Costing Climate Change Impacts to Public Infrastructure

2022 ICEAA Professional Development & Training Workshop

Thursday May 19, 2022

FAO
FINANCIAL ACCOUNTABILITY OFFICE OF ONTARIO

Extreme weather events are having significant impacts on public infrastructure

Photo by David J. Phillip / AP

In 2019, Tropical Storm Imelda dropped record rainfall on Texas, with severe flooding in Houston.

Photo by Noah Berger / AP

In 2020, over 9,000 fires burned more than 4 million acres in California (4 per cent of the state's landmass).

Photo by Thomas Black

In 2021, Winter Storm Uri's extreme cold caused blackouts in Texas and the costliest damages ever recorded.

About the FAO

The FAO was established in 2015, modelled on the federal Parliamentary Budget Office.

An independent, non-partisan office that supports the Legislative Assembly by providing MPPs with balanced, timely and accurate economic and financial analysis, as well as estimates of the financial costs or benefits of specific bills or proposals.

The FAO's Costing Climate Change to Public Infrastructure (CIPI) Project was launched in 2019 after a Member of Provincial Parliament asked the FAO to analyze the costs that climate change impacts could impose on Ontario's provincial and municipal infrastructure, and on the long-term budget outlook of the province.

Outline

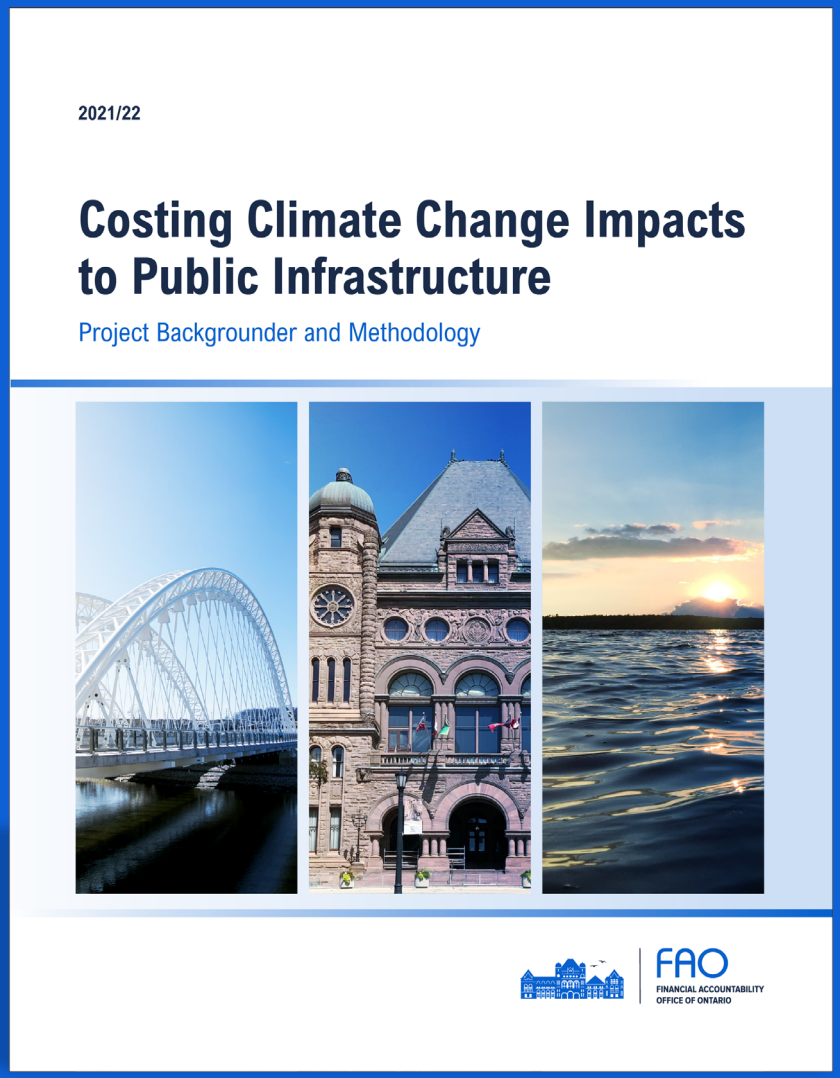
CIPI Methodology

- Provincial and Municipal infrastructure
- Infrastructure cost projections
- Climate Change projections
- Climate Change impacts on infrastructure costs

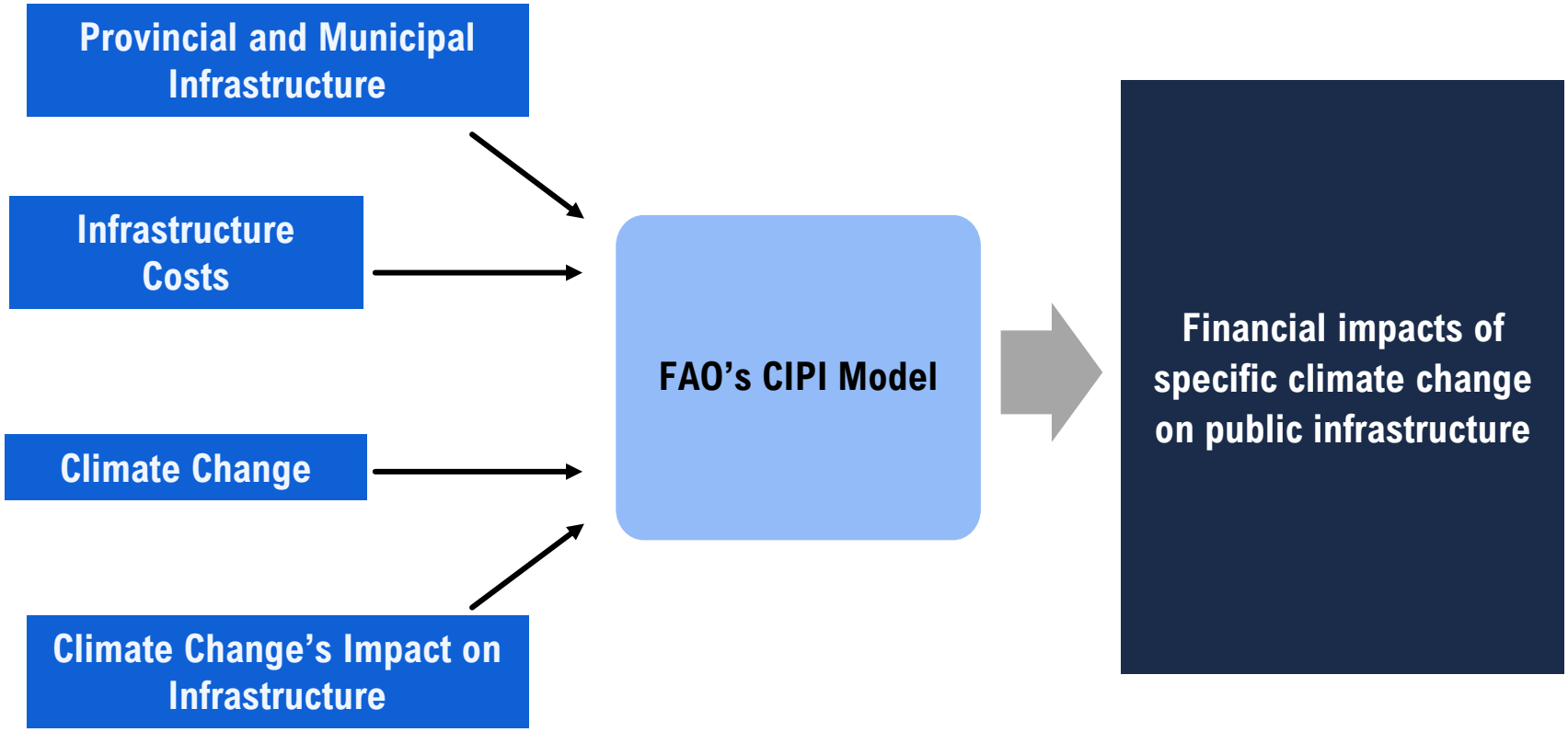
CIPI Results

- Baseline costs in a stable climate
- Impacts of climate change on baseline cost in absence of adaptation
- Impact of climate change on baseline cost if adaptation actions are undertaken

