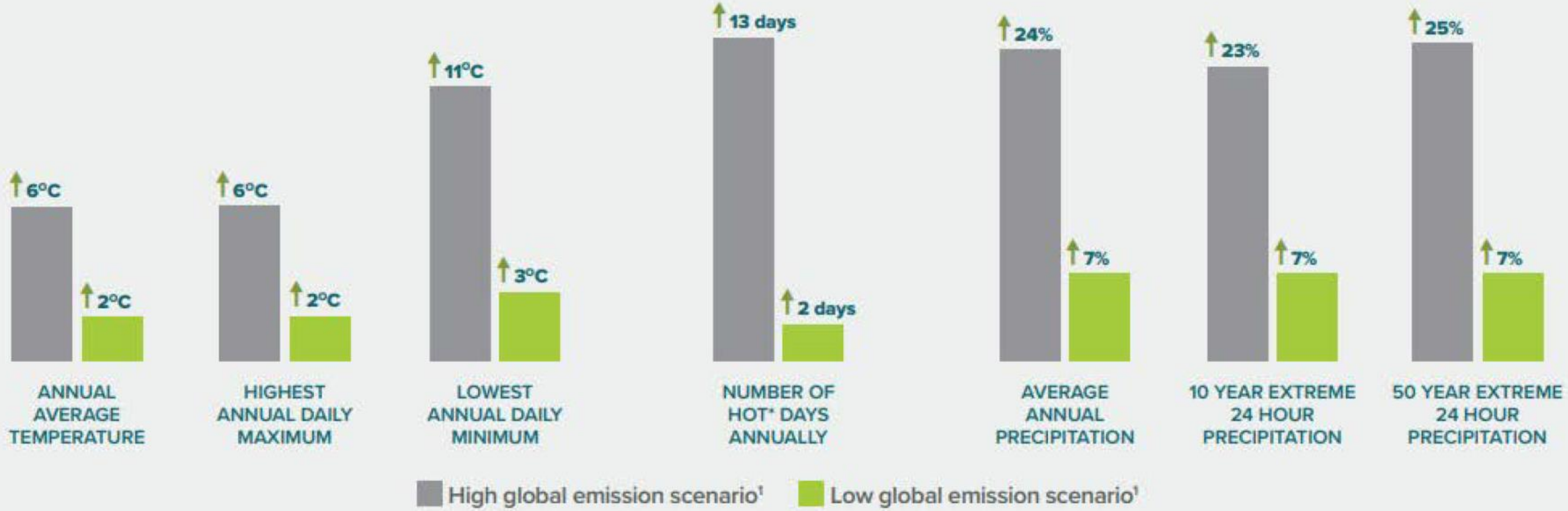
CANADA'S **CHANGING CLIMATE**

PROJECTED CHANGES THIS CENTURY

Canada's climate has warmed and will warm further in the future, driven by human influence.
Global emissions of carbon dioxide from human activities will largely determine how much warming the country—and the world—will experience in the future.

HIGH VS LOW EMISSION PROJECTIONS

TWO VERY DIFFERENT FUTURES FOR CANADA



Median values. Changes are for 2081-2100 relative to the 1986-2005 reference period.

[1] **High and low global emission scenarios.** The high emission scenario RCP 8.5 is associated with an increase in global average temperature of about 3.7 °C by late century relative to the 1986-2005 reference period. The low emission scenario RCP 2.6 is associated with an increase in global average temperature of about 1.0 °C by late century relative to the 1986-2005 reference period.

