MANITOBA CLIMATE
RESILIENCE TRAINING

Natural Infrastructure Solutions to Enhance Climate Resilience

SUPPLEMENTARY HANDOUTS

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THE URGENCY OF BUILDING RESILIENCE AND REDUCING CARBON EMISSIONS

Comparing the **recent past** (1976-2005) to the **near future** (2051-2080)

Communities	Average hottest temperature of the year			Average coldest temperature of the year			Average number of days per year above 25 °C			Average number of below-zero days per year			Average length of the frost-free season		
	Recent Past	Low-Carbon Future	High-Carbon Future	Recent Past	Low-Carbon Future	High-Carbon Future	Recent Past	Low-Carbon Future	High-Carbon Future	Recent Past	Low-Carbon Future	High-Carbon Future	Recent Past	Low-Carbon Future	High-Carbon Future
Winnipeg	34.5 °C	37.8 °C	39.3 °C	-36.0 °C	-31.5 °C	-29.8 °C	55	87	98	189	161	149	127	149	161

Source: Prairie Climate Centre.
Available at: https://climateatlas.ca/sites/default/files/Manitoba-Report_FINAL_EN.pdf

Prairie Climate Centre
From Risk to Resilience

Manitoba
AND CLIMATE CHANGE

Virtually all social, economic and ecological systems in Manitoba are dependent, either directly or indirectly, on a stable and predictable climate system.

However, Manitoba's climate is changing, and the province is projected to continue to warm much faster than the global average—a product of the region's northern latitude and continental geography. These changes are likely to have very large impacts on the province and its people.

This report offers a summary of projected climate changes for several Manitoba communities, an overview of some important regional and local impacts, and ideas and approaches that can be used to take meaningful climate action across the province.

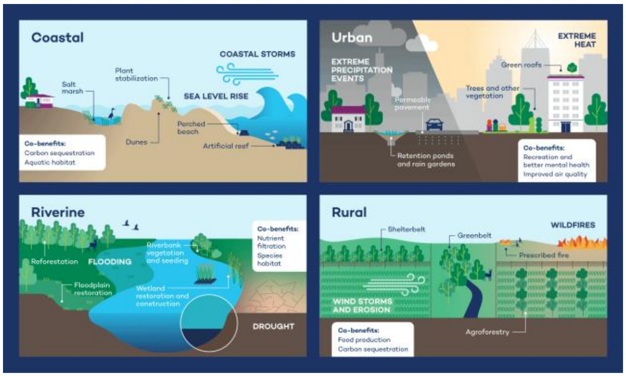
How is Manitoba expected to change?

This map shows how climate change is likely to affect communities across Manitoba in the coming decades. It is evident that dramatic changes are expected in the future under the High Carbon future scenario.* And this is just a small sample of the many kinds of data available in the Climate Atlas.

Manitoba's southern cities and towns that already experience hot summers will face large increases in both daytime and nighttime temperatures. Many northern places will have to start coping with significant heat for the first time, which will have serious consequences for communities, ecosystems and infrastructure. Changes in seasonal patterns of precipitation will impact the entire province.

Climate change will affect our seasonal experience of place, identity, and community, as well as our built environment, governance, and economy. However, solutions to this pressing global problem do exist. When these solutions incorporate local perspectives, expertise, and commitment, we can take meaningful and effective adaptation and mitigation measures where we live.

NATURAL INFRASTRUCTURE IN DIFFERENT SETTINGS



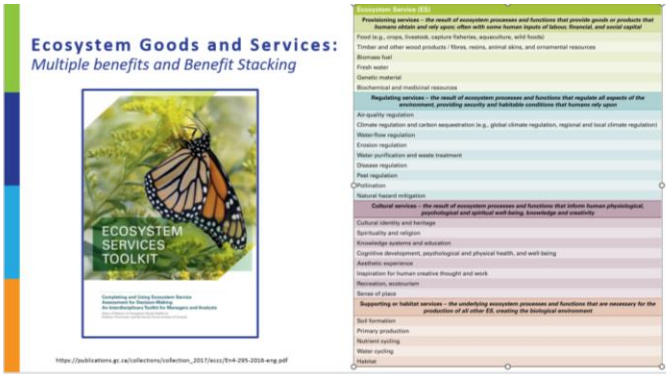
Source: Advancing the Resilience of Canadian Infrastructure – A review of literature to inform the way forward.
Available at: https://www.iisd.org/publications/climate-resilience-canadian-infrastructure