CIPI Methodology

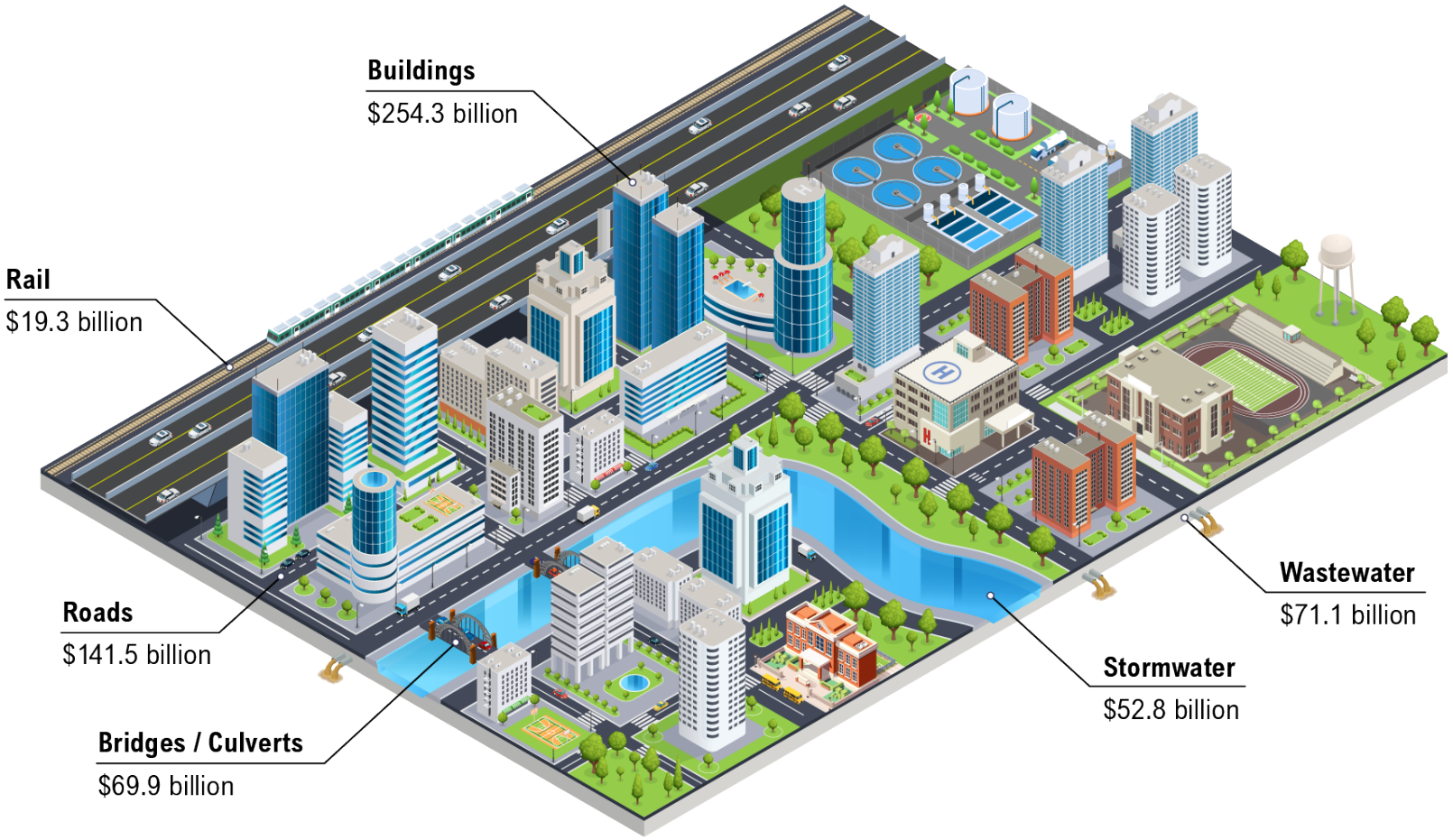


The FAO's modelling framework



Provincial and Municipal Infrastructure

Scope of Public Infrastructure Examined in the CIPI Project



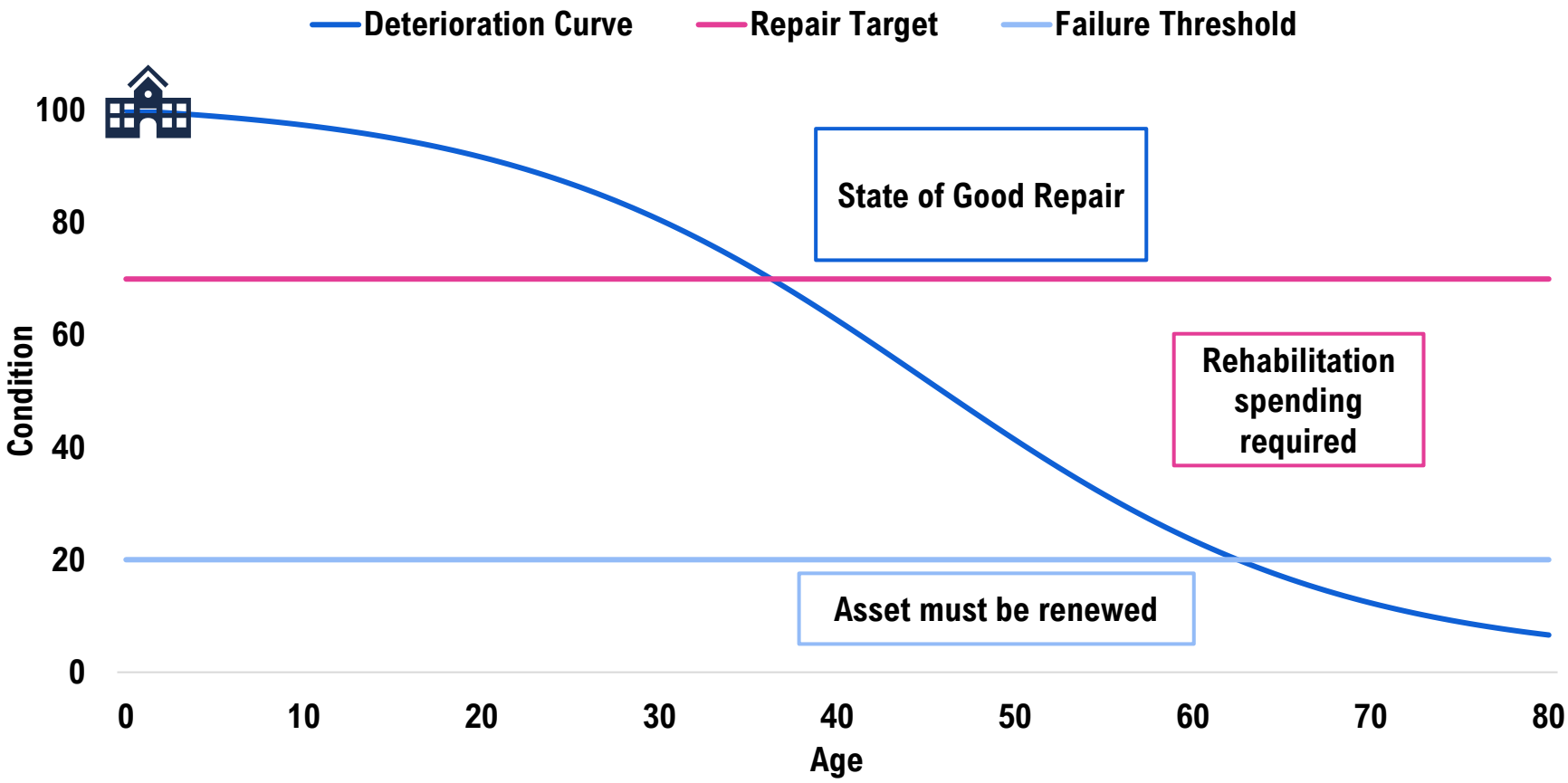
Infrastructure Costs

What are the usual costs of maintaining this infrastructure?

Annual Operations and Maintenance Expenses

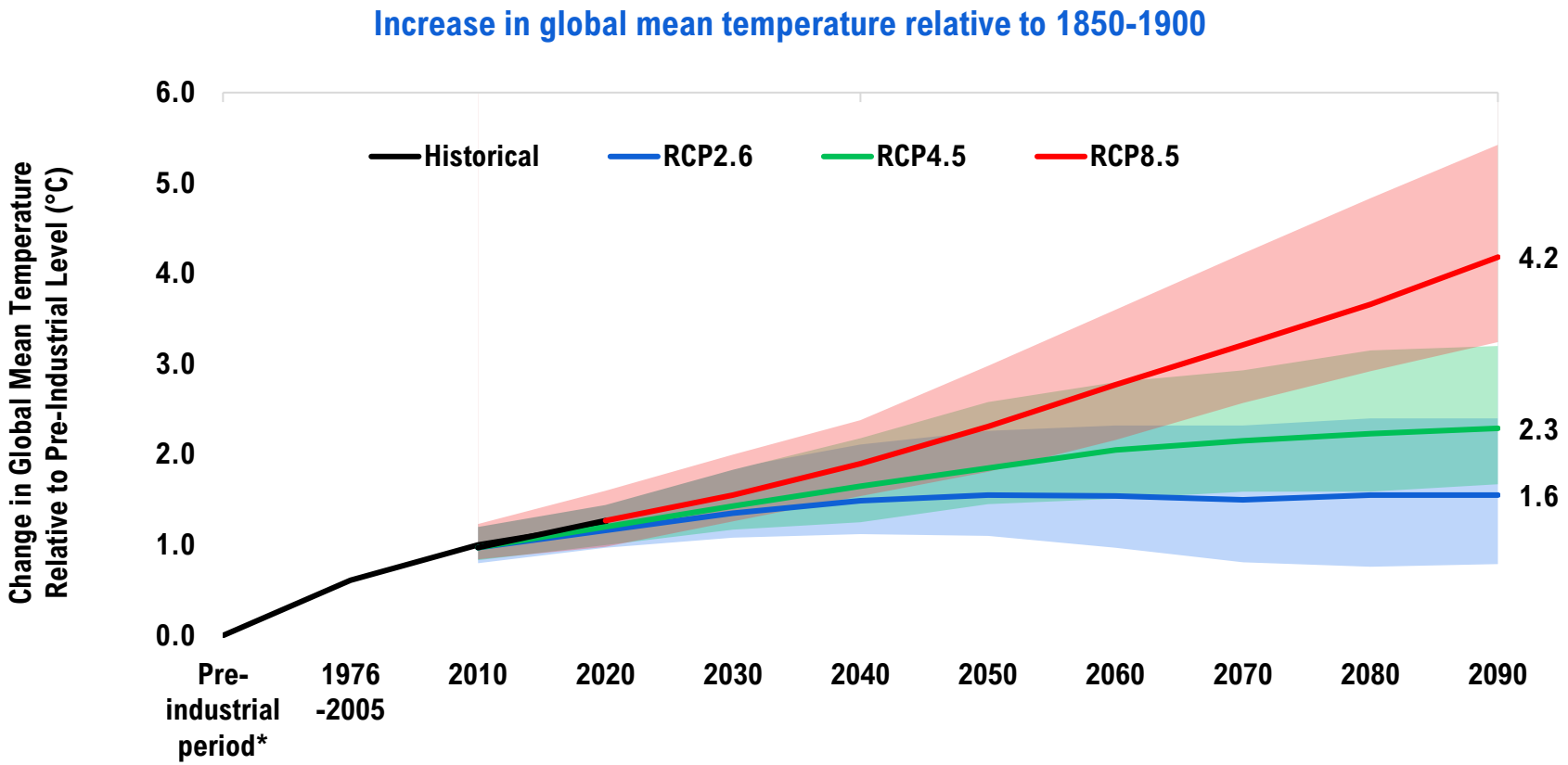
Intermittent Capital Expenses including Rehabilitation and Renewal

Infrastructure deterioration models project costs



Climate Change

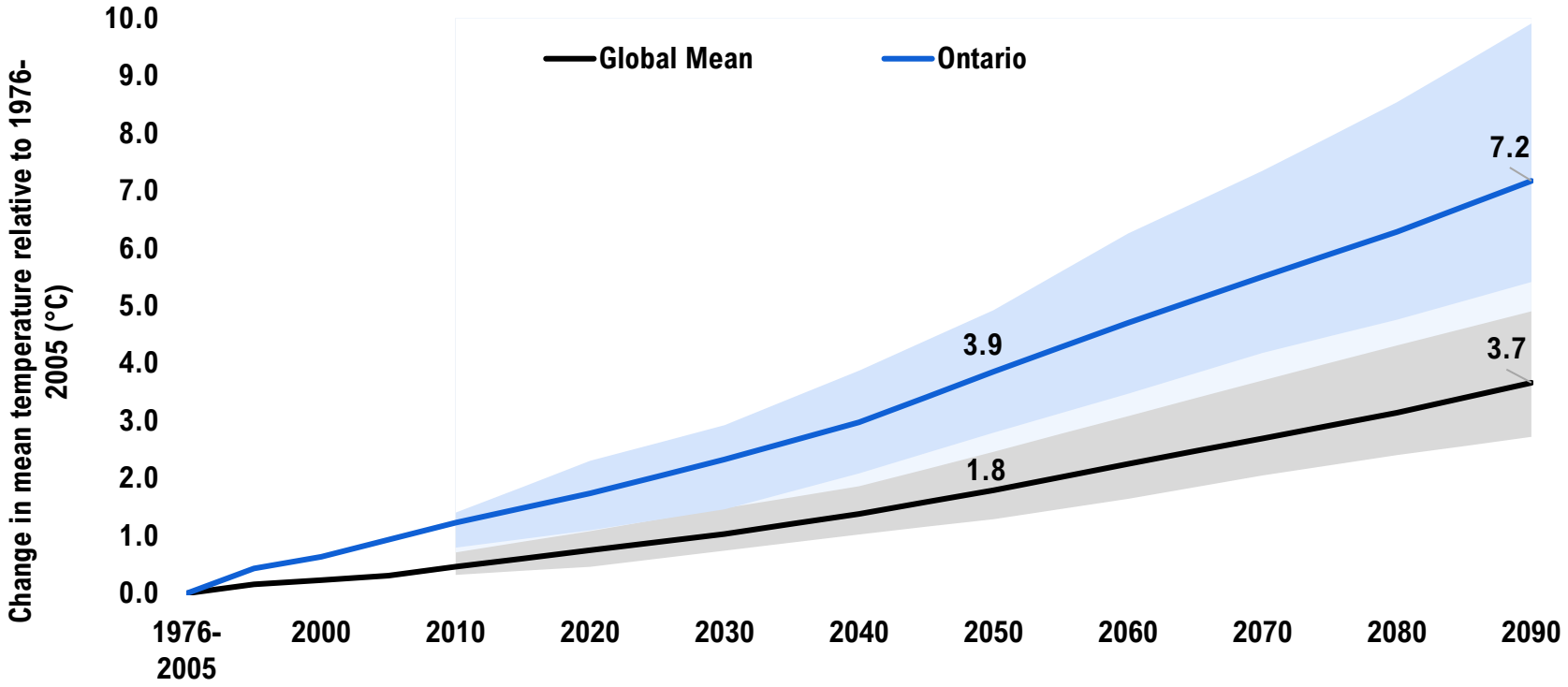
How is the climate changing?