*Hot day = daily maximum temperature is above 30°C

https:// changingclimate.ca/site/assets/uploads/sites/2/2019/04/6269_infographic_Canada_v05.pdf

West Coast – too wet

West Coast – too dry

East Coast – too wet

https://www.cbc.ca/news/canada/newfoundland-labrador/nl-rain-storm-wednesday-1.6260478

The Middle – too dry…too wet

The North – too warm

Key Observation #1

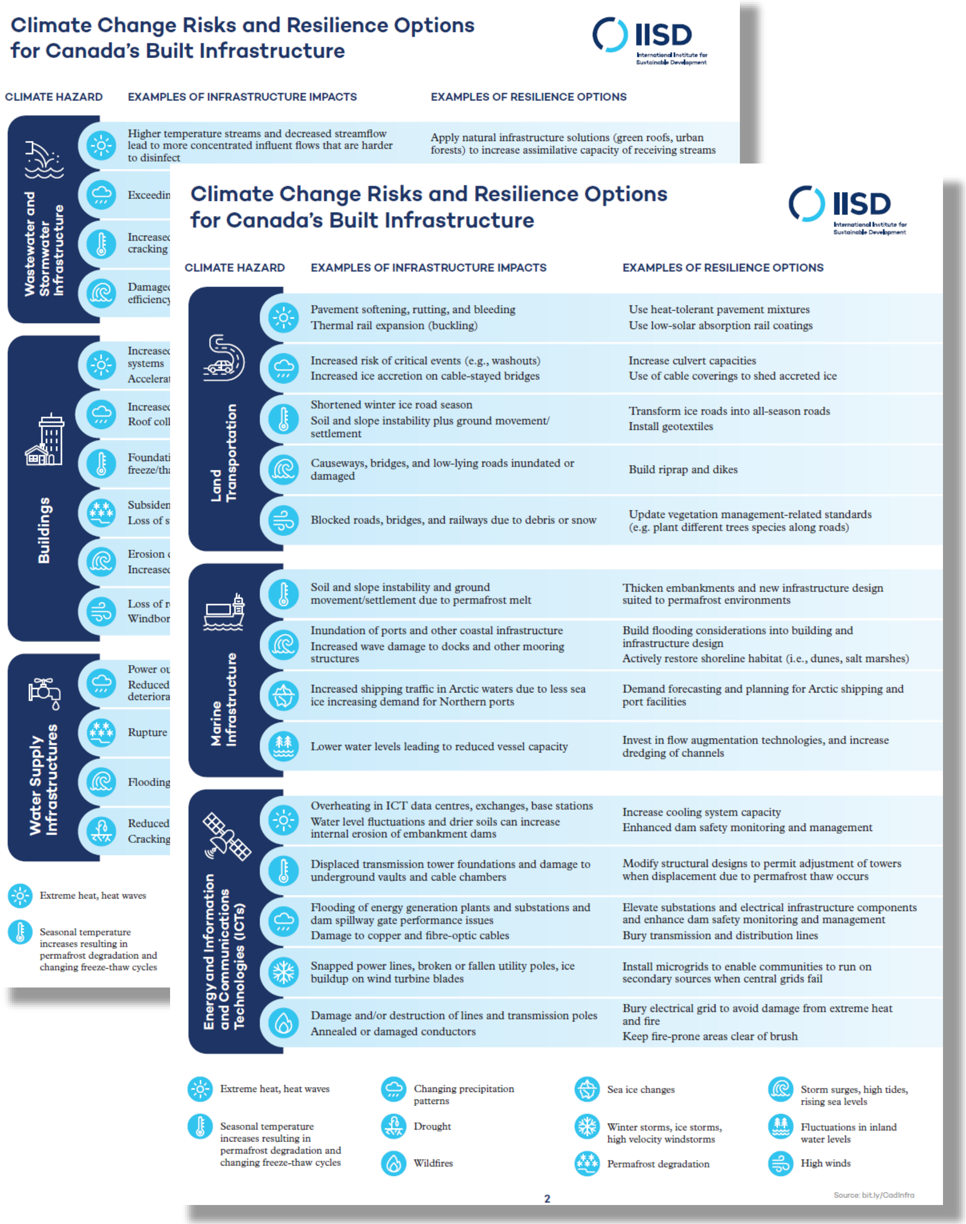
Considerable activity over the past decade, as evidenced by the sheer volume of literature available on resilience options for infrastructure.

