Costs of Inaction:

Economic Analysis of Calgary’s Climate Risks

Final Report: Executive Summary

April 2022

Prepared for:

City of Calgary

Economic Analysis of Calgary's Climate Risks

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1 EXECUTIVE SUMMARY

1.1 Introduction

Climate change is already causing economic impacts today and will do so increasingly in the future. These impacts affect different aspects of the economy, public health and the natural environment. Cities—with 80% of the population and 60% of public infrastructure in Canada—are on the frontlines when it comes to both the impacts of climate change and taking action to reduce these impacts. Building resilience and adapting cities to unavoidable climate change has been estimated to require an annual investment of 0.26% of GDP, which equates to about $320 million per year for Calgary over the next 10 years. Given the potential magnitude of climate adaptation investment costs, there is a need to provide decision-makers—who face limited human and financial resources—with defensible economic information on projected costs and associated benefits to support adaptation investment decisions. A key piece of economic information used to persuade senior leadership and Council of the need and urgency to allocate resources to adaptation planning in the future is the "cost of inaction"—i.e., the economic consequences that result from allowing climate change to continue unabated and without further planned adaptation. This information is used to inform the overall scale of investment in adaptation, the selection, timing and sequencing of specific adaptation options, and the distribution of adaptation costs and benefits. Indeed, the first key message in the costs and benefits chapter of the National Issues 2021 volume of Canada in a Changing Climate states: "*Faced with limited resources and competing priorities, economic analysis can help decision-makers clarify trade-offs, and make the case for allocating resources to climate adaptation and specific actions, by providing information on the costs and benefits of different choices*."

In accord with this key message, the City of Calgary commissioned an analysis of the economic impacts of the physical risks of climate change for Calgary to communicate the magnitude of the problem to senior leadership and the Council to: (a) support investment in climate adaptation; and (b) inform the Climate Strategy.

1.2 Approach

The costs of inaction were estimated following best practice in three steps.

1. The first step involves: estimating economic impacts today (for the purpose of this study, taken to be 2025), based on current exposures of human and natural systems in Calgary, current vulnerabilities (the susceptibility of these systems to harm from the climate), and current climate conditions.
2. The second step involves: estimating economic impacts in the future (specifically, in 2055 and 2085) under current climate conditions but allowing for projected socioeconomic change—i.e., growth in Calgary's human and natural systems, growth in prices and wealth, and anticipated changes in vulnerability.

3. The third step involves: overlaying projected future climate change on top of the projected future Calgary.

This approach enables isolation of the incremental impact of further climate change (i.e., beyond 2025) from the influence of anticipated growth and development of the City.

1.2.1 Scope: impacted systems and types of costs included

The human and natural systems included in the assessment are listed in Table ES 1. For each system, the table shows the climate variable(s) driving the estimated impacts—the so-called "climate impact-drivers". The corresponding economic consequences quantified in the study are also shown. Two broad types of economic consequences are assessed:

1. **Direct-tangible costs**. These costs arise from the physical impacts of climate impact-drivers, such as damage or disruption, to (tangible) goods and services that can be traded in a market and thus have an observed price as a basis for monetization (e.g., costs incurred to repair or replace damaged homes, the medical treatment costs for heat stress, etc.).
2. **Direct-intangible costs**. These costs arise from physical impacts to (intangible) items not bought or sold in a traditional market and thus with no readily observable price as a basis for monetization (e.g., ecosystem services, stress or pain levels, travel delays). Economists have developed multiple techniques to 'shadow price' these intangible (non-market or welfare) impacts.

Secondary-tangible costs were also estimated. These costs arise from the ripple effect of the direct tangible impacts on the wider economy as subsequent spending (both indirect and induced) is affected. Indirect impacts result from changes to upstream inter-industry purchases by the directly impacted economic sector(s) in Calgary. Induced impacts result from changes in the production of goods and services in response to changes in consumer income and household expenditures driven by the direct and indirect impacts as they ripple through the regional economy.