*1850-1900 base period.
Note: Lines indicate the median estimate and the shaded areas show the range of 5th and 95th percentile projections.
Source: Intergovernmental Panel on Climate Change

Ontario will experience greater warming than the global average

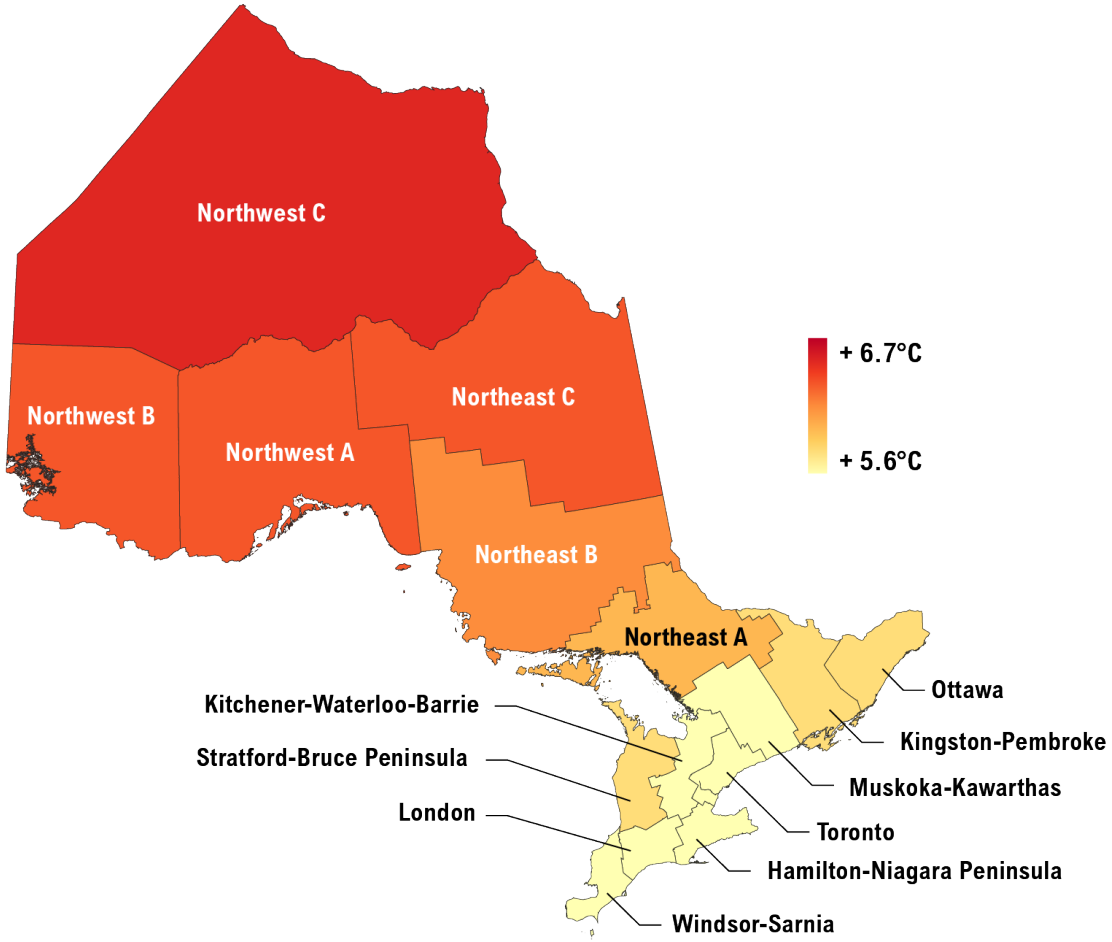
Ontario's mean temperature projected to rise faster than global mean temperature under RCP8.5



Note: Shaded areas show the range of 5th and 95th percentile projections for the global mean, and the range of 10th and 90th percentile projections for Ontario.
Source: Intergovernmental Panel on Climate Change67 and Canadian Centre for Climate Services.

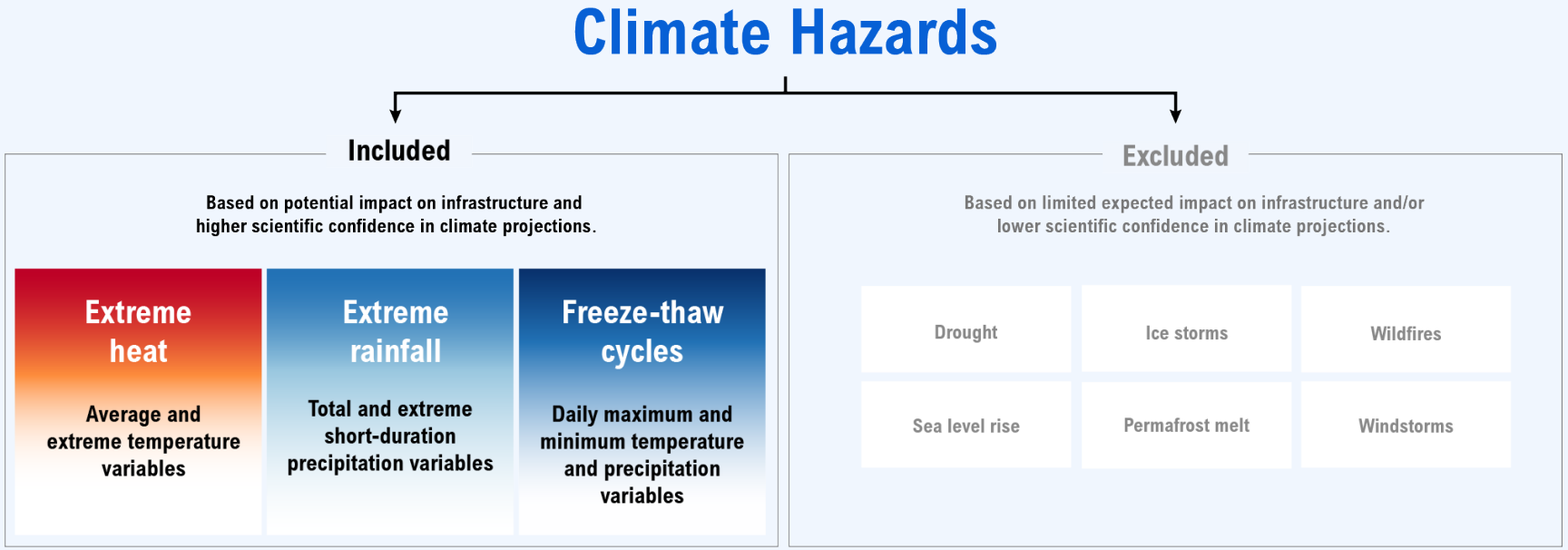
Climate Change impacts will vary by region in Ontario

Median projected change in annual mean temperature from 1976-2005 to 2071-2100, RCP8.5



Note: Colour distribution is based on the multi-model median projection
Source: Canadian Centre for Climate Services.

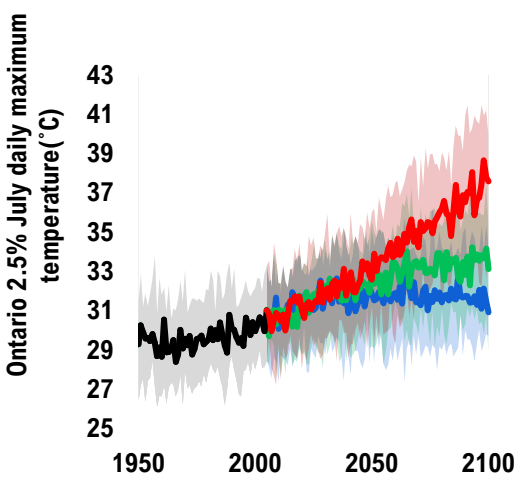
Not all climate hazards are included in the study



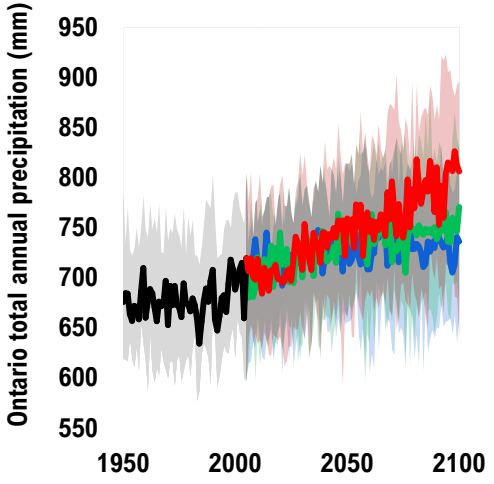
Source: FAO.

Climate change will bring more extreme heat and extreme rainfall, but less freeze-thaw cycles in Ontario

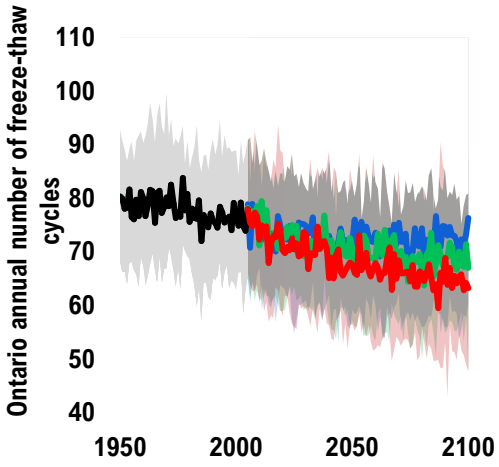
More Extreme Heat



More Extreme Rainfall



Less Freeze-Thaw Cycles



Low emissions scenario | Medium emissions scenario | High emissions scenario

Source: Environment Canada, Canadian Centre for Climate Services.

Climate Change's Impact on Infrastructure

How will climate change impact infrastructure?

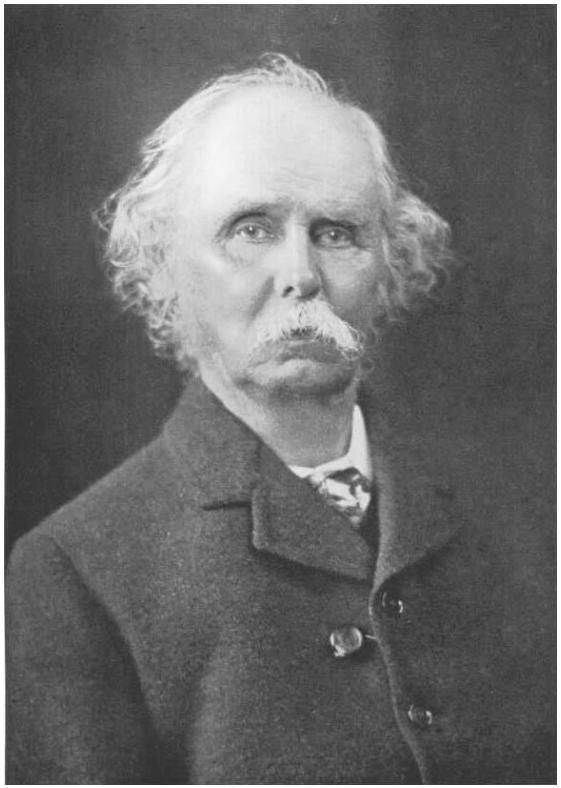
Damage Costs

Changing O&M expenses and deterioration rates caused by climate change

Adaptation Costs

Adapting assets via retrofits or renewals to eliminate damage costs from changing climate

How to translate changing climate hazards to changes in infrastructure costs?