Table 7. Natural infrastructure solutions for reducing exposure and vulnerability to climate change hazards

Climate hazard	Natural infrastructure solutions
Sea level rise, coastal storms and flooding, loss of ice cover[1,2,3,4,5,6]	• Artificial reefs • Oyster and coral reefs • Living shorelines • Salt marshes • Wetlands • Submerged aquatic vegetation • Maritime forests and shrub communities • Beaches and dunes • Barrier islands • Plant stabilization • Beach nourishment • Perched beach (enabled by a submerged sill)
Riverine flooding[4,5,6]	• Floodplain restoration • Wetland restoration/conservation/ construction • Flood setbacks • Two-stage channels • Relief channels • In-stream structures • Bank vegetation and seeding • Re/afforestation and forest conservation • Riparian buffers • Reconnecting rivers to floodplains • Establishing flood bypasses
Increased stormwater (urban and rural) from extreme precipitation events[4,5,6]	• Green roofs • Bioswales • Bioretention ponds • Rain gardens • Water harvesting • Urban trees • Vegetative swales • Green spaces (bioretention and infiltration) • Permeable pavements • Wetland restoration/conservation/ construction
Extreme heat[4,6]	• Trees and other vegetation • Green roofs • Hybrid green and cool/reflective roofs

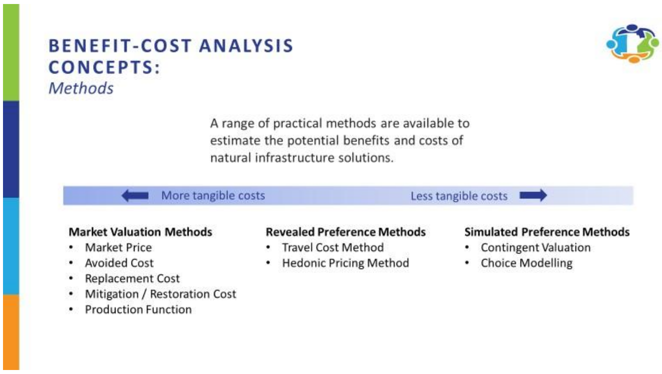
Climate hazard	Natural infrastructure solutions
Drought[5,13,14,15,16,17]	• Re/afforestation and forest conservation • Reconnecting rivers to floodplains • Wetland restoration/conservation/ construction • Water harvesting • Green spaces (bioretention and infiltration) • Permeable pavements • Riparian buffers • Restore water table depth (infilling ditches, channels) • Promote drought-resilient native species
Windstorms and wind erosion[4,7,8,17,18,19]	• Tree walls/shelterbelts/windbreaks • Agroforestry and agro woodlots, including alley cropping • Increase tree species diversity • Manage for unevenly aged stands
Wildfires[9,10,11,12,17,20,21,22,23]	• Green firebreaks • Fuel-break systems and buffer zones • Open spaces and greenbelt areas • Prescribed fire to reduce future burn intensity • Promote fire-resistant native species, where appropriate
Water erosion[5]	• Re/afforestation and forest conservation • Riparian buffers • Reconnecting rivers to floodplains

Sources: [1]USACE, 2015; [2]USACE, 2013; [3]Leys & Bryce, 2016; [4]ICF, 2018; [5]United Nations Environment Programme (UNEP), 2014; [6]Environmental and Energy Study Institute, 2019; [7]Agriculture and Agri-Food Canada, 2010; [8]Bellet, 2013; [9]Cui et al., 2019; [10]Food and Agriculture Organization, 2002; [11]USDA, 2011; [12]FireSmart Canada, 2003; [13]Parks Canada, 2021; [14]Chimner et al., 2019; [15]Schimelpfenig et al., 2014; [16]Howie et al., 2009; [17]Canadian Council of Forest Ministers, 2009; [18]Messier et al., 2019; [19]Lafond et al., 2014; [20]Halofsky et al., 2020; [21]Gillson et al., 2019; [22]Enright et al., 2014; [23]Guiterman et al., 2018.