This applies to all infrastructure types reviewed:

- Wastewater and stormwater
- Buildings
- Water supply
- Transportation
- Marine
- Energy and ICTs

Three categories of resilience options:

1. Risk-informed planning and assessment
2. Structural changes
3. Enhanced monitoring and maintenance



Climate Change Risks and Resilience Options for Canada's Built Infrastructure

CLIMATE HAZARD	EXAMPLES OF INFRASTRUCTURE IMPACTS	EXAMPLES OF RESILIENCE OPTIONS
Land Transportation	Pavement softening, rutting, and bleeding Thermal rail expansion (buckling)	Use heat-tolerant pavement mixtures Use low-solar absorption rail coatings
	Increased risk of critical events (e.g., washouts) Increased ice accretion on cable-stayed bridges	Increase culvert capacities Use of cable coverings to shed accreted ice
	Shortened winter ice road season Soil and slope instability plus ground movement/settlement	Transform ice roads into all-season roads Install geotextiles
	Causeways, bridges, and low-lying roads inundated or damaged	Build riprap and dikes
	Blocked roads, bridges, and railways due to debris or snow	Update vegetation management-related standards (e.g. plant different trees species along roads)
Marine Infrastructure	Soil and slope instability and ground movement/settlement due to permafrost melt	Thicken embankments and new infrastructure design suited to permafrost environments
	Inundation of ports and other coastal infrastructure Increased wave damage to docks and other mooring structures	Build flooding considerations into building and infrastructure design Actively restore shoreline habitat (i.e., dunes, salt marshes)
	Increased shipping traffic in Arctic waters due to less sea ice increasing demand for Northern ports	Demand forecasting and planning for Arctic shipping and port facilities
	Lower water levels leading to reduced vessel capacity	Invest in flow augmentation technologies, and increase dredging of channels
Energy and Information and Communications Technologies (ICTs)	Overheating in ICT data centres, exchanges, base stations Water level fluctuations and drier soils can increase internal erosion of embankment dams	Increase cooling system capacity Enhanced dam safety monitoring and management
	Displaced transmission tower foundations and damage to underground vaults and cable chambers	Modify structural designs to permit adjustment of towers when displacement due to permafrost thaw occurs
	Flooding of energy generation plants and substations and dam spillway gate performance issues Damage to copper and fibre-optic cables	Elevate substations and electrical infrastructure components and enhance dam safety monitoring and management Bury transmission and distribution lines
	Snapped power lines, broken or fallen utility poles, ice buildup on wind turbine blades	Install microgrids to enable communities to run on secondary sources when central grids fail
	Damage and/or destruction of lines and transmission poles Annealed or damaged conductors	Bury electrical grid to avoid damage from extreme heat and fire Keep fire-prone areas clear of brush

Extreme heat, heat waves
Seasonal temperature increases resulting in permafrost degradation and changing freeze-thaw cycles
Changing precipitation patterns
Drought
Wildfires
Sea ice changes
Winter storms, ice storms, high velocity windstorms
Permafrost degradation
Storm surges, high tides, rising sea levels
Fluctuations in inland water levels
High winds

2

Source: bit.ly/CadInfra

Water Supply Infrastructure

Climate hazard	Examples of infrastructure impacts	Examples of resilience options
Changing precipitation patterns	• Power outages due to electrical storms affecting pumping stations • Reduced structural integrity and/or accelerated deterioration of dams	• Enhanced and redundant backup power supplies • Adopt structural adaptations to dams, weirs, and drainage canals
Permafrost degradation	• Rupture of water lines and storage tanks	• Use of polystyrene insulation beneath roads
Storm surges and sea level rise	• Flooding of treatment plant infrastructure	• Seawalls, dikes, floodwalls, levees, local surge barriers, etc.
Drought	• Reduced source of potable water • Cracking of earthen dams, increasing flood risk	• Demand management and use of natural infrastructure such as bioswales, constructed wetlands, rain gardens, and bioretention systems • Structural adaptations to dams, weirs, and drainage canals

Sources: [1]Bush & Lemmen, 2019; [2]ECCC, 2016; [3]ECCC, 2020; [4]Melillo et al., 2014; [5]Clavet-Gaumont et al., 2017; [6]Amec Foster Wheeler & Credit Valley Conservation, 2017; [7]Lemmen & Warren, 2004; [8]McClearn, 2020; [9]Felio, 2015; [10]EPA, 2021.