Regarding the secondary-tangible costs, they are sometimes erroneously viewed as a net gain for society. While some sectors, like remediation services and construction, might benefit from increased demand for clean-up and restoration services following an extreme weather event, this benefit should be viewed more as a transfer of resources towards sectors responding to the event and away from those that suffer damages as a direct result of the event. The costs incurred to restore assets to their pre-event state thus represents an "opportunity cost"—these expenditures would not have been incurred in the absence of climate change impacts.

1.2.2 Scope: climate scenarios and timeframes

The base year selected for quantifying economic impacts is 2025. This year was chosen as it is the central year of the 30-year meteorological averaging period (2011-2040) between: (a) the climate baseline used by the City of Calgary (1981-2010); and (b) the two future 30-year averaging period used for the City's climate projections—i.e., the 2050s (2041-2070) and the 2080s (2071-2100).

In addition to 2025, economic impacts are quantified for 2055 and 2085; the central years for the 2050s and 2080s time periods. For each of 2025, 2055 and 2085, economic impacts are calculated with respect to the projected changes in relevant climate variables under RCP (Representative Concentration Pathway) 8.5. Hence, estimated costs for 2025 are really the expected annual costs—for (say) roads—of climate change between 1981-2010 and 2011-2040. Likewise, estimated costs for 2055 represent the expected annual costs (for roads) of climate change between 1981-2010 and 2041-2070. Primary interest rests with the difference in estimated economic impacts between 2025 and 2055 and between 2025 and 2085; these differences represent the costs attributable to further climate change beyond what may be currently experienced in Calgary.

When assessing climate-related economic risks it is prudent to consider the greatest plausible change scenario relative to the present, which in practice means working with the RCP 8.5 scenario (i.e., the most conservative of global "no climate policy" scenarios). The primary justification for using RCP 8.5 is that it means no economic risks are missed. Uncertainties relating to whether the future unfolds along RCP 8.5 or along a different, lower emission pathway, are managed when subjecting adaptation strategies and measures to economic analysis.

All estimated economic impacts are reported in constant 2020 dollars.

1.3 Findings

Projected expected annual direct costs in 2025, 2055 and 2085 are presented in Table ES 1. By mid-century, total expected tangible costs (due to impacts on market goods and services) are estimated at $1.6B annually; roughly 4 times higher than expected costs in the immediate future (i.e., in 2025). By the 2080s, total expected tangible costs are estimated to increase to $5.1B annually; roughly 14 times larger than expected costs for 2025. Looking at intangible costs (due to impacts on non-market goods and services), total expected costs by the 2050s are estimated at $1.2B annually, rising to $3.2B annually by the 2080s. Total annual social costs (i.e., tangible plus intangible costs) are expected to reach $2.6B and $7.8B by the 2050s and 2080s, respectively. Put another way, by the 2050s and 2080s expected social costs from climate-related impacts to Calgary are anticipated to amount to, respectively, about $2.6B and $7.8B on average in any given year.

The breakdown of total annual social costs by exposed system for 2025, 2055 and 2085 is shown in Figure ES 1. When considering the figure, note that losses due to climate-related impacts are increasing for all exposed systems over the course of the century, even though the contribution of individual systems to total losses declines between 2025 and 2055 and 2085. With that caveat in mind, the largest source of losses for Calgarians in all three time periods is deteriorating air quality associated with increased concentrations of ground-level O_3 as temperatures rise, accounting for 28%-33% of total losses in all three time periods considered. Damages to buildings from flooding and storm events is the second largest source of losses, accounting for 23%-27% of total losses across all time periods.

Table ES 1: Projected direct economic impacts of climate change for Calgary, by exposed system, climate impact-drivers and future time period