Source: The Economic Journal

Source: UC Berkeley Economics

Estimating Climate Cost Elasticities

Given the change in the climate indicator from the late 20th century, what would be…
…the change in the component's **useful service life (USL)**?
…the change in the annual **operations and maintenance (O&M) expense**?
..the **cost to design a climate resilient component (renewal adaptation)** with the same functionality?
…the **cost to retrofit** the component to be resilient to the climate hazard?

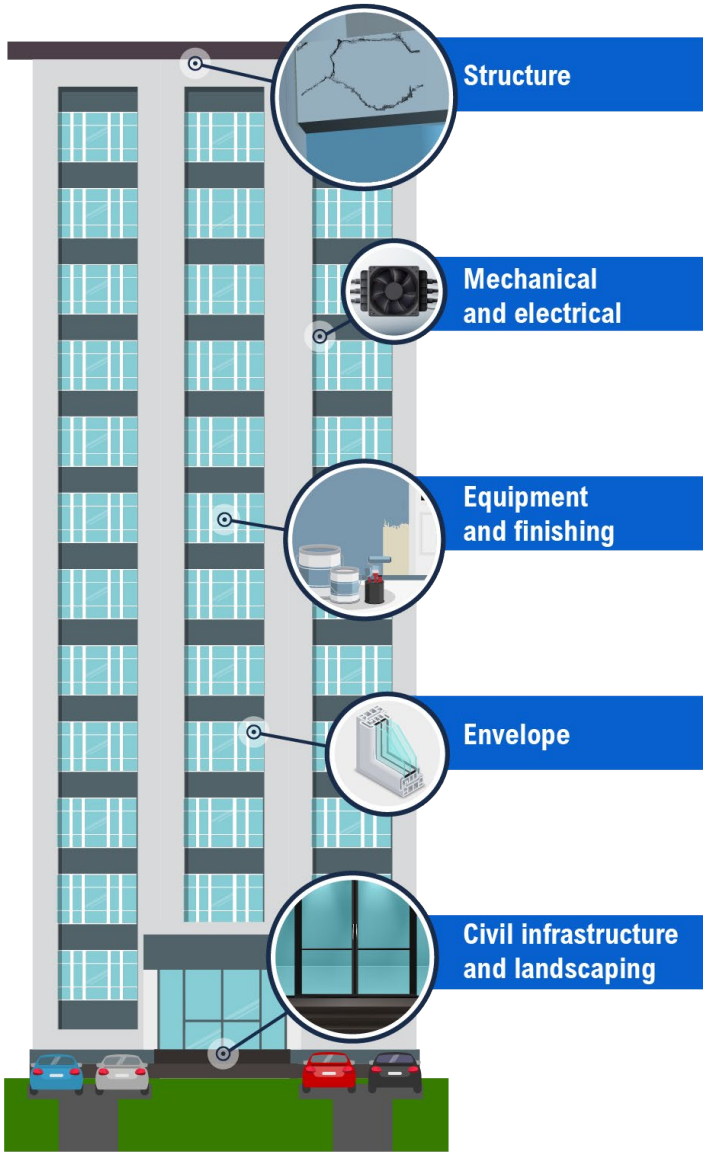
Source: WSP Global

Climate cost elasticities are estimated for each relevant asset component

Note: For more examples of how these climate hazards impact building components, see WSP 2021.

Source: WSP.

Components of Public Buildings

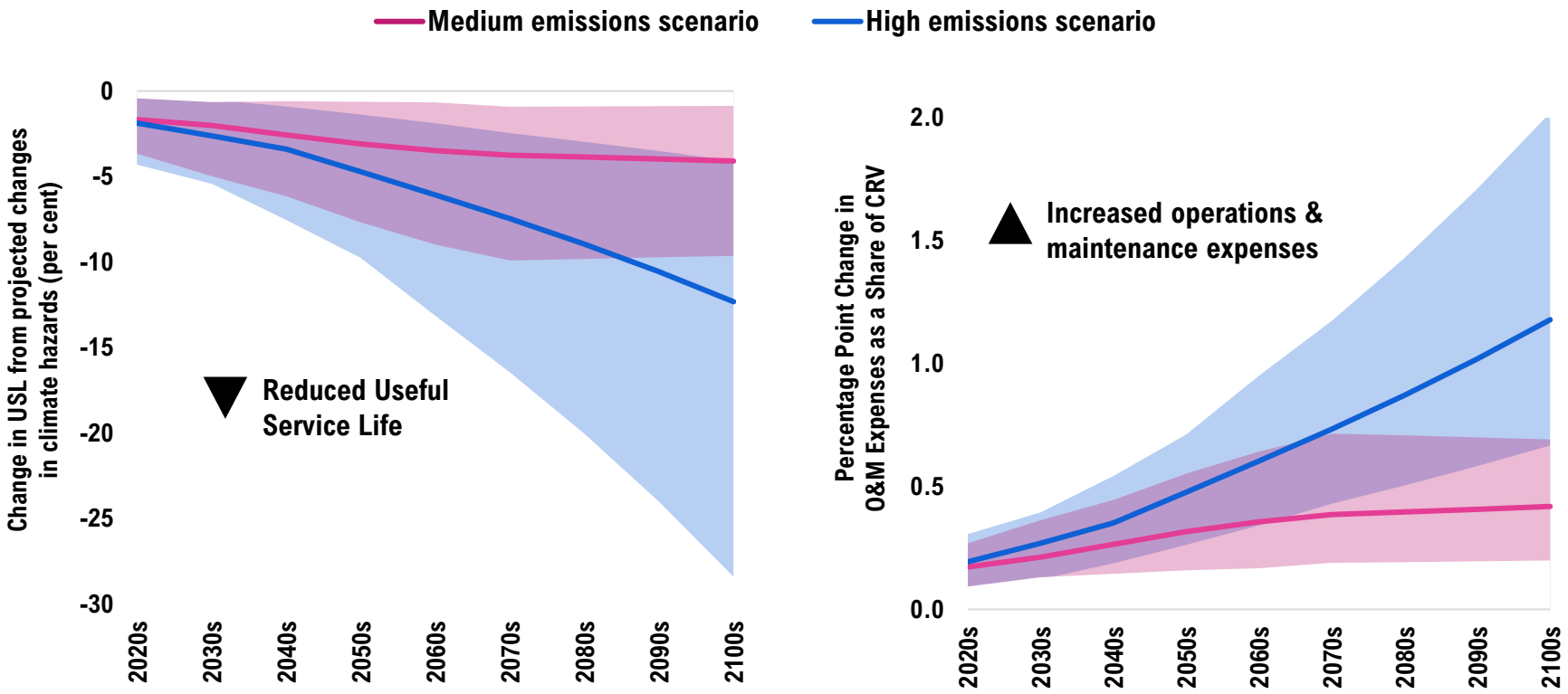


Climate cost elasticity estimates

Climate Hazard	Building Component	Climate Indicator	Climate Change (Δc)	USL (Δp) (%)			O&M Costs (Δp) (%)			Renewal Costs (Δp) (%)			Retrofit Costs (Δp) (%)		
				Pessimistic	Most-likely	Optimistic	Pessimistic	Most-likely	Optimistic	Pessimistic	Most-likely	Optimistic	Pessimistic	Most-likely	Optimistic
Extreme heat	Civil and Landscaping	Mean July daily maximum temperature	7.4°C	-1.4	-0.9	-0.5	0.1	0.1	0.0	1.9	1.8	1.8	2.8	2.5	2.2
	Structure	N/A	Negligible climate impact												
	Envelope	2.5% July daily maximum temperature	7.1°C	-1.8	-1.3	-0.8	0.1	0.1	0.1	2.7	2.6	2.6	4.0	3.5	2.9
	Equipment and Finishing	N/A	Negligible climate impact												

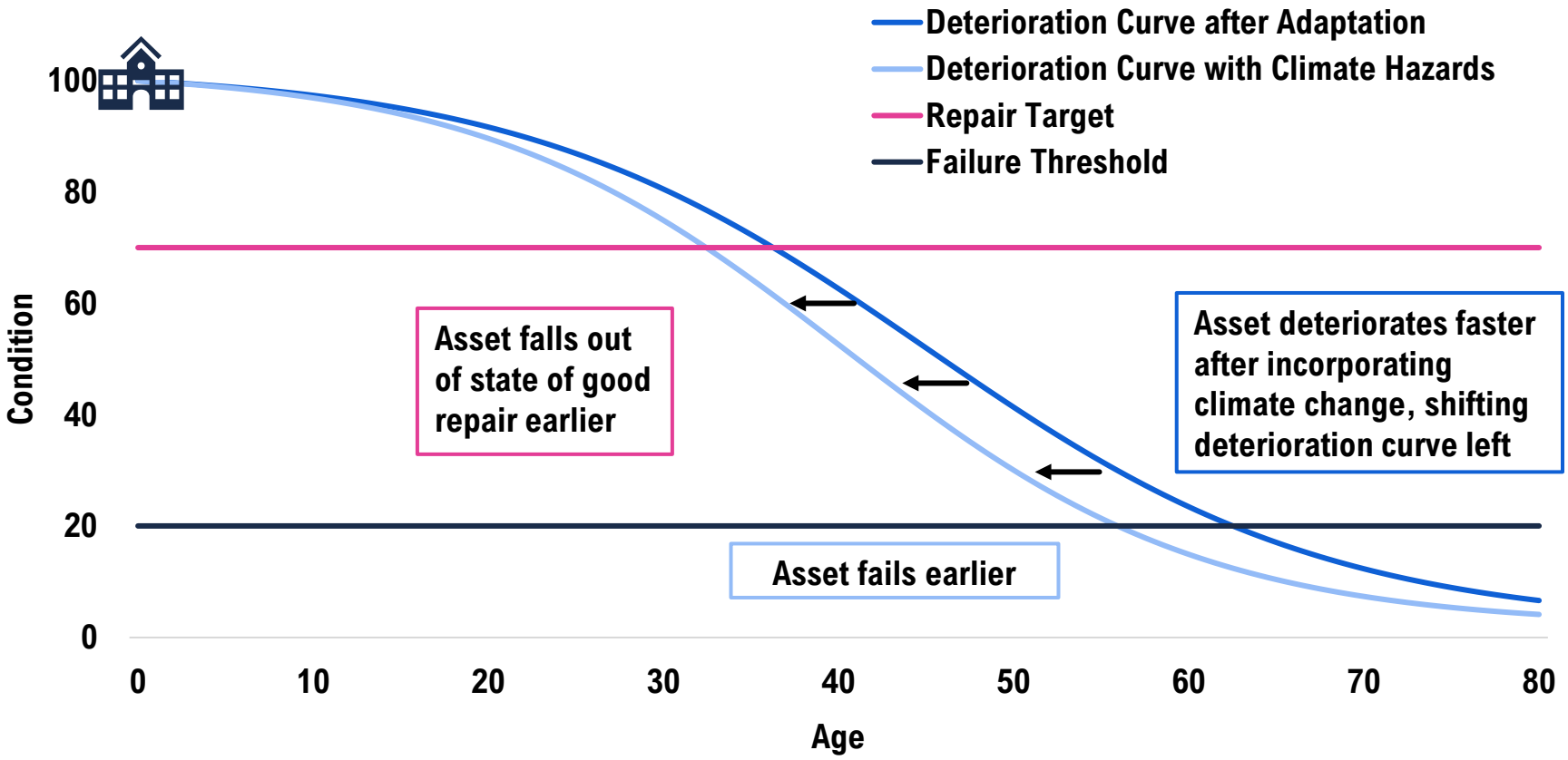
Source: WSP, 2021, Costing climate change impacts and adaptation for provincial and municipal public infrastructure in Ontario, Deliverable #10 – Final Report

