REBUILDING BETTER

A GUIDE FOR LOCAL GOVERNMENTS

LORENA POLOVINA

UBC SUSTAINABILITY SCHOLAR 2022

PREPARED FOR

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The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations.

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EXECUTIVE SUMMARY

Climate change is impacting our health and economy in unprecedented ways. Following the 2021 wildfires, heat dome, and atmospheric river floods, BC communities continue to experience the effects over a year later. When the built environment is impacted due to a climate event – be it destroyed completely or stressed to the point where it has failed or may at any moment – it can have an enormous impact on the safety and wellbeing of the community, disrupting their way of life and the systems that support them.

Current disaster recovery prioritizes short term rebuilding over long term resilience. As climate events such as heat stress, wildfires, and floods increase in frequency and duration, it is important that decision-makers shift away from short-term thinking, which typically prioritizes attempting to quickly 'return to normal' at the expense of rethinking the possible futures for communities by making buildings and infrastructure more resilient to future weather events.

In responding to the challenges and opportunities facing communities due to extreme weather events, an approach is needed which bridges emergency response, climate adaptation, and climate mitigation in the built environment. Low Carbon Resilience (LCR), which is the intersection between efforts to mitigate climate change, adapt, and reduce vulnerabilities while maximizing co-benefits to communities, serves as a strong basis for this approach.

The guide takes a holistic approach by considering how buildings, infrastructure and land use can work together to create resilient communities. The information that follows includes guidance on best practices and example policies for re-building after an extreme weather event while advancing low carbon resilient considerations, specifically in buildings, infrastructure systems such as stormwater and wastewater, and land use.

This guide emphasizes the most important decisions that will influence emissions, reduce risks, and maximize co-benefits in the built environment in a format that makes sense in both emergency recovery response and in planning to avoid the worst impacts of disasters. Existing research, policy examples, expertise and case studies have been compiled and combined with stakeholder interviews to make rebuilding in a low carbon and resilient way the easiest option when disaster strikes.

This report will help local governments:

- Understand what low carbon resilience is as it applies to buildings, stormwater and wastewater infrastructure and land use
- How to increase resilience to floods and wildfires
- What policy recommendations support LCR approaches

Icons are used to highlight recommendations, as well as resources and links to relevant organizations, policies, case studies and reports that provide further information on the topic. The icons are summarized below and recommendations are summarized on the following pages:

Recommendations *Organizations* *Case Studies* *Policy Examples* *Relevant Reports*

BUILDINGS

LEVERAGE EXISTING HIGH PERFORMANCE BUILDING EXPERTISE

Local governments can leverage high-performance building expertise by:

- ☐ Adopting higher steps of the BC Energy Step Code in their community.
- ☐ Waiving or reducing building permit fees for high performance buildings.
- ☐ Encouraging a transition to outcome-based energy targets such as Energy Use Intensity (EUI).
- ☐ Instituting a special property tax rate for buildings that achieve a certain EUI rating over a given period.
- ☐ Promoting passively designed buildings that prioritize natural ventilation.

PROMOTE RESILIENT RETROFITS

- ☐ Expedite building permits for buildings that pursue resilient retrofits
- ☐ Advocate for the creation of a resiliency guide program equivalent to EnerGuide
- ☐ Provide a clear pathway for homeowners to make their homes more energy efficient and resilient. One interviewee noted that many homeowners are aware of energy efficiency grants but do not seek them out because they are time consuming to find and apply for.
- ☐ Consider concierge-style program offerings to assist residents and businesses in taking the steps needed to undertake resiliency retrofits, while also increasing industry capacity to do so
- ☐ Require that resiliency measures are installed during maintenance or renovation projects in community-owned buildings

CONSIDER RESILIENCY WHEN SITING BUILDINGS

- ☐ Identify south-facing development sites that have minimal obstruction blocking access to sunlight and provide opportunities for planting trees and shrubs to control solar gain
- ☐ Design subdivisions that cluster buildings, retain existing vegetation and natural areas – for carbon storage and GHG reduction – and maximize infrastructure use.
- ☐ Locate important buildings on higher ground away from flood-prone zones
- ☐ Orient buildings towards prevailing winds to maximize natural ventilation. This must be balanced against solar gains.

LOW CARBON MATERIALS

Local governments can support the incorporation of low carbon materials by implementing policies that:

- ☐ Encourage materials which are sourced close to the site of construction. This has the added benefits of supporting the local economy and reducing transportation emissions.

- ☐ Promote carbon-storing materials and strategies that contribute even further to meeting carbon-neutral goals by 2030
- ☐ Require rain-screened assemblies for regions that see high precipitation
- ☐ Support manufacturing practices that promote the production of new region-specific biogenic materials (e.g., fiber and purposefully-grown materials)
- ☐ Facilitate economic opportunity zones pairing agriculture residue products with materials manufacturing

DESIGN FOR EASE OF REPAIRS

Local governments can promote ease of repairs in buildings by requiring both new construction and 'substantial improvement' projects to:

- ☐ Be constructed with materials and utility equipment resistant to flood damage, using methods and practices that minimize flood damage;
- ☐ Elevate the lowest floor, including the basement, two feet above the base flood elevation, and two feet above the highest adjacent grade for certain high-risk zones;
- ☐ Floodproof nonresidential construction two feet above the base flood elevation so that the structure is watertight, with structural components capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy; and
- ☐ Design fully enclosed, non-basement areas below the lowest floor used solely for vehicle parking, building access, or storage and that are subject to flooding to automatically equalize hydrostatic flood forces on exterior walls by allowing the entry and exit of floodwater.