Exposed human and natural systems	Climate impact-drivers	Economic consequences	2025 ($ 2020 M)	2055 ($ 2020 M)	2085 ($ 2020 M)	Change: 2025 to 2055 ($ 2020 M)	Change: 2025 to 2085 ($ 2020 M)
Roads	High temperatures, heavy precipitation, freeze-thaw cycles	Damages	6	46	110	40	104
		Delays (value of time)	1	6	14	5	14
LRT rails	High temperatures	Damages	0.0	0.2	2	0.2	2
Buildings	Fluvial and pluvial flooding	Damages	69	231	596	162	526
	Fluvial and pluvial flooding	Indirect losses	29	81	181	52	153
	Hail storm, high winds, freezing rain, freeze-thaw cycles, heavy snow	Damages	66	238	946	173	881
	Heating degree days, cooling degree days	Energy costs	-9	195	968	203	977
Electricity T&D (linear)	High temperatures, hail storm, high winds, freezing rain, heavy snow, pluvial flooding	Damages	6	22	79	16	73
Potable water (linear)	Cold temperatures, multi-year drought, freeze-thaw cycles	Damages	0.5	2	13	2	12
Wastewater (linear)	Freeze-thaw cycles, pluvial flooding	Damages	15	78	183	63	168
Drainage (linear)	Freeze-thaw cycles, pluvial flooding	Damages	15	80	187	65	171
City trees	High temperatures, multi-year drought, heavy snow, freezing rain, high winds, lightning	Damages	48	119	391	71	343
		Ecosystem services	3	15	95	12	92
Natural areas	High temperatures, multi-year drought, extreme cold, hail storm, heavy snow, freezing rain, high winds, urban flooding	Damages	53	102	276	49	223
		Ecosystem services	110	202	543	92	433
Labour	High temperatures	Lost output	38	219	700	181	662
Public health	Air quality (ground-level ozone) - acute mortality	Welfare losses	158	554	1,402	396	1,244
	Air quality (ground-level ozone) - acute mortality	Lost output	17	78	246	61	229
	Air quality (ground-level ozone) - chronic mortality	Welfare losses	75	291	797	215	722
	Air quality (ground-level ozone) - chronic mortality	Lost output	8	41	140	33	132
	Air quality (ground-level ozone) - morbidity	Welfare losses	2	7	20	5	18
	High temperatures - mortality	Welfare losses	41	134	323	93	283
	High temperatures - mortality	Lost output	4	19	57	14	52
	High temperatures - hospitalizations	Healthcare costs	2	6	16	5	14
	High temperatures - hospitalizations	Lost output	0.1	0.3	0.8	0.2	0.7
Sub-total		Tangible costs	367	1,556	5,093	1,189	4,725
		Intangible costs	390	1,209	3,195	819	2,805
Total		**Social costs**	**728**	**2,628**	**7,845**	**1,900**	**7,117**

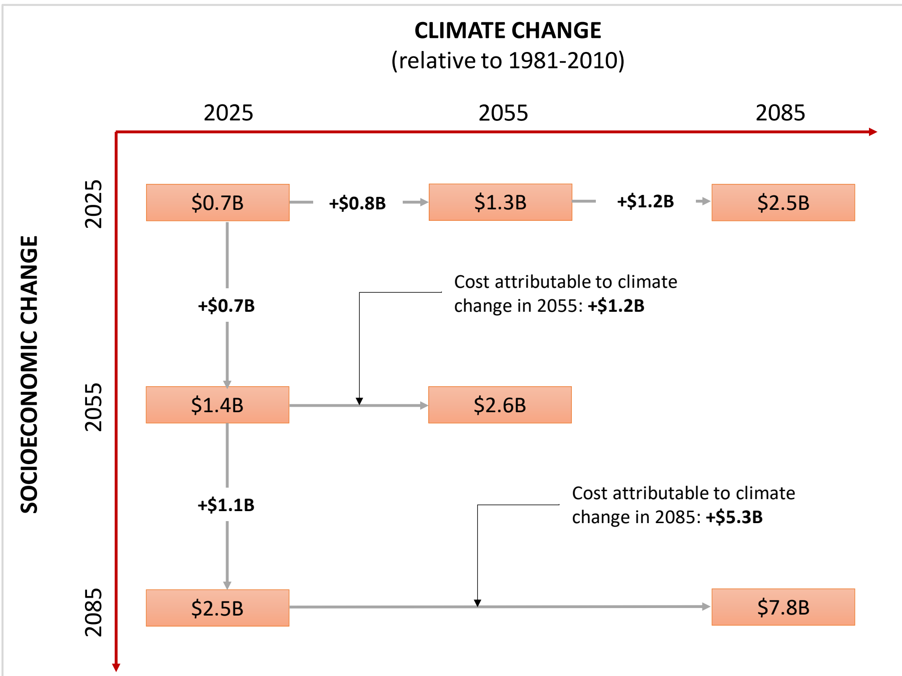
Note: Total social costs do no include the lost output (human capital) costs associated with excess mortality as that would amount to double counting, as the intangible costs (welfare losses) are valued using the Value of a Statistical Life, which will include an element of foregone output.