All these damage impacts are modelled through two channels



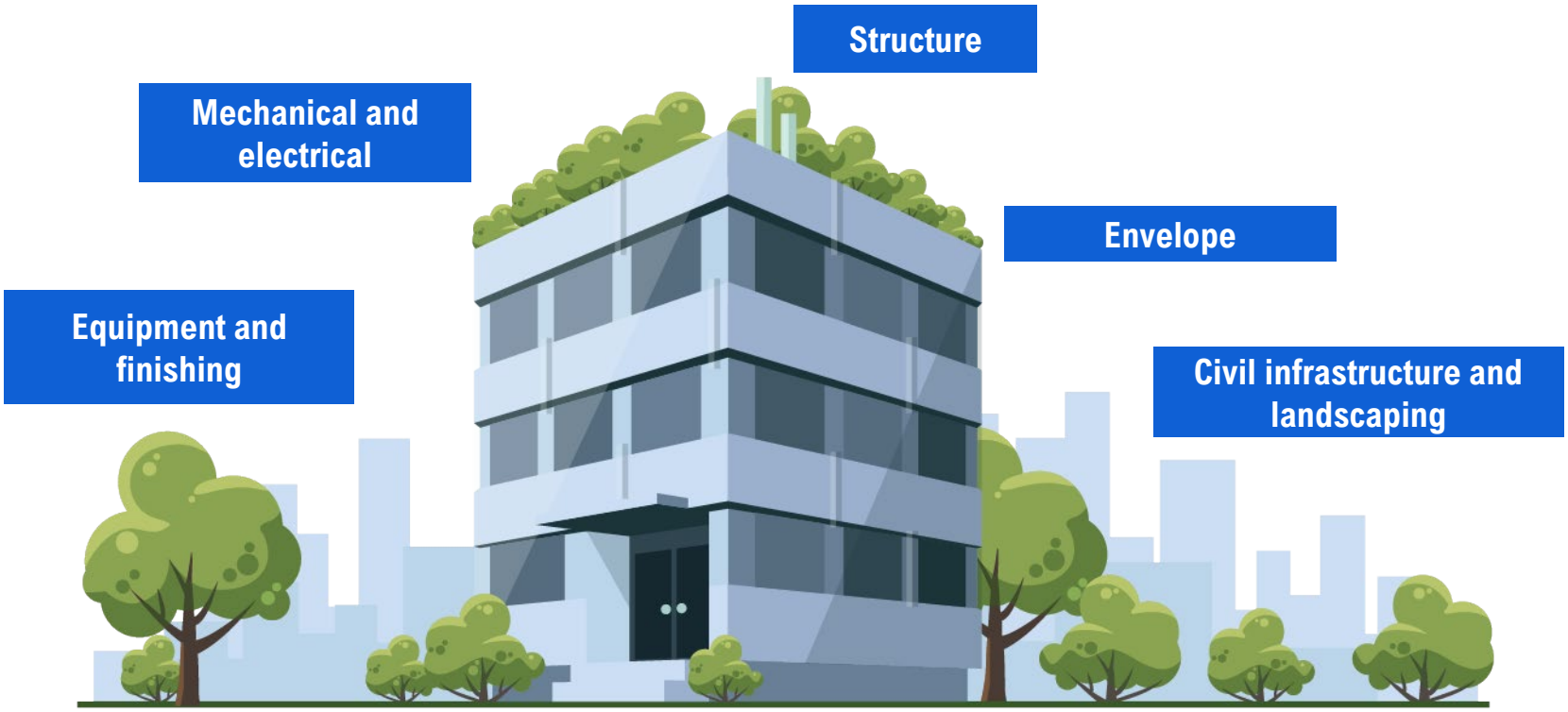
Note: The solid line is the median (or 50th percentile) climate projection using "most likely" engineering outcomes. The coloured bands represent the range of possible outcomes in each emissions scenario given climate and engineering uncertainty.
Source: WSP and FAO.

Estimating damage costs



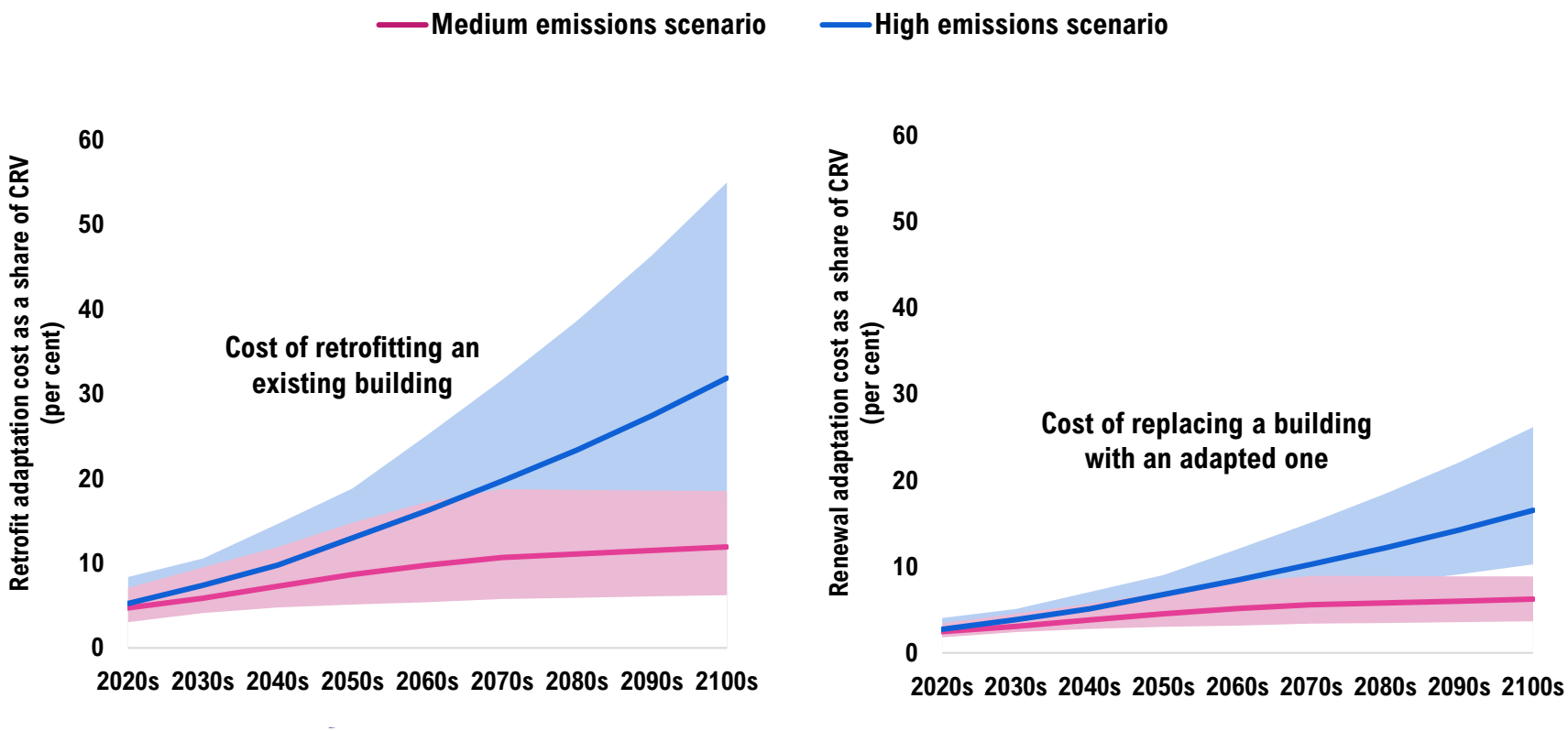
Source: FAO.

And building components can be adapted in different ways to extreme rainfall and heat



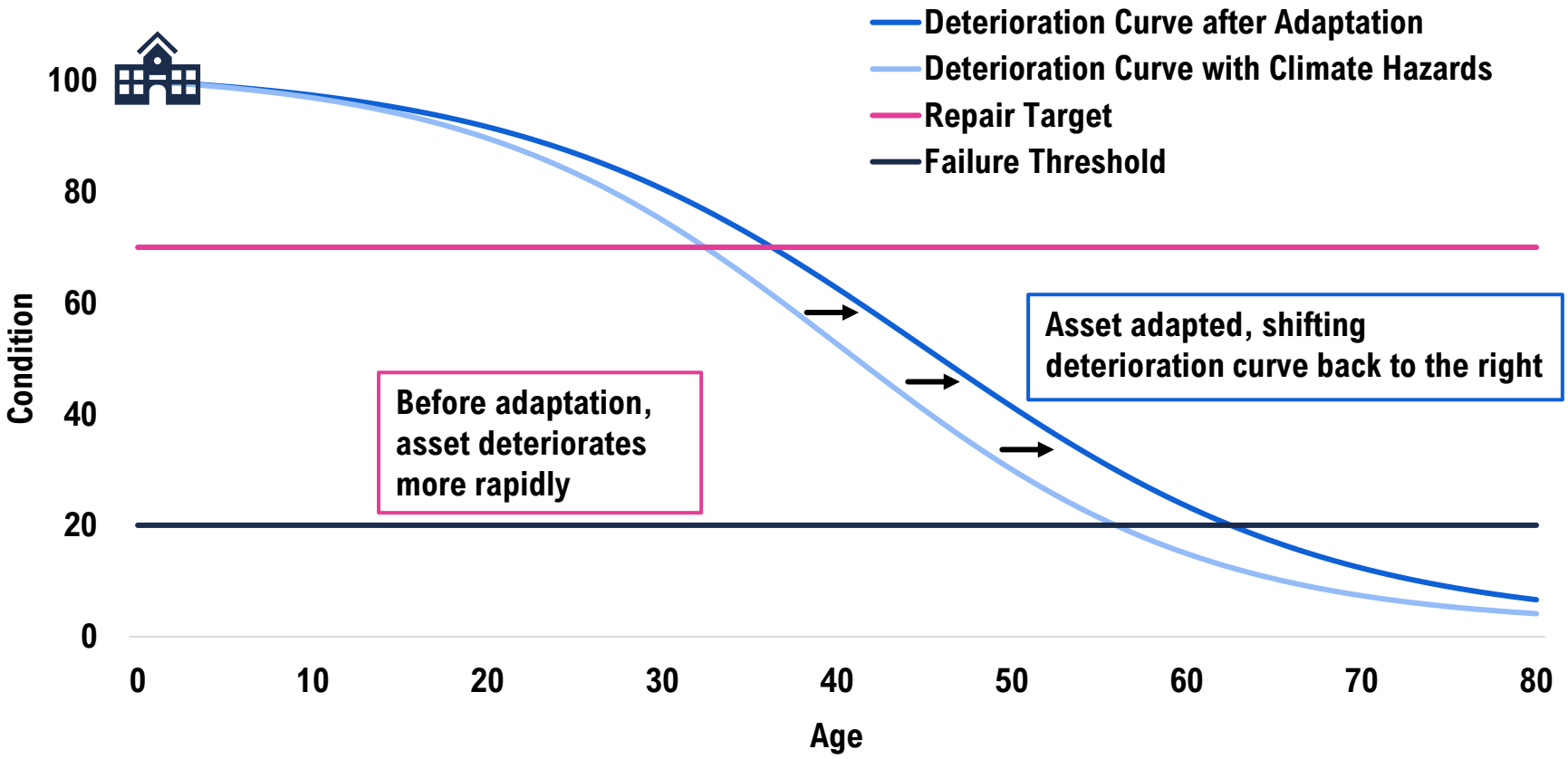
Note: For more examples of how these climate hazards impact building components, see WSP 2021.
Source: WSP.