Wastewater and Stormwater Infrastructure

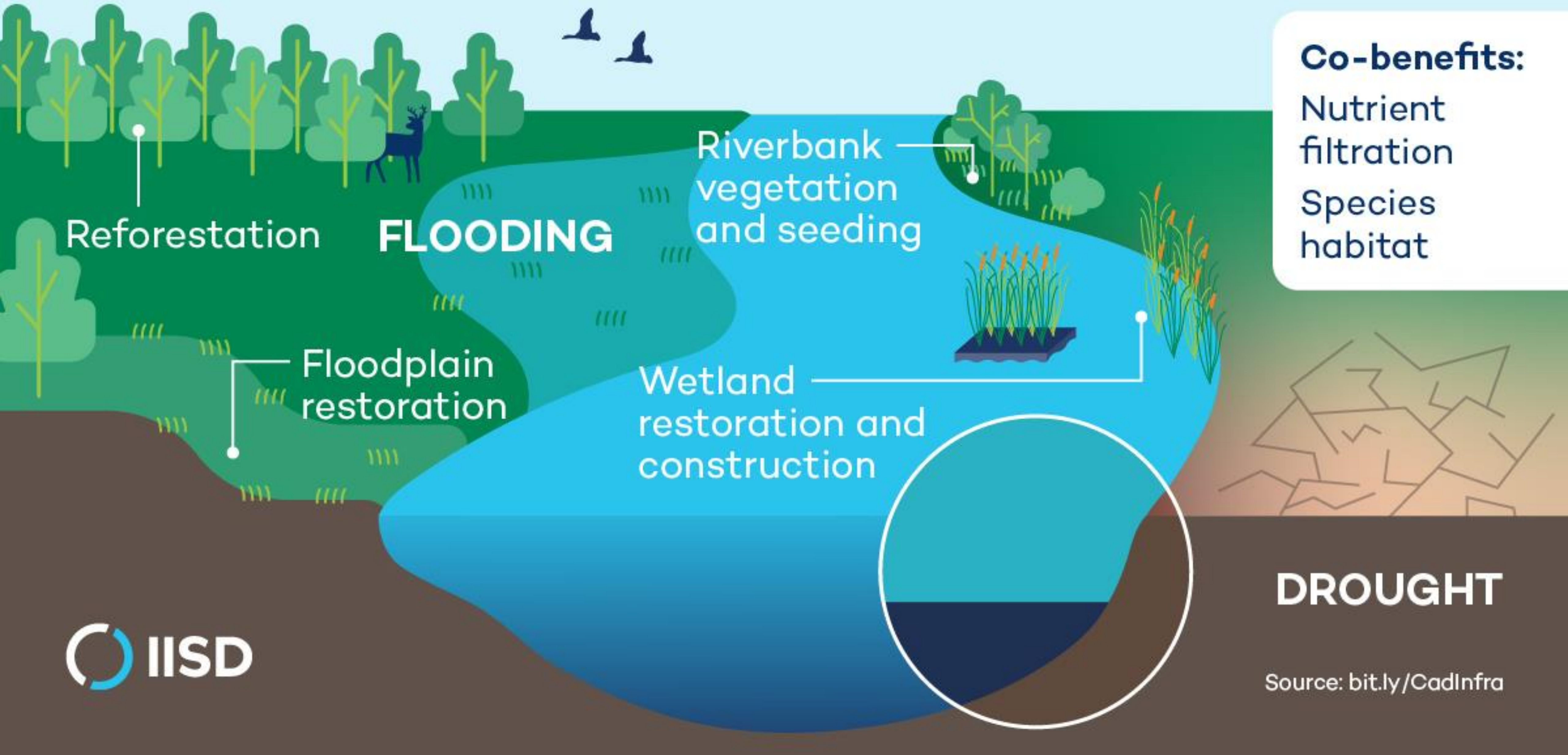
Climate hazard	Examples of infrastructure impacts	Examples of resilience options
Heat	• Higher temperature streams and decreased streamflow lead to more concentrated influent flows that are harder to disinfect	• Apply natural infrastructure • Install effluent cooling systems
Changing precipitation patterns	• Exceeding stormwater/drainage systems	• Increased capacity of stormwater and drainage collection systems • Reduce or green up impervious surfaces (e.g., roofs, parking areas)
Seasonal temperature changes	• Increased frequency, duration, and severity of thermal cracking and rutting	• Use phase-change materials to reduce the number of freeze/thaw cycles
Storm surges	• Damaged or flooded structures that reduce treatment efficiency	• Hybrid built and natural infrastructure solutions (e.g., terraced berms, drainage improvements, bulkheads, beach nourishment, reinforced dunes, offshore breakwaters, living shorelines)