Other important sources of losses from climate-related impacts are: reductions in labour productivity due to heat stress in the workplace; damage to natural areas and City trees with associated disruption to ecosystem services from a range of climate impact-drivers, deaths and hospitalizations associated with the exposure of the population to heat extremes, and (towards the end of the century) building energy costs as a result of rising temperatures.

Figure ES 1: Projected direct economic impacts of climate change for Calgary in 2025, 2055 and 2085, by exposed system

To isolate the role climate change plays vis-à-vis socioeconomic change, consider Figure ES 2, which shows the projected aggregate direct economic impacts of climate change for a future Calgary, across all systems, climate impact-drivers and tangible and intangible impacts considered. In the absence of any new autonomous or planned adaptation, **the imposed direct annual costs of climate change for Calgary are estimated at about $1.2B and $5.3B (2020 dollars) in 2055 and 2085, respectively**. That is to say, in the 2050s and 2080s expected losses attributable to projected changes in Calgary's climate are anticipated to amount to, respectively, $1.2B and $5.3B on average in any given year.

Figure ES 2: Projected aggregate direct economic impacts of climate change for Calgary (2020 dollars)



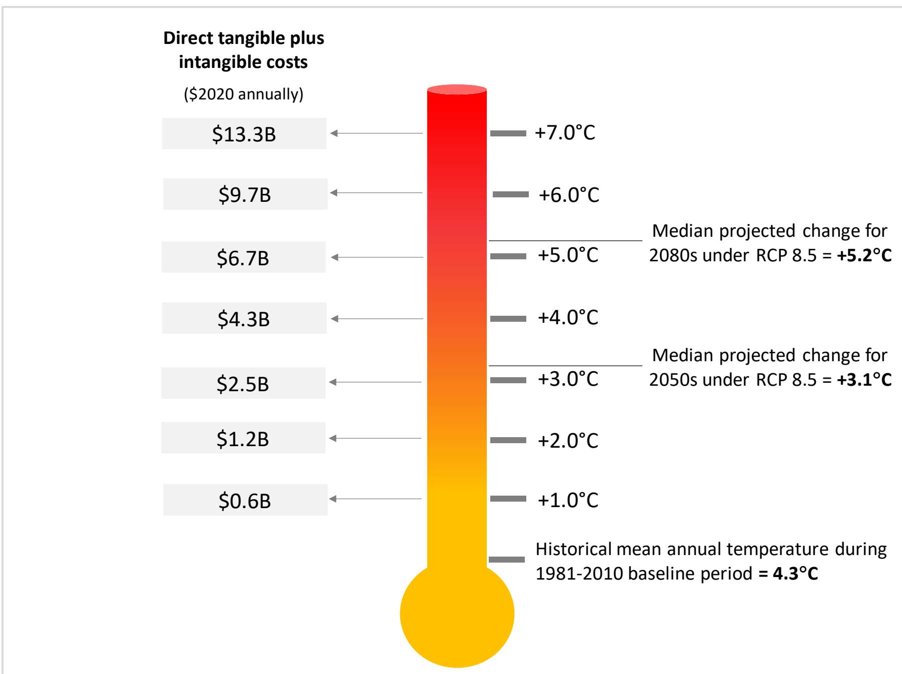
The tangible costs shown in Table ES 1 were used to 'shock' a macroeconomic model for the City of Calgary to gain some insights into the associated macroeconomic consequences of climate change for the City. The results are shown in Table ES 2. The overall (direct, indirect and induced) impact of climate change for gross output by mid-century is estimated at $5.2B annually (an increased opportunity cost of $3.9B relative to 2025). By the 2080s, the overall opportunity cost of climate change for gross output is projected to amount to $16.6B (an increased loss of $15.3B relative to 2025). Looking at value-added, annual GDP losses due to climate-related impacts on Calgary in 2055 and 2085 are estimated at $2.2B and $7.1B; representing increased GDP losses of $1.7B and $6.5B, respectively, relative to 2025. Table ES 2 also shows expected annual forgone municipal, provincial and federal tax revenues because of climate related-impacts on Calgary.