Cost of adapting a building to extreme rainfall and heat were estimated by WSP



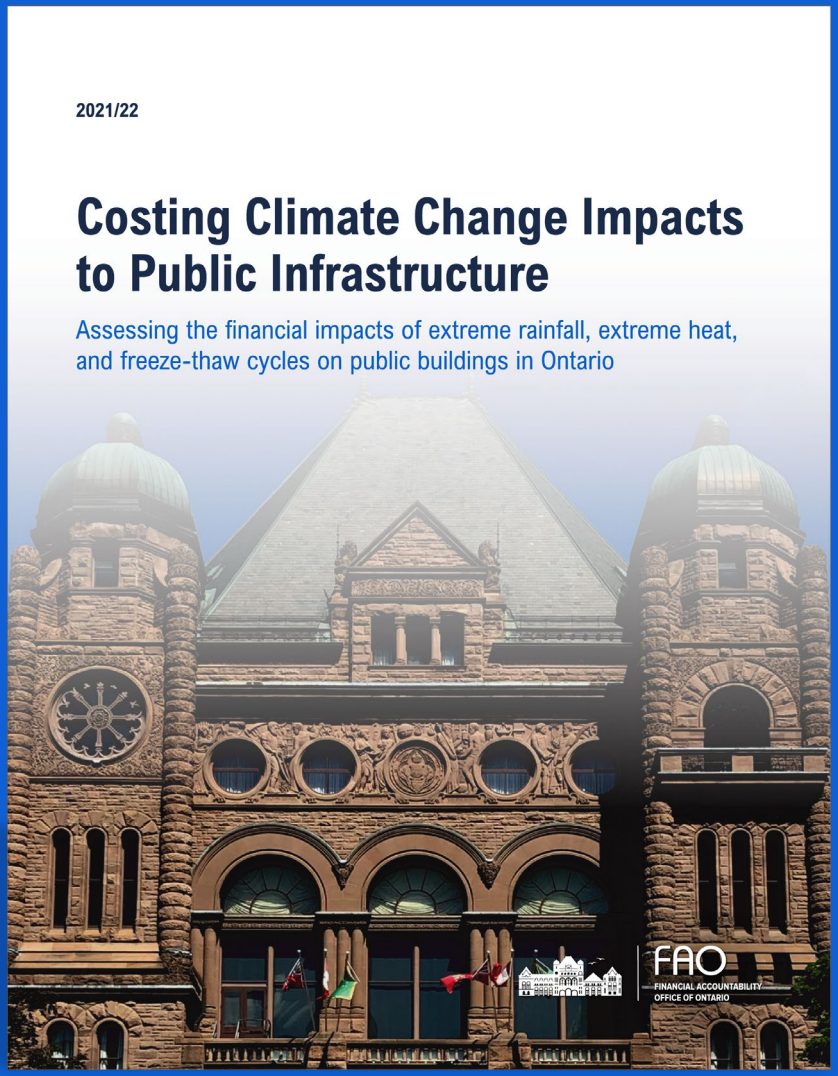
Note: The solid line is the median (or 50th percentile) climate projection using "most likely" engineering outcomes. The coloured bands represent the range of possible outcomes in each emissions scenario given climate and engineering uncertainty.
Source: WSP and FAO.

Estimating adaptation costs

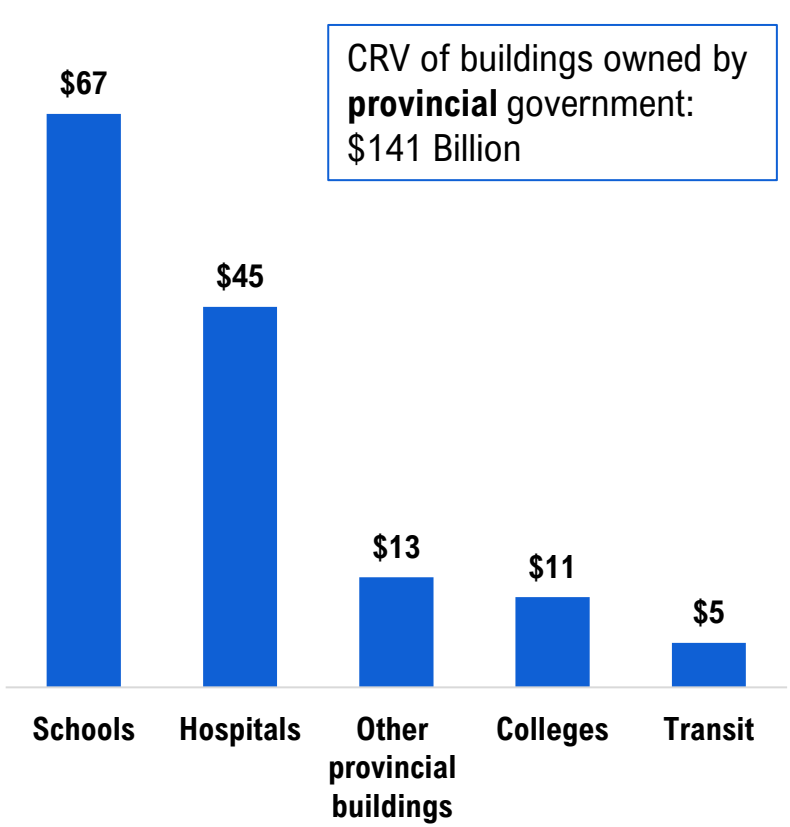


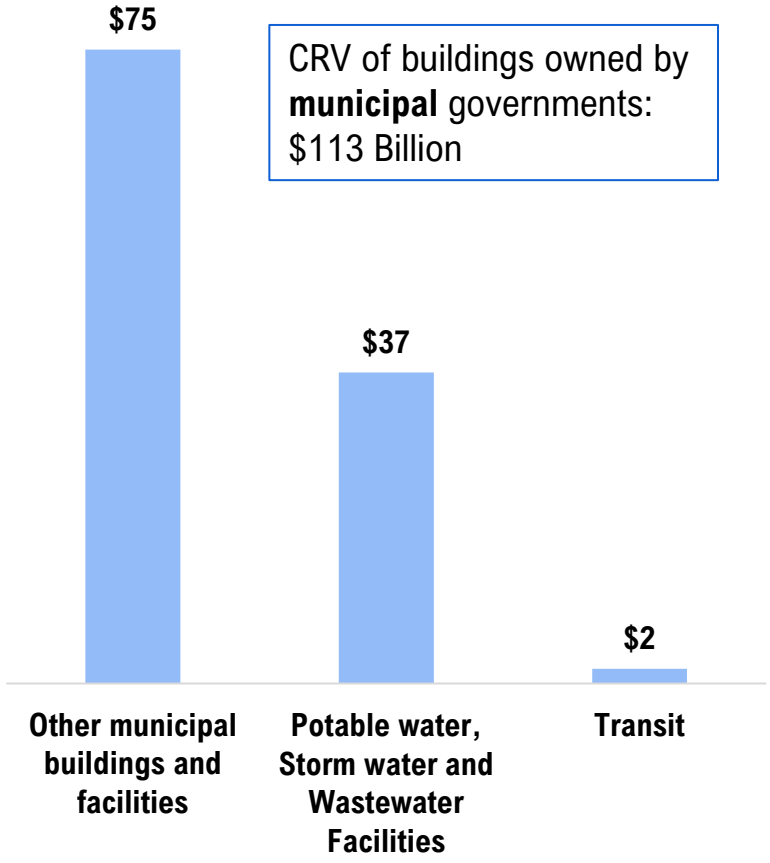
Source: FAO.

Costing Results from CIPI Buildings Report



Provincial and municipal governments manage $254 billion in buildings and facilities





2020$, Billions.
Percentages are share of total building CRV. Federal infrastructure was excluded.
Source: FAO.

The CIPI buildings report examines the following questions in the context of this portfolio

1 | Baseline Cost of maintaining Ontario's public buildings in a stable climate

2 | How climate change impacts baseline costs in the absence of adaptation

3 | Impact of climate change on baseline cost if adaptation actions are undertaken

These assets need regular spending, even if the climate remained stable*

Total cost of bringing and maintaining Ontario's buildings portfolio into a state of good repair 2022-2100

$799 billion
($10 billion per year)

Total cost by spending type 2022-2100

Operations and Maintenance Expense
$296 billion
($4 billion per year)

Rehabilitation and Renewal
$503 billion
($6 billion per year)

A "stable climate" means that all climate indicators remain unchanged from their 1975-2005 average levels over the projection to 2100.
Note: All values presented in real 2020 dollars.
Source: FAO.

The CIPI buildings report examines the following questions in the context of this portfolio over the 2022-2100 period

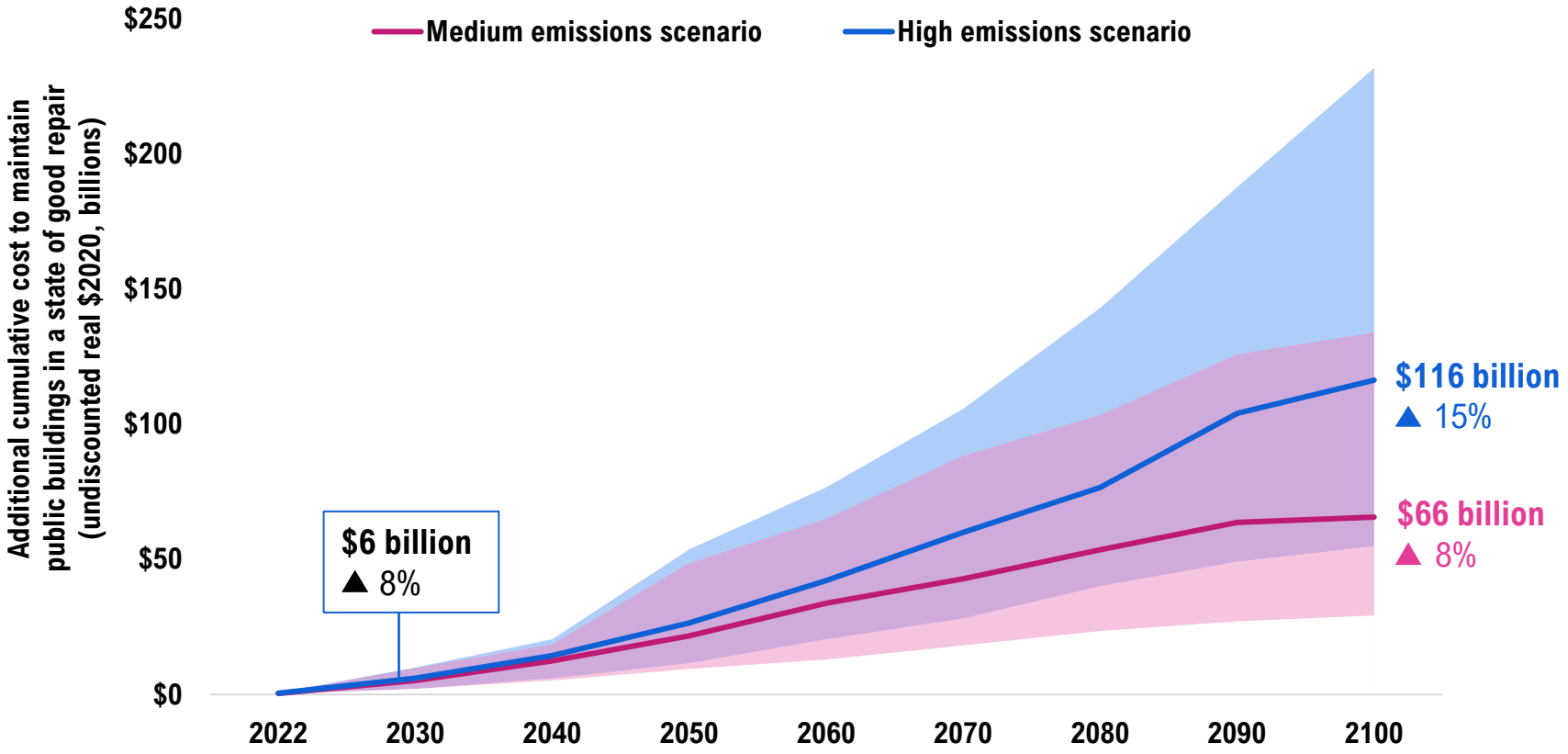
1 | Baseline Cost of maintaining Ontario's public buildings in a stable climate

Baseline
$799 Billion

2 | How climate change impacts baseline costs in the absence of adaptation

3 | How climate change impacts baseline costs if adaptation actions are undertaken

Without adaptation, maintaining public buildings under climate change is becoming more expensive



Notes: The solid line is the median (or 50th percentile) projection. The coloured bands represent the range of possible outcomes in each emissions scenario. The costs presented in this chart are in addition to the projected baseline costs over the same period. The per cent changes are the changes relative to baseline costs over the same period.
Source: FAO.