Source: Ecosystem Services Toolkit, prepared by The Value of Nature to Canadians Study Taskforce Federal, Provincial, and Territorial Governments of Canada.
Available at: https://publications.gc.ca/collections/collection_2017/eccc/En4-295-2016-eng.pdf

Ecosystem Service (ES)
Provisioning services – *the result of ecosystem processes and functions that provide goods or products that humans obtain and rely upon; often with some human inputs of labour, financial, and social capital*
Food (e.g., crops, livestock, capture fisheries, aquaculture, wild foods)
Timber and other wood products / fibres, resins, animal skins, and ornamental resources
Biomass fuel
Fresh water
Genetic material
Biochemical and medicinal resources
Regulating services – *the result of ecosystem processes and functions that regulate all aspects of the environment, providing security and habitable conditions that humans rely upon*
Air-quality regulation
Climate regulation and carbon sequestration (e.g., global climate regulation, regional and local climate regulation)
Water-flow regulation
Erosion regulation
Water purification and waste treatment
Disease regulation
Pest regulation
Pollination
Natural hazard mitigation
Cultural services – *the result of ecosystem processes and functions that inform human physiological, psychological and spiritual well-being, knowledge and creativity*
Cultural identity and heritage
Spirituality and religion
Knowledge systems and education
Cognitive development, psychological and physical health, and well-being
Aesthetic experience
Inspiration for human creative thought and work
Recreation, ecotourism
Sense of place
Supporting or habitat services – *the underlying ecosystem processes and functions that are necessary for the production of all other ES, creating the biological environment*
Soil formation
Primary production
Nutrient cycling
Water cycling
Habitat



Source: Chapter 5: The Economics of Valuing Ecosystem Services and Biodiversity.
Available at: http://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/Ecological%20and%20Economic%20Foundations/TEEB%20Ecological%20and%20Economic%20Foundations%20report/TEEB%20Foundations.pdf

Method			Comment/Example	References
Market valuation	**Market Price**		Mainly applicable to the "goods" (e.g. fish) but also some cultural (e.g. recreation) and regulating services (e.g. pollination).	Brown et al. 1990; Kanazawa 1993
	Cost based	**Avoided cost**	The value of the flood control service can be derived from the estimated damage if flooding were to occur.	Gunawardena & Rowan 2005; Ammour et al. 2000; Breaux et al. 1995; Gren 1993
		Replacement cost	The value of groundwater recharge can be estimated from the costs of obtaining water from another source (substitute costs).	
		Mitigation/ restoration costs	E.g. cost of preventive expenditures in absence of wetland service (e.g. flood barriers) or relocation.	
	Production function/ factor income		How soil fertility improves crop yield and therefore the income of the farmers, and how water quality improvements increase commercial fisheries catch and thereby incomes of fishermen.	Pattanayak & Kramer 2001
Revealed preference	**Travel Cost Method**		E.g. part of the recreational value of a site is reflected in the amount of time and money that people spend while traveling to the site.	Whitten & Bennet 2002; Martin-López et al. 2009b
	Hedonic Pricing Method		For example: clean air, presence of water and aesthetic views will increase the price of surrounding real estate.	Bolitzer & Netusil 2000; Garrod & Willis 1991
Simulated valuation	**Contingent Valuation Method (CVM)**		It is often the only way to estimate non-use values. For example, a survey questionnaire might ask respondents to express their willingness to increase the level of water quality in a stream, lake or river so that they might enjoy activities like swimming, boating, or fishing.	Wilson & Carpenter 2000; Martin-López et al. 2007
	Choice modelling		It can be applied through different methods, which include choice experiments, contingent ranking, contingent rating and pair comparison.	Hanley & Wright 1998; Lii et al. 2004; Philip & MacMillan 2005
	Group valuation		It allows addressing shortcomings of revealed preference methods such as preference construction during the survey and lack of knowledge of respondents about what they are being asked to allocate values.	Wilson & Howarth 2002; Spash 2008

PELLY'S LAKE – MANITOBA

Background: Pelly's Lake is a 121-hectare water retention wetland system situated in the Pembina Valley near Holland, Manitoba. It was engineered in 2015 to manage water releases for flood attenuation and enable biomass harvesting of cattails.