To illustrate the economic consequences for Calgary from different levels of climate change relative to the 1981-2010 baseline period, projected direct annual tangible and intangible costs associated with one degree Celsius increments in Calgary's *mean annual temperature* relative to the baseline period are shown in Figure ES 3. By way of example, if Calgary develops as projected and the climate continues to change in accordance with RCP 8.5, then by the 2080s expected direct annual tangible plus intangible costs are estimated at about $7.3B.

Table ES 2: Projected direct, indirect and induced tangible economic impacts of climate change for Calgary, by time period

Macroeconomic indicators	2025 ($ 2020 M)	2055 ($ 2020 M)	2085 ($ 2020 M)
Tax revenues	32	137	456
Labour income	281	1,180	3,613
Gross output	1,265	5,192	16,610
GDP	529	2,185	7,037

Figure ES 3: Projected aggregate economic impacts of different amounts of future climate change for Calgary (direct tangible and intangible costs) (2020 billion dollars annually)



1.4 Key limitations

This assessment of the economics consequences of climate change for Calgary has several limitations that should be borne in mind when interpreting the results:

- The systems included in the assessment produce service flows (e.g., drinking water, power, etc.) that residents and businesses in Calgary value. With the exception of the time value of delays on the road network and the ecosystem services generated by natural areas and City trees, the dollar value of loss or disruption to these services flows is not captured in the results.

- For several exposed systems and climate impact-drivers, the analysis focused on a single event of defined intensity. For example, the estimated impacts of *high temperatures* for City trees are based on damages expected from "three consecutive days with maximum daily temperature ≥29°C". While the intensity levels of the events considered is towards the upper tail-end of the distribution of possible events, other events with lesser intensities, but a higher likelihood of occurring, may still collectively result in material damages.
- The analysis does not account for the potential of compounding and cascading effects. There are multiple ways that climate change can produce these effects. Compound effects occur, for example, when one set of climate impact-drivers result in multiple "impact chains" occurring simultaneously or in sequence, thus amplifying the overall consequences (e.g., the same climatic drivers that cause heat stress for workers and the general population can also cause drought and wildfire). When climate hazards occur in sequence (like the extreme heat and wildfires or the succession of "atmospheric rivers" that hit British Columbia in 2021) they act as a series of toppling dominos that accumulate and intensify, each becoming harder to manage as capacity to cope and recover becomes more strained, ultimately turning them into disasters. Cascading effects are indirect biophysical impacts of direct effects, such as when direct damages or losses to one system (like power outages from damage to electricity T&D infrastructure) from exposure to a climate hazard leads to spin-off impacts for other systems (like traffic signals, pumping stations, etc.). In this study, climate impact-drivers are assessed as discrete events occurring in isolation in any given year.
- The analysis does not account for feedback effects on projected growth. Simply put, the analysis measures the impacts of climate change on the level of output and not the growth rate. Climate change can cause lasting damage to natural, manufactured and human capital and productivity in most affected systems in the City and is thus likely to impact long-term growth rates underpinning the projections of socioeconomic change. Studies that have investigated the impact of climate change on growth rates have found substantially larger losses than those that measured impacts on the annual level of output (as done in this study).

Collectively, these limitations suggest the projected economic risks of climate change for Calgary are almost certainly larger than the estimates presented in this report.

ALL ONE SKY FOUNDATION is a not-for-profit, charitable organization established to help vulnerable populations at the crossroads of energy and climate change. We do this through education, research and community-led programs, focusing our efforts on adaptation to climate change and energy poverty. Our vision is a society in which ALL people can afford the energy they require to live in warm, comfortable homes, in communities that are resilient and adaptive to a changing climate.

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