The CIPI buildings report examines the following questions in the context of this portfolio over the 2022-2100 period

1 | Baseline Cost of maintaining Ontario's public buildings in a stable climate

Baseline
$799 Billion

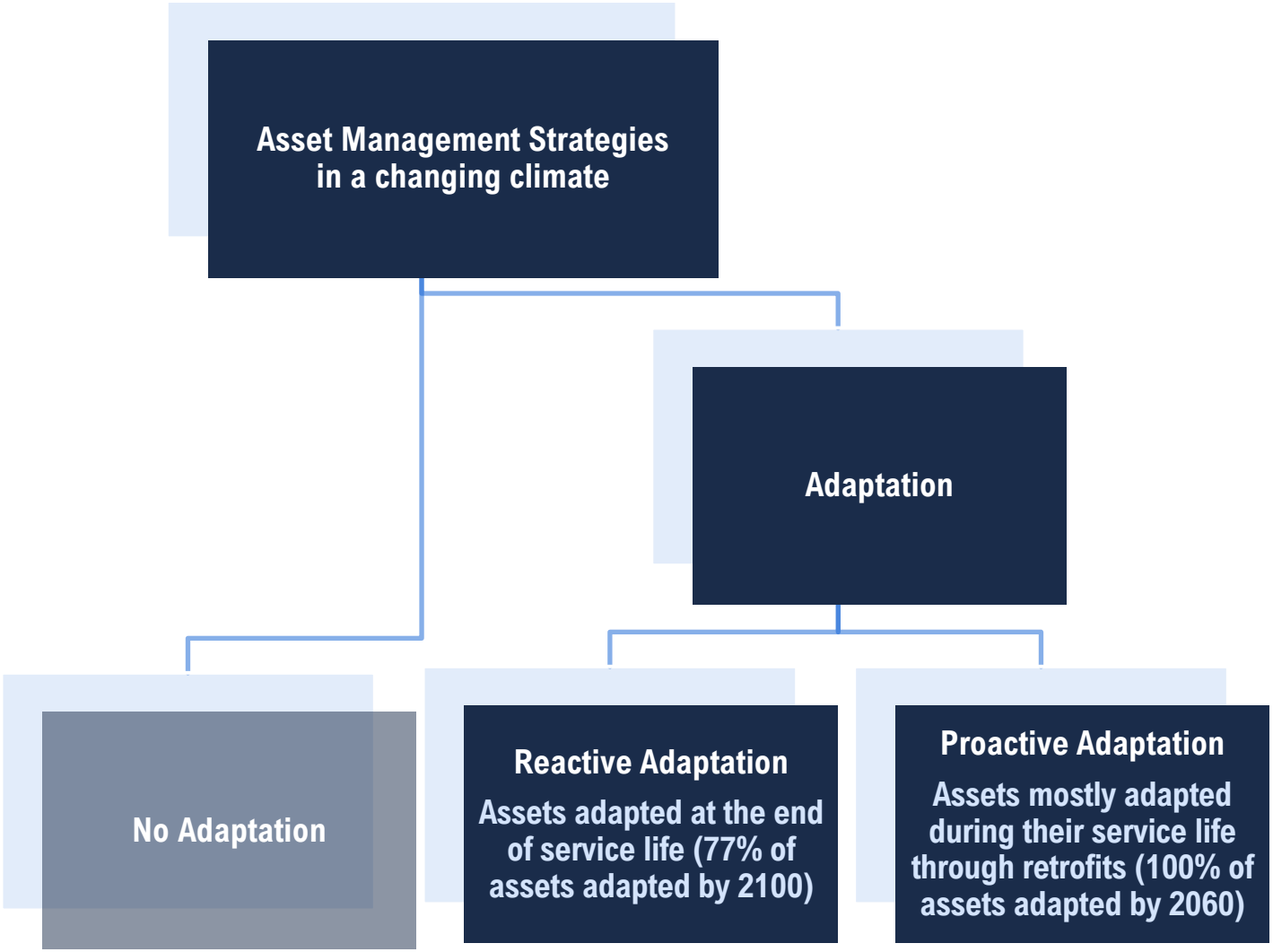
2 | How climate change impacts baseline costs in the absence of adaptation

Medium emissions scenario
$66 Billion
▲ 8%

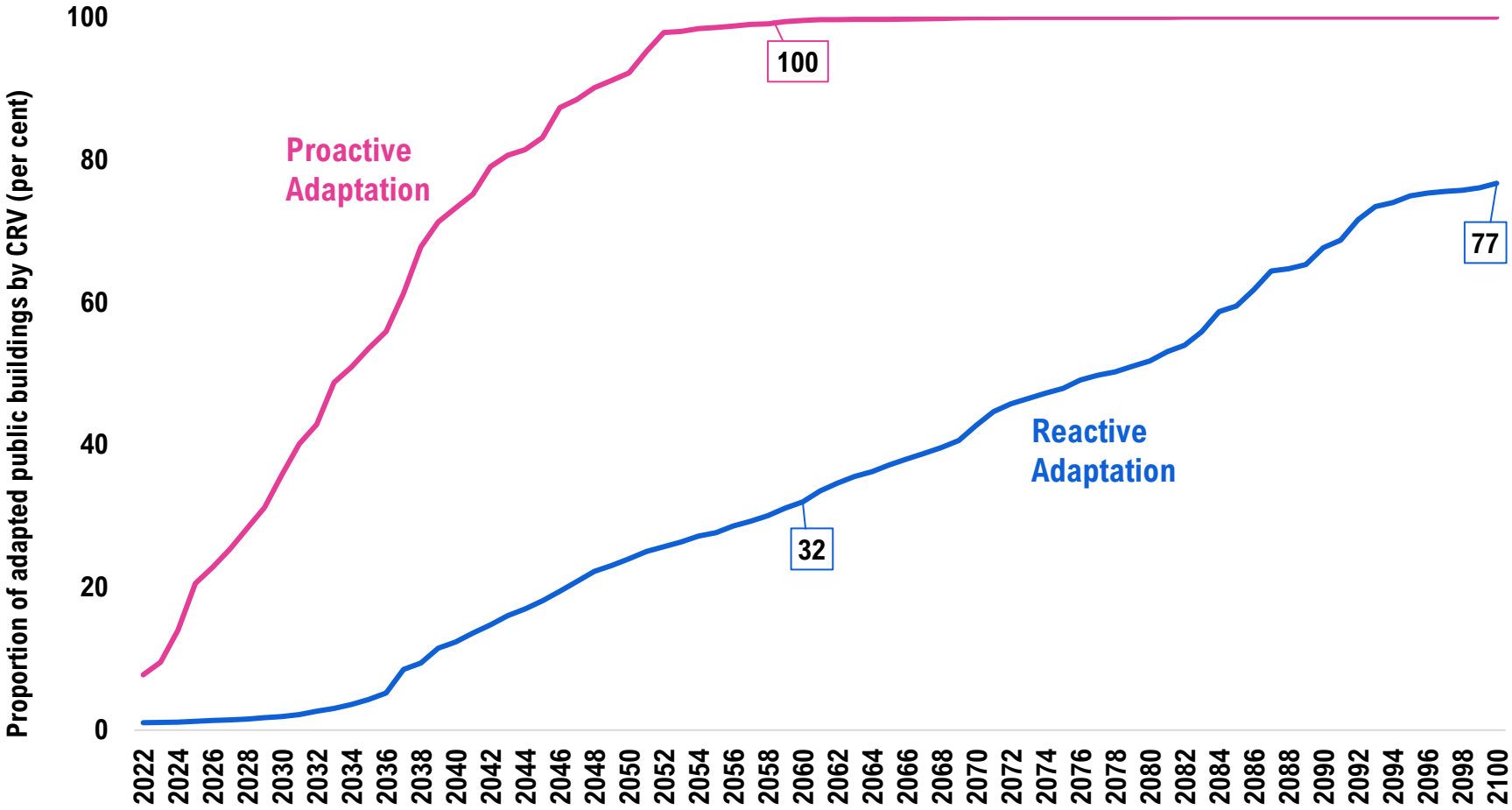
High emissions scenario
$116 Billion
▲15%

3 | How climate change impacts baseline costs if adaptation actions are undertaken