CONSIDER WATER DESIGN AS A RESILIENCY MEASURE

Local governments can encourage resilient water systems by:

- ☐ Creating incentives and removing barriers for relatively low-cost, but high-impact water efficiency and net zero water strategies
- ☐ Promote the use of lower-technology and lower-cost but high-benefit strategies like greywater reuse, rainwater capture, and high water efficiency fixtures whenever possible
- ☐ Consider incentives for mixed-use buildings and neighbourhoods that can balance greywater creation and use

PLAN FOR ALTERNATE USE CASES FOR EXISTING PUBLIC BUILDINGS

- ☐ Considering how existing public building stock can functionally operate in an emergency. Some examples of this are:
  - Arenas can function as emergency shelters
  - The fire station/city hall can house an emergency operations centre
  - Libraries can function as cooling centers in heat event (many local governments already do this)
- ☐ Ensure that the designated emergency-use area has capacity for additional heat/cool/water demands when volumes of people increase

- ☐ Consider installing a large kitchen in public buildings to serve an increased number of people
- ☐ Conduct emergency scenario planning when designing a new building. Some examples are:
    - Make sure critical IT infrastructure is not located in a basement in a flood-prone area
    - Design a fire-proofed part of the building that keeps important records/sets of keys etc.
- ☐ Create a plan for how donations will be received, sorted, and stored.
- ☐ Ensure there is enough storage for emergency needs or consider which rooms can serve as storage spaces.

SUPPORT ADOPTION OF INNOVATIVE MATERIALS AND CONSTRUCTION METHODS

Local governments can promote the implementation of innovative materials and construction methods by:

- ☐ Considering building demonstration projects for affordable housing and community center structures
- ☐ Prioritize permitting for impactful prototype projects

INFRASTRUCTURE

LEVERAGE NATURAL ASSETS AND INCORPORATE GREEN INFRASTRUCTURE

Local governments can leverage natural assets and incorporate green infrastructure by:

- ☐ Set up performance objectives for improving the resilience of infrastructure systems, rather than taking a prescriptive approach.
- ☐ Consider delivering services such as wastewater treatment through engineered wetlands that can also treat wastewater. See the Omega Center for Sustainable Living Case Study in Appendix C.
- ☐ Designing parks, bioswales, and permeable pavement/sidewalks to act as bioretention areas during heavy rain events
- ☐ Adding to the urban forest (treed ecosystems within urban areas) by creating or expanding wooded areas and parks and planting street trees. Enhance the natural green network by increasing the quantity, density and diversity of trees.
- ☐ Planting trees in trenches rather than in large underground containers so trees live longer and grow larger as they mature.

CONSIDER ALL ASPECTS OF SITE DESIGN IN INFRASTRUCTURE PLANNING

- ☐ Understand the local conditions of a place by looking at natural phenomena such as wind direction, local plants, sun exposure, etc.. to inform the site layout.
- ☐ Orient buildings towards the south, with the longer axis running east-west. A southern building orientation is ideally achieved on south-facing lots with minimal obstructions that can block solar access (sun/shade analysis can identify the impact of obstructions).
- ☐ Use deciduous trees on the southern and western-facing side of a building to maximize the warming effect of solar radiation in winter months and the cooling effect of shade in summer months.
- ☐ Locate coniferous trees so they block winter winds without blocking solar gain. The north face of the building is particularly suitable for this.
- ☐ Avoid storm damage to buildings and structures by planting low, shrub-like trees or hedges near buildings and taller trees farther away.

LAND USE

ZONING FOR COMPACT COMMUNITIES

- ☐ Increasing density in areas that are less prone to natural disasters
- ☐ Increase zoning for mixed use development, which increases walkability, access to amenities and diverse transportation modes such as cycling (reducing vulnerabilities if roads are cut off, fuel supplies are low, etc.)
- ☐ Encourage densifying single family lots by removing barriers to constructing duplexes and laneway homes
- ☐ Implement setback relaxations for buildings that have thicker, more insulated walls
- ☐ Concentrate growth in small areas to reduce the impact on existing natural areas and reduce servicing costs (consider reducing DCCs).
- ☐ Encourage the use of small lots where single-family developments are being considered
- ☐ Create/ update existing policies that support compact subdivision development.

PROTECT NATURAL ASSETS & PROMOTE CREATION OF NEW NATURAL AREAS

Local Governments can improve their natural assets and reduce risk to disasters by:

- ☐ Establish urban growth boundaries to maintain land conservation
- ☐ Naturalize rivers and streams to increase resilience to floods and heat events
- ☐ Construct inland wetlands, bioswales, and urban watersheds to slow down stormwater
- ☐ Encourage climate-appropriate and fire-smart vegetation to reduce water use and the possibility of additional fuels
- ☐ Consider possibility of using a constructed wetland to treat wastewater, which might be a suitable solution for a small community. See Case Study 1.