Sources: [1]Bush & Lemmen, 2019; [2]ECCC, 2016; [3]ECCC, 2020; [4]Amec Foster Wheeler & Credit Valley Conservation, 2017; [5]Mercer Clarke & Clarke, 2018; [6]Melillo et al., 2014; [7]EPA, 2021.

Key Observation #2

Natural infrastructure is becoming a mainstream option for enhancing the resilience of built infrastructure and communities.

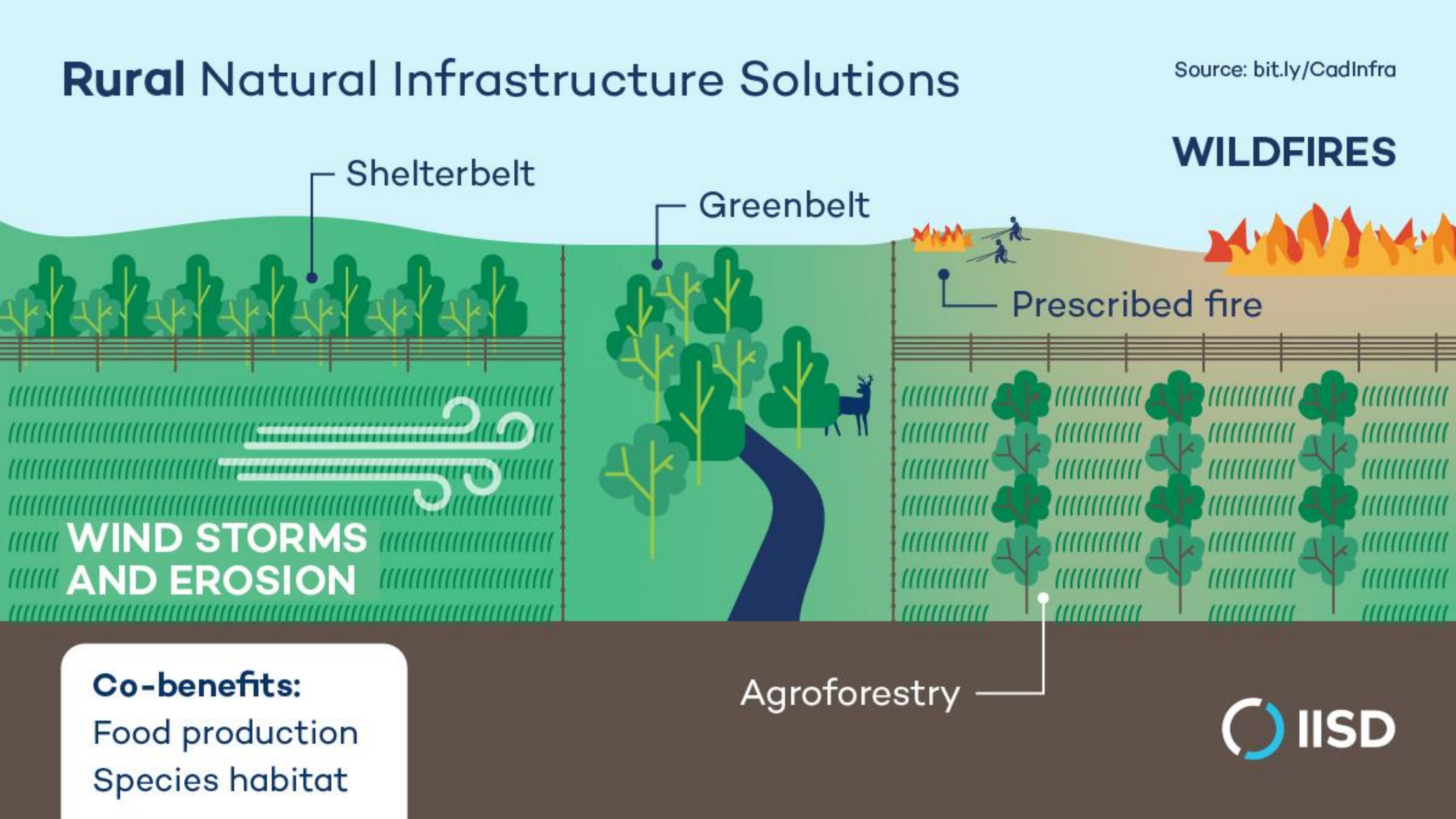
Riverine Natural Infrastructure Solutions