The FAO costed two adaptation strategies

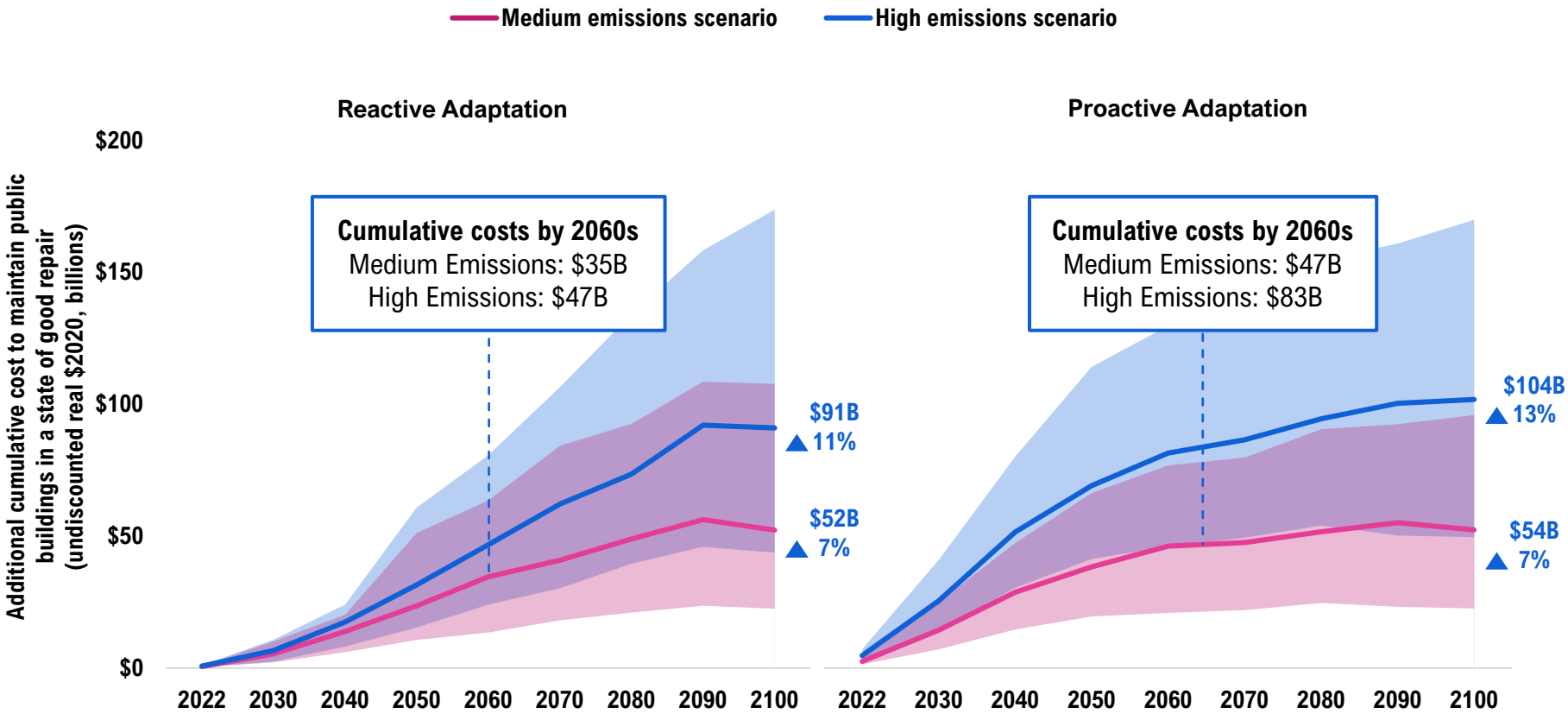


Reactive adaptation strategy results in slower adaptation



Source: FAO.

Adaptation of public buildings will require significant investments



Notes: The solid line is the median (or 50th percentile) projection. The coloured bands represent the range of possible outcomes in each emissions scenario.
The costs presented in this chart are in addition to the projected baseline costs over the same period.
Source: FAO.

The CIPI buildings report examines the following questions in the context of this portfolio over the 2022-2100 period

1 | Baseline Cost of maintaining Ontario's public buildings in a stable climate

Baseline
$799 Billion

2 | How climate change impacts baseline costs in the absence of adaptation

Medium emissions scenario
$66 Billion
▲ 8%

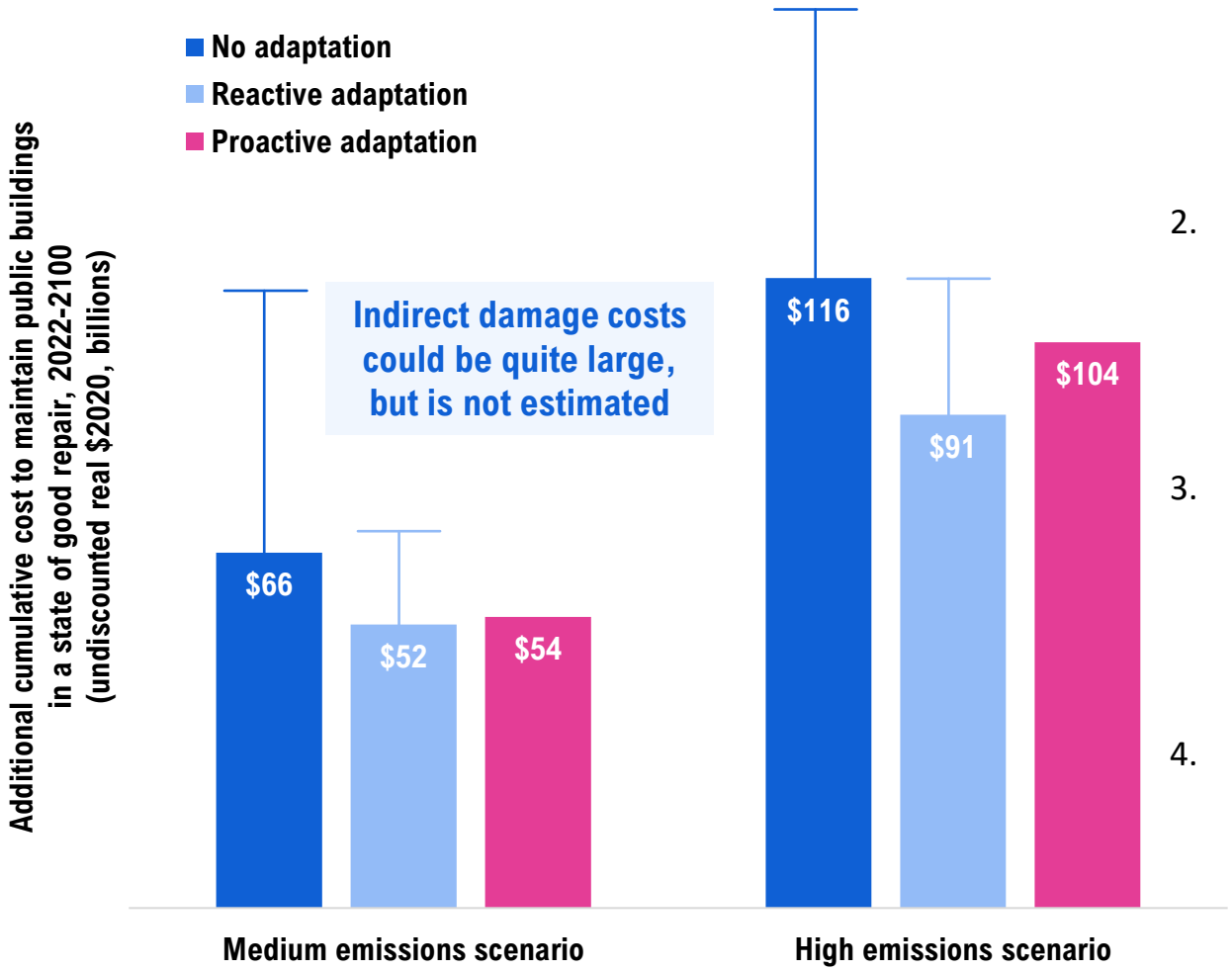
High emissions scenario
$116 Billion
▲15%

3 | How climate change impacts baseline costs if adaptation actions are undertaken

Medium emissions scenario
Reactive: $52 Billion
▲ 7%
Proactive: $54 Billion
▲ 7%

High emissions scenario
Reactive: $91 Billion
▲ 11%
Proactive: $104 Billion
▲ 13%

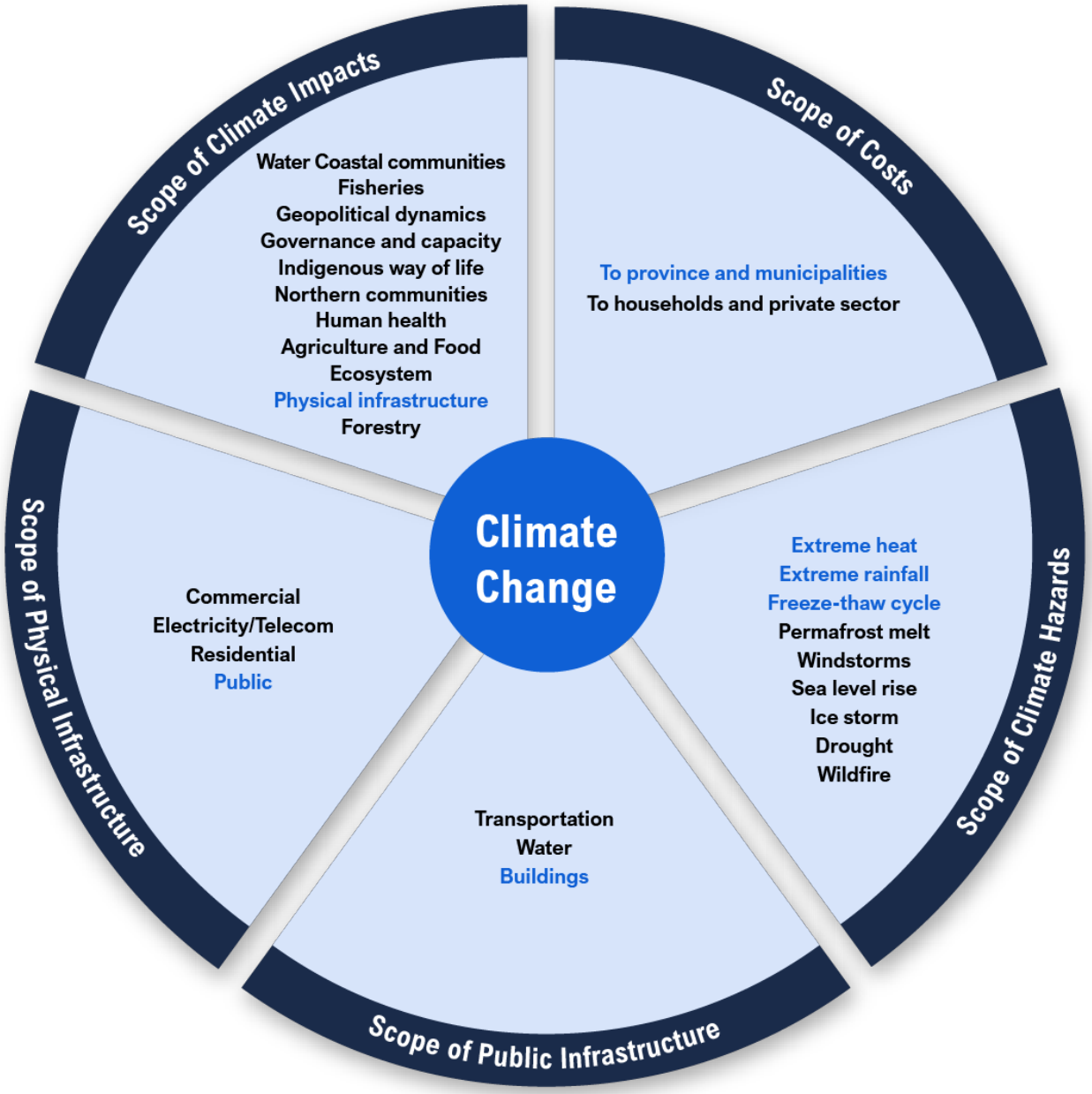
Comparing the cost of different asset management strategies



1. The severity of climate change matters to infrastructure costs. Costs in medium emissions scenario are much lower than in the high emissions scenario.
2. While adaptation will be expensive, it is modestly less costly for provincial and municipal governments than not-adapting over the long term.
3. While reactive adaptation appears cheaper than proactive adaptation, only 77 per cent of assets are adapted in this strategy.
4. These cost estimates do not include many indirect costs of climate damage

Note: The costs presented in this chart are in addition to the baseline costs over the same period.
Determining the most cost-effective strategy for an individual asset would require comparing the costs of different adaptation strategies over its service life, for a broader range of climate hazards and societal costs, and in consideration of its specific circumstances.
Source: FAO.

The FAO costed a small part of all climate change impacts



Source: Council of Canadian Academies and FAO.

Climate change will have material impacts on provincial and municipal infrastructure budgets

Photo by Patrick Hendry on Unsplash

- The FAO's portfolio-level results show that climate change will materially increase the cost of maintaining public buildings in Ontario.
- The extent of these additional costs on the province's budget over the long term will depend on how severe global climate change becomes.

Thank you!

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