INCREASE TREE COVER AND GREEN SPACES IN URBAN AREAS

- ☐ Preserve and increase urban tree canopies and green spaces to reduce ambient temperatures and provide air filtration
- ☐ Increase park designations and dedications, maintain wildlife and greenspace corridors, and ensure access to shaded natural outdoor spaces in all parts of the community
- ☐ Create naturalized pollinator meadows on managed lands
- ☐ Educate residents on benefits of 'xeriscaping' or low water use landscaping techniques to minimize and/or eventually eliminate the need for irrigation.
- ☐ Lead by example by planting native or naturalized species and drought resistant plants on community-owned buildings
- ☐ Use low-maintenance, salt-tolerant species along streets, sidewalks, and other public spaces

INCREASE RESILIENCE TO FIRES

Local governments can support wildfire prevention through the following policies:

- ☐ Proactively reduce wildfire risk in publicly-owned interface areas through fuel removal and/or prescribed burning programs
- ☐ Leverage existing grants to restore forests proactively following a wildfire
- ☐ Support efforts that promote using forest byproducts
- ☐ Reduce barriers to prescribed burning permits

INCREASE RESILIENCE TO FLOODS

Local governments can promote the use of Nature-based Solutions for flood mitigation through implementing policy that:

- ☐ Renaturalizes shorelines and floodplains in areas where development has already occurred
- ☐ Prioritizes interconnected natural water infiltration and attenuation systems over hard infrastructure, and/or considers hybrid solutions
- ☐ Provides for multi-purpose spaces, whereby overland waterflows can purposefully be directed to a natural area during peak times, and recede leaving a park area available for community use
- ☐ Increases urban green spaces and tree cover
- ☐ Streamlines permitting processes for Nature-based Solutions so that projects are considered and prioritized over engineered-asset approaches
- ☐ Limits steep slope development and minimizes risk of landslides following heavy rainfall or snowmelt by planting stabilizing species of trees, redirecting waterflows, etc.

RELOCATION

Local governments can consider the following policy suggestions during a relocation:

- ☐ Move smallest homes for lighter footprint on infrastructure.
- ☐ Consider deep energy retrofits for houses that are moved. For example, investing in an insulated foundation can lead to significant energy savings for homeowners.
- ☐ Consider district energy use such as geothermal heat pumps, which are more applicable in a larger, district wide setting.
- ☐ Locate important buildings on higher ground away from flood-prone zones

DEFINITIONS

Climate Adaptation

Climate change adaptation refers to actions that reduce the negative impact of climate change, while taking advantage of potential new opportunities. It involves adjusting policies and actions because of observed or expected changes in climate[1]. It involves accepting that climate and weather conditions are changing, understanding what that means in a local and regional context, and preparing accordingly.

Climate Mitigation

Climate change mitigation means avoiding and reducing the factors that contribute to climate change and extreme weather impacts, such as emissions of heat-trapping greenhouse gases into the atmosphere. Addressing other factors contributing to these impacts such as biodiversity loss, deforestation, and ocean acidification may also be considered within this definition.

Hard approaches

Wastewater and stormwater infrastructure that involves engineered solutions such as dikes, culverts, groynes, seawalls, revetments; also known as grey infrastructure[2].

Low Carbon Resilience

Low Carbon Resilience (LCR) is the deliberate design and use of techniques, methods, policies, and technologies to both reduce greenhouse gas emissions and adapt our infrastructure and society to future climate scenarios. LCR focuses on opportunities to reduce vulnerabilities while maximizing co-benefits of actions, such as improving biodiversity, reducing traffic congestion, and creating jobs.

Nature-based solutions

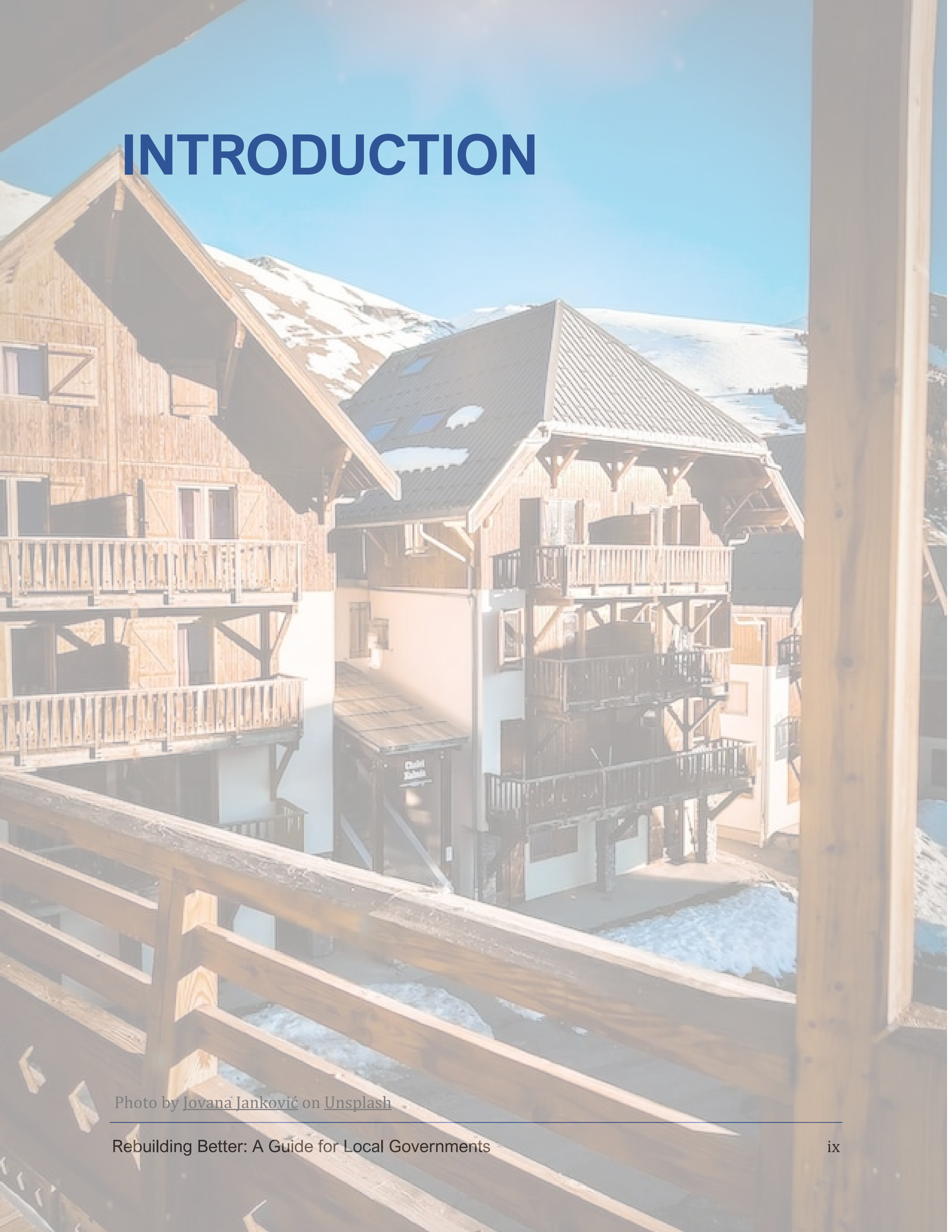
Nature-based solutions are approaches that use nature and natural processes for delivering infrastructure services, and integrative solutions to meet the rising challenge of urban resilience[3].

Soft approaches

Wastewater and stormwater infrastructure that prioritize working with natural systems to deliver infrastructure services and increase resilience to extreme weather events; Can be used interchangeably with *nature-based solutions* (see above).

[1] Natural Resources Canada. 2022. *What is climate change adaptation?*
[2] CSA Group. 2021. *Nature-based Solutions for Coastal and Riverine Flood and Erosion Risk Management*
[3] The World Bank. 2021. *A Catalogue of Nature-Based Solutions*

INTRODUCTION



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INTRODUCTION

Buildings foster community, provide shelter, facilitate work, and inform infrastructure networks such as roads, energy. and sewers; they are the links to the places where we live, work, and play.

Climate change is impacting our health and economy in unprecedented ways. Following the 2021 wildfires, heat dome, and atmospheric river floods, BC communities continue to experience the effects over a year later. Climate events, both singular and cumulative, has a significant impact on the built environment, particularly buildings and infrastructure. Buildings foster community, provide shelter, facilitate work, and inform infrastructure networks such as roads, energy. and sewers; they are the links to the places where we live, work, and play.

When the built environment is impacted due to a climate event – be it destroyed completely or stressed to the point where it has failed or may at any moment – it can have an enormous impact on the safety and wellbeing of the community, disrupting their way of life and the systems that support them. Communities become separated as people relocate, either temporarily or permanently; goods may stop flowing or be in short supply; and immediate safety measures take priority. All of this hampers a community's ability to move to recovery and increase the challenges of rebuilding after the event has passed. The recovery process is slow and arduous in the best of times, and has recently been made all the more challenging by disrupted supply chains, the ongoing pandemic, and political turmoil.

Amidst the challenge of addressing immediate risks and harms to community members, climate events provide an opportunity to make communities more resilient to future weather events and improve their short- and long-term outcomes. The value of a low carbon resilient (LCR) approach is reducing vulnerabilities while maximizing co-benefits of actions, such as improving the thermal climate of a neighbourhood, reducing combined sewer overflows, and creating jobs.

The information that follows includes guidance on best practices and example policies for re-building after an extreme weather event while advancing low carbon resilient considerations, specifically in buildings and the infrastructure systems that support them. This guide emphasizes the most important decisions that will influence emissions, reduce risks, and maximize co-benefits in the built environment in a format that makes sense in both emergency recovery response and in planning to avoid the worst impacts of disasters. Existing research, templates, and expertise has been compiled and combined with stakeholder interviews to make rebuilding in a low carbon and resilient way the easiest option when disaster strikes.

OVERVIEW

What this report covers

Geography: The report is geared for local governments throughout British Columbia faced with rebuilding/ relocating following a climate event and/or for local governments who want to make their communities more resilient. Much of the information included can be applied to other jurisdictions.

Building Types: The focus is on local government buildings, which a given community has greatest control over; however, many of the strategies here can also be applied to residential and commercial buildings.

Infrastructure Types: The focus is on stormwater infrastructure, particularly on green rainwater infrastructure types and suitability.

Policy: The information provided is intended to guide updates to local government policies and decision-making frameworks on land use, infrastructure planning, and building regulations, in order to increase local and regional resilience during extreme weather events and the recovery following them while also reducing future risks.

Climate Change Projections: The report recommends preparing for a global temperature range increase of 3.3-5.9 degrees, which is a worst-case scenario described by Representative Concentration Pathway (RCP) 8.5. [4]

Methodology

The report is divided into the following sections:

- Buildings
- Stormwater Infrastructure
- Land Use
- People

In order to inform decision-making, it is important that communities first understand their risks and then prioritize accordingly; as such, the guide reviews climate risks and climate data. The guide discusses features and strategies that make buildings more resilient to natural disasters, adopting a broad view, by also considering how infrastructure and land use influence the resilience of a community. Many of the strategies outlined in the guide work in tandem with each other to provide co-benefits.

Lastly, the guide touches on challenges and recommendations with the people aspect of rebuilding. While the social impact of rebuilding was originally out of scope, nearly all interviewees touched on

[4] IPCC. 2014. *Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Core Writing Team, R.K. Pachauri and L.A. Meyer, eds. IPCC, Geneva, Switzerland: IPCC. Available at https://www. ipcc.ch/report/ar5/syr/.

the social challenges that face communities when disaster strikes. Their challenges and recommendations are highlighted in the People section.

What this report will help you do

This report will help local governments:

- Understand what low carbon resilience is as it applies to buildings, stormwater and wastewater infrastructure and land use
- How to increase resilience to floods and wildfires
- What policy recommendations support LCR approaches

What is out of scope

The following items are out of scope:

- Research that falls out of BC (unless referencing a case study, policy example or relevant research)
- Topics that fall outside of built environment (exception for land use planning, stormwater infrastructure and wastewater infrastructure as it relates to the built environment)
- Emergency Management Procedures (how we communicate during a disaster)
- Transportation (escape routes, materials for transportation)
- River bank improvement (unless discussing risk and vulnerability against disasters)
- Considerations outside the sphere of influence of local governments (unless discussing implementation strategies that might be helpful for operational staff)

CASE FOR ACTION

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THE CASE FOR ACTION

It is estimated that for every dollar spent on disaster mitigation, $6 are saved in recovery costs.

Current disaster recovery prioritizes short term rebuilding over long term resilience. As climate events such as heat stress, wildfires and floods increase in frequency and duration, it is important that decision-makers shift away from short-term thinking, which typically prioritizes attempting to quickly 'return to normal' at the expense of rethinking the possible futures for communities by making buildings and infrastructure more resilient to future weather events and reducing future harm.

In a rebuild scenario, it is also tempting to build higher and stronger, such as by raising dikes to protect against floods; however, this can have adverse effects. With increased dike heights, the flood risk also grows because water surges with greater force, resulting in a greater number of casualties and economic damage.[5] The materials used to construct the dikes may also be carbon-intensive (such as cement), contributing to further climate risks. Further, the most recent surge levels may not be indicative of future event extremes and additional analysis on design thresholds may be required. These factors must be considered when planning to repair or replace buildings and their associated infrastructure.

Understanding how to best prioritize disaster resiliency efforts is challenging; however, taking no/limited action still presents risks for communities. It is estimated that for every dollar spent on disaster mitigation, $6 are saved in recovery costs.[6] Although it is often difficult to appreciate the benefits of disaster mitigation until after the disaster passes, integrating low carbon resilient measures into both the planning and recovery phases provides communities with a multitude of benefits: reduced short- and long-term costs and risks; improved health outcomes for residents; and not least of all, the peace of mind knowing that they are better prepared in the event of a disaster.

SOCIAL IMPACTS

The social impacts of disasters, such as dealing with traumatized residents and a traumatized workforce, was a key recovery challenge noted during stakeholder interviews. Disasters can exacerbate ongoing social challenges, and they affect vulnerable populations disproportionately. Some of the social impacts that have resulted from extreme weather events include: increased

[5] Zevenbergen C., et al. (2013). *Tailor made collaboration: A clever combination of process and content.* https://www.un-ihe.org/sites/default/files/13270-rvdr-brochure-governance-engels_def-pdf-a.pdf
[6] PEW Trusts. 2018. *Every $1 invested in disaster mitigation saves $6.* https://www.pewtrusts.org/en/research-and-analysis/articles/2018/01/11/every-$1-invested-in-disaster-mitigation-saves-$6

mental health issues, alcohol misuse, domestic violence, chronic disease, and short-term unemployment.[7]

A report by the global management firm Deloitte, estimated social costs associated with the Black Saturday Bushfires in Australia were larger than the financial costs – at least $3.9 billion in social impacts and $3.1 billion in direct financial impacts.[8]

There were 619 deaths in the 2021 heat dome, many attributed to a lack of in-building cooling, which incapacitated the Lower Mainland paramedic service and had a wider impact on the health care system during that time.[9]

ENVIRONMENTAL IMPACTS

Natural disasters such as wildfires, floods, and tornadoes often greatly upset natural ecosystems, significantly disrupting mammal and marine life habitats, defoliating forests, and causing other types of structural changes to ecosystems such as riverbank or foreshore erosion; endangered species are especially vulnerable when habitat is destroyed.

Water quality is impacted when sewage treatment facilities flood or debris enters reservoirs and waterways, creating risks and harm for resident and migratory species. Wildlife can be killed by the force of the disaster or impacted indirectly through changes in habitat and food availability. Each of these impacts can dramatically change the ecosystem balances within a given area for many years, affecting plant and animal life and potentially changing the long-term biodiversity of an area.[10]

In the 2021 atmospheric rivers event, livestock could not be transported safely out of the impacted regions, which also puts pressure on farmers.

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[7] Victorian Council of Social Service (VCOSS). 2016. *The social impact of natural disasters – at what cost?* *https://vcoss.org.au/emergency-management/2016/03/the-social-impact-of-natural-disasters-at-what-cost/*

[8] Deloitte Access Economics. 2016. *The economic cost of the social impact of natural disasters.* http://australianbusinessroundtable.com.au/assets/documents/Report%20-%20Social%20costs/Report%20-%20The%20economic%20cost%20of%20the%20social%20impact%20of%20natural%20disasters.pdf

[9] BC Coroners Service. 2022. *Extreme heat and human mortality: A review of heat-related deaths in B.C. in Summer 2021* https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/extreme_heat_death_review_panel_report.pdf

[10] SWCA. 2017. *After the storm : The environmental impacts of natural disasters.* https://www.swca.com/news/2017/11/after-the-storm-the-environmental-impacts-of-natural-disasters#:~:text=Pollutants%20from%20flooded%20industrial%20sites,of%20structural%20changes%20to%20ecosystems.

ECONOMIC IMPACTS

Extreme weather events place enormous pressure on economic systems, both because of physical damage as well as lost revenue for businesses. The atmospheric river floods washed out the Coquihalla highway, stranding people for days and impacting shipment deliveries. Some of the economic impacts from recent extreme weather events are summarized below:

- Cost of Canadian wildland fire protection has increased from $800 to $1.4 billion over the last 10 years[11]
- $416 million in disaster funding from homes lost in 2021 BC wildfires.[12]
- Communities in the Lower Mainland have identified over $3 billion in dike and flood protection upgrades to prepare for climate change[13] [14]
- By mid-2020, insured catastrophic losses in Canada reached $1.8 billion. The average residential flood loss was $41,000.[15]
- Federal and provincial governments spend $600 million in annual disaster assistance payments related to flooding[16]

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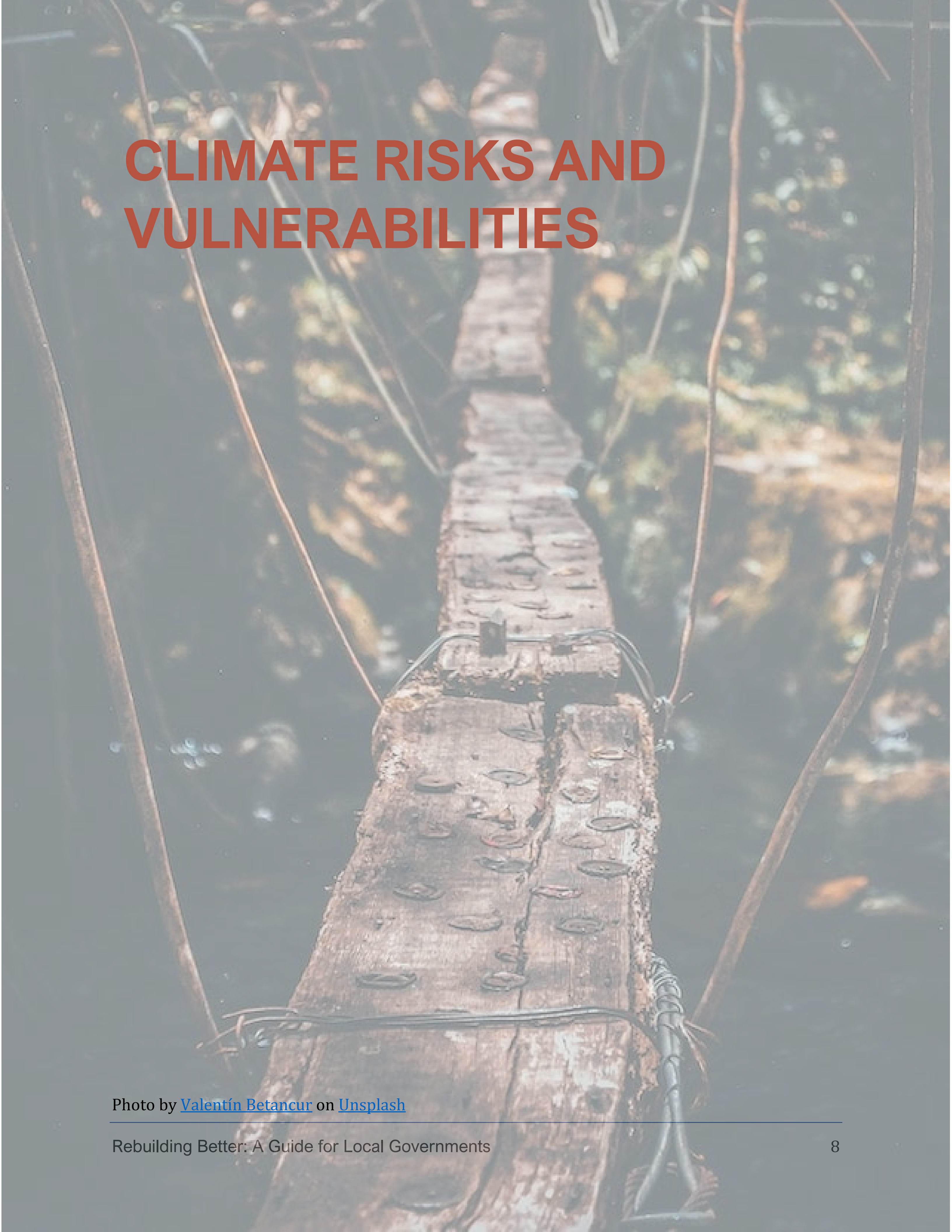
[11] Natural Resources Canada. 2021. *Cost of wildland fire protection* https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/forest-change-indicators/cost-fire-protection/17783
[12] Vancouver Sun. 2022. *$416 million in disaster funding comes through for homes lost in B.C. wildfires* https://vancouversun.com/news/local-news/disaster-funding-for-homes-lost-in-bc-wildfires
[13] Vancouver Sun. 2021. *B.C needs billions in dike upgrades to prepare for climate change* https://vancouversun.com/news/b-c-needs-billions-in-dike-upgrades-to-prepare-for-climate-change
[14] CBC News. 2022. *Abbotsford approves proposal to overhaul flood mitigation systems in city.* https://vancouversun.com/news/b-c-needs-billions-in-dike-upgrades-to-prepare-for-climate-change
[15] IBC. 2020. *Task force for a resilient recovery.* https://www.recoverytaskforce.ca/wp-content/uploads/2020/08/IBC-Resilient-Retrofit-Proposal_2pgr_17Aug-2020.pdf
[16] ibid



CLIMATE RISKS AND VULNERABILITIES

Photo by Valentín Betancur on Unsplash

CLIMATE RISKS AND VULNERABILITIES

FUTURE CLIMATE DATA

As a vast province with widely varying climates from coastal rainforests to deserts, BC will experience a range of climate change effects. Climate scientists predict that by the 2050s, many regions across BC can expect the following changes in the coming decades, including:

- Warmer temperatures year-round
- Hotter summers, which will be more pronounce for communities located in the bottom of valleys
- Warmer winter temperatures and less snow, particularly for Northern BC
- Increased precipitation across all seasons except summer
- Increased duration of growing season for areas such as the Okanagan[17]

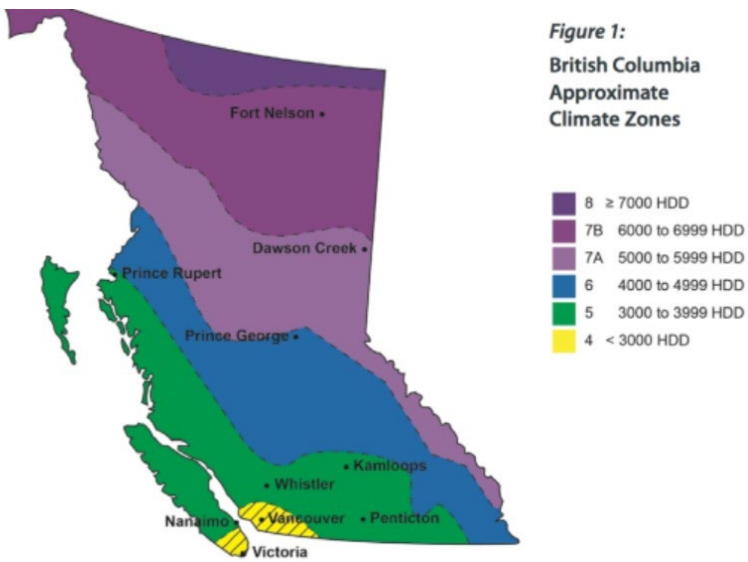


Figure 1 British Columbia Climate Zones (Source: Energy Efficiency Requirements for Houses in British Columbia)

Predicting human activity and their resulting future GHG emissions is challenging, which is why the Intergovernmental Panel on Climate Change (IPCC) has characterized multiple possible scenarios. The scenarios have associated Representative Concentration Pathways (RCPs), which represent a greenhouse gas (GHG) concentration trajectory. RCP 2.6 shows the best-case scenario if carbon

[17] Pinna Sustainability. 2020. Climate Projections for the Okanagan Region https://www.rdos.bc.ca/assets/PLANNING/AreaX/2020/ClimateProjections/FinalReport.pdf

emission targets under the Paris Agreement are reached, and RCP 8.5 is the worst-case "business-as-usual" scenario.[18]

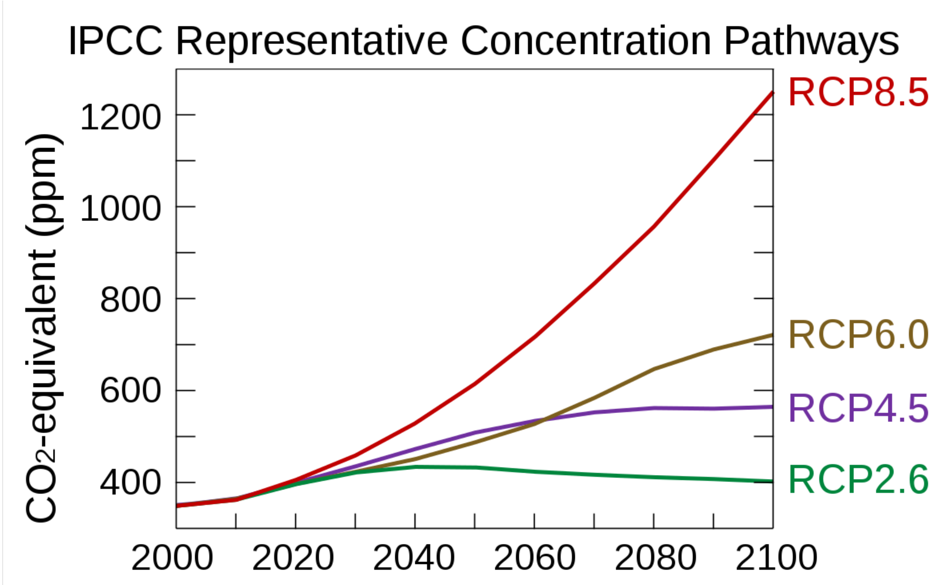


Figure 2 IPCC Representative Concentration Pathways (Source: Fifth IPCC Assessment Report)

Many jurisdictions within BC are adopting the worst-case climate scenario (RCP 8.5), which describes a local temperature range increase between 3.3 to 5.9°C, as a benchmark for adaptive design; buildings and infrastructure designed to this standard can be expected to remain functional at year 2100 conditions and would have an extended functional service life beyond 2100 if a better-than-worst-case scenario occurs.

[18] IPCC. 2014. *Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Core Writing Team, R.K. Pachauri and L.A. Meyer, eds. IPCC, Geneva, Switzerland: IPCC. Available at https://www. ipcc.ch/report/ar5/syr/.

CLIMATE RISKS

Warmer temperatures year-round will reduce heating demand in the winter months, and could lead to summer cooling demand outpacing winter heating demand in the coming decades.[19] This will result in shifting energy costs, and increased peak energy requirements during the summer months. In valley bottoms that currently experience the warmest temperatures and will continue to, the inefficient building stock will likely lead to increased energy use for cooling, high costs for those with cooling, and increased risks to vulnerable people who do not have access to cooling or cannot afford to utilize it. Future heavy rains are likely to cause an increase in storm and flood damage to buildings, and when combined with additional energy costs and vulnerabilities of increased heat, will likely cause economic stress to property owners and residents.

Figure 3 Climate Risks (Source: Climate Projections for the Okanagan Region)

While current buildings are not well prepared to address current or future climate-related challenges, for the most part, new buildings are also not being designed to perform efficiently in the future climate. This further limits the ability of local governments to buffer themselves from increasing heat waves, compromised air quality, and expected water shortages. This issue, along with the increased awareness of the intrinsic and economic value of preserving agricultural lands and natural areas, is sure to be exacerbated as development pressures increase to accommodate population growth and more climate-related migration.

There is also a risk arising from the likelihood that in many jurisdictions, these events will come in greater frequency and duration. This may leave some communities in a continued state of recovery, compounding problems and leading to fatigue of those involved in decision-making and implementation efforts. One interviewee raised a concern that with more frequent events people will become desensitized and lose compassion for each other.[20]

[19] Pinna Sustainability. 2020. Climate Projections for the Okanagan Region https://www.rdos.bc.ca/assets/PLANNING/AreaX/2020/ClimateProjections/FinalReport.pdf
[20] Personal Interview. June 30, 2022. Name Withheld.

RELIABLE DATA SOURCES

For reliable data sources on how future climate projections will affect their region, local governments can use the following resources:

- Climatedata.ca provides high-resolution climate data to help decision makers build a more resilient Canada.
  - Local governments can explore climate impacts by Location (City/Town), Variables (such as Cooling Degree Days) and Sector (Transportation, Health etc…)
  - They provide educational resources on how to use climate scenarios for decision-making purposes
  - Climate modelling for RCPs 2.6, 4.5 and 8.5.
- Pacific Climate Impacts Consortium is a regional climate service centre at the University of Victoria that provides practical information on the physical impacts of climate variability and change in the Pacific and Yukon Region of Canada. Via their website, local governments can access a variety of tools and sources of climate information:
  - Data Portal that allows you to download various weather data such as BC station data, weather files, among others.
  - Analysis tools to understand climate variability
  - All publications published by PCIC
  - Software used for climate data interpretation

LOW-CARBON RESILIENCE IN THE BUILT ENVIRONMENT

In responding to the challenges and opportunities facing communities due to extreme weather events, an approach is needed which bridges emergency response, climate adaptation, and climate mitigation in the built environment. Local governments can mitigate the risk of a disaster before one happens and utilize tools in the middle of responding to a disaster to maximize the positive outcomes of each action they take.

Low Carbon Resilience (LCR) – the intersection between efforts to mitigate climate change, adapt, and reduce vulnerabilities while maximizing co-benefits to communities – serves as a strong basis for this approach. Application of a LCR framework can take many forms, including using nature-based solutions, but is based in the application of a lens that considers all these factors together in decision-making. This holistic, integrated, system-level approach considers the system being designed as an interconnected whole which is also part of something larger, to create solutions that benefit both human needs and the environment.

Typical resilience measures focus on the hardening of buildings and infrastructure (e.g., by thickening walls, increasing the height of dikes, etc.). While these solutions are valid and serve their purpose, they often also promote a negative feedback loop. Defensive building approaches often use high-carbon solutions (such as concrete sea walls) and work against natural systems; this approach results in less resilient social systems, services, and communities, and increases the costs of repairing them in future.[21] A LCR approach differs because it expands on existing services provided by nature, to plan for both community and ecosystem resilience under climate change, while also limiting further contributions to climate change during the implementation of the resilience measures.

[21] Policy Options. 2022. *Build back softer* *https://policyoptions.irpp.org/magazines/january-2022/build-back-softer/*

BUILDINGS