Direct Financial Benefits (IBC, 2018):

- The direct financial benefits from the operation of Pelly's Lake are derived from the profits of cattail biomass harvesting, estimated at $**25,100 per year**.

Environmental Co-Benefits (IBC, 2018):

- Nutrient removal (phosphorus and nitrogen) = $**257,400 per year** (in 2017 dollars)
- Carbon sequestration = $**77,500 per year** (in 2017 dollars)
- Flood protection = $**89,540 per year** (in 2017 dollars)

Net Benefits (IBC, 2018):

- Total direct financial benefits and total environmental co-benefits = $**449,540 per year** (in 2017 dollars)
- Net benefits (total benefits less O&M and harvest cost of $**125,000 per year**) = $**324,540 per year** (in 2017 dollars)
- Net present value of **$3.7 million with a benefit/cost ratio of 3.64**.

Source: IBC - Insurance Bureau of Canada. (2018). *Combatting Canada's rising flood costs: Natural infrastructure is an underutilized option.* http://www.ibc.ca/on/resources/studies/natural-infrastructure-is-an-underutilized-option
See also: IISD (2019). An Application of the Sustainable Asset Valuation (SAVi) Methodology to Pelly's Lake and Stephenfield Reservoir, Manitoba, Canada: Assessing the Value of Nature-based Infrastructure. International Institute for Sustainable Development. https://www.iisd.org/system/files/publications/savi-pellys-lake-stephenfield-canada-en.pdf

OTHER KEY TERMS:
Green Infrastructure

Canadian Council of Ministers of the Environment definition:

- *"Natural vegetative systems, engineered and built features, and green technologies that collectively provide society with a multitude of economic, environmental and social outcomes."*

JOHN HIRSCH PLACE – WINNIPEG, MB

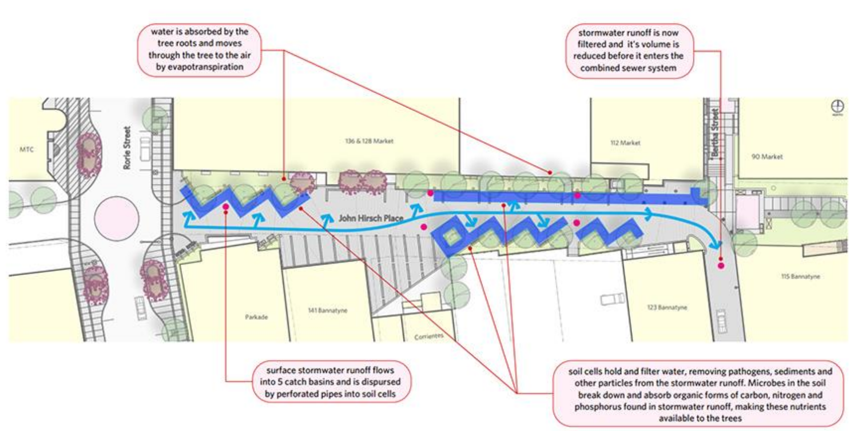
Background: John Hirsh Place in Winnipeg's historic Exchange District is the city's first Woonerf – a living street with shared space for pedestrians and back-lane traffic, incorporating a low-impact design approach to reduce stormwater runoff.

Low-impact Development Design:

- Excess surface runoff flows into 5 catch basins and is dispersed by perforated pipes into strata soil cells beneath the roadway.
- These strata cells hold and filter stormwater, removing pathogens, sediments and other particles. Microbes in the soil break down and absorb organic carbon, nitrogen and phosphorus.
- Rainwater and surface runoff is then absorbed by tree roots and removed by evapotranspiration, reducing stormwater runoff before it enters the city's combined sewer system.

Diverse Project Design Team

- A diverse design team was assembled for the project including transportation engineers, land drainage engineers, and landscape architects, blending traditional roadway improvements with innovative drainage solutions.



Source: John Hirsch Place – Winnipeg's First Woonerf. WSP Global.
Available at: https://citygreen.com/case-studies/john-hirsch-place-winnipegs-first-woonerf/