Floating Treatment Wetlands


https://www.iisd.org/projects/floating-treatment-wetlands

https://www.winnipegfreepress.com/local/province-opens-red-river-floodway-569554112.html


Rural Natural Infrastructure Solutions
Source: bit.ly/CadInfra
WILDFIRES
Shelterbelt
Greenbelt
Prescribed fire
WIND STORMS AND EROSION
Agroforestry
Co-benefits:
Food production
Species habitat
IISD

Engineered Wetlands

Source: IISD.org

Key Observation #3

A diverse range of strategies, policies, guides, standards, codes, and financing programs have emerged to help inform resilience options for infrastructure.

For example, at the federal level in Canada:

- Climate Lens General Guidance (and Public Infrastructure Engineering Vulnerability Committee – PIEVC risk assessment guidance)
- Climate-Resilient Buildings and Core Public Infrastructure Initiative
- Investing in Canada Infrastructure Program and the Disaster Mitigation and Adaptation Fund
- Municipalities for Climate Innovation and Asset Management programs implemented by the Federation of Canadian Municipalities

But is it all enough?

The Gap

Overall infrastructure gap of $150 billion to $1 trillion (First Nations ~$30 billion)

(Advisory Council on Economic Growth, 2016)

The State

2019 Canadian Infrastructure Report Card: "concerning amount of municipal infrastructure in poor or very poor condition".

(BluePlan Engineering, 2019, p. 9)

The Risk

Physical infrastructure ranked as Canada's most consequential risk area

(Council of Canadian Academies, 2019)

The Consequence

CICC 2021 Report concluding Canada's infrastructure is not prepared for the climate crisis

(Canadian Climate Institute, 2021)

While there has been considerable activity to increase the climate resiliency of infrastructure in Canada, greater effort and investment are needed to match the expanding scale of the issue.

Informing the Way Forward

- Extreme heat, heat waves
- Seasonal temperature increases resulting in permafrost degradation and changing freeze-thaw cycles
- Changing precipitation patterns
- Drought
- Wildfires
- Sea ice changes
- Winter storms, ice storms, high velocity windstorms
- Permafrost degradation
- Storm surges, high tides, rising sea levels
- Fluctuations in inland water levels
- High winds

Increased incentive for implementing resilience options

Risk-informed planning and assessment

Structural changes

Enhanced monitoring and maintenance

Integrating natural infrastructure solutions

More and diverse sources of financing

Public-private partnerships and investment

Greater use of innovative financing options

Whole-of-society approach

Systems thinking and policy coherence

Flexible, robust, and redundant options and pathways

Greater consideration of interrelated social factors

Miigwhech,
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Merci,
Thank you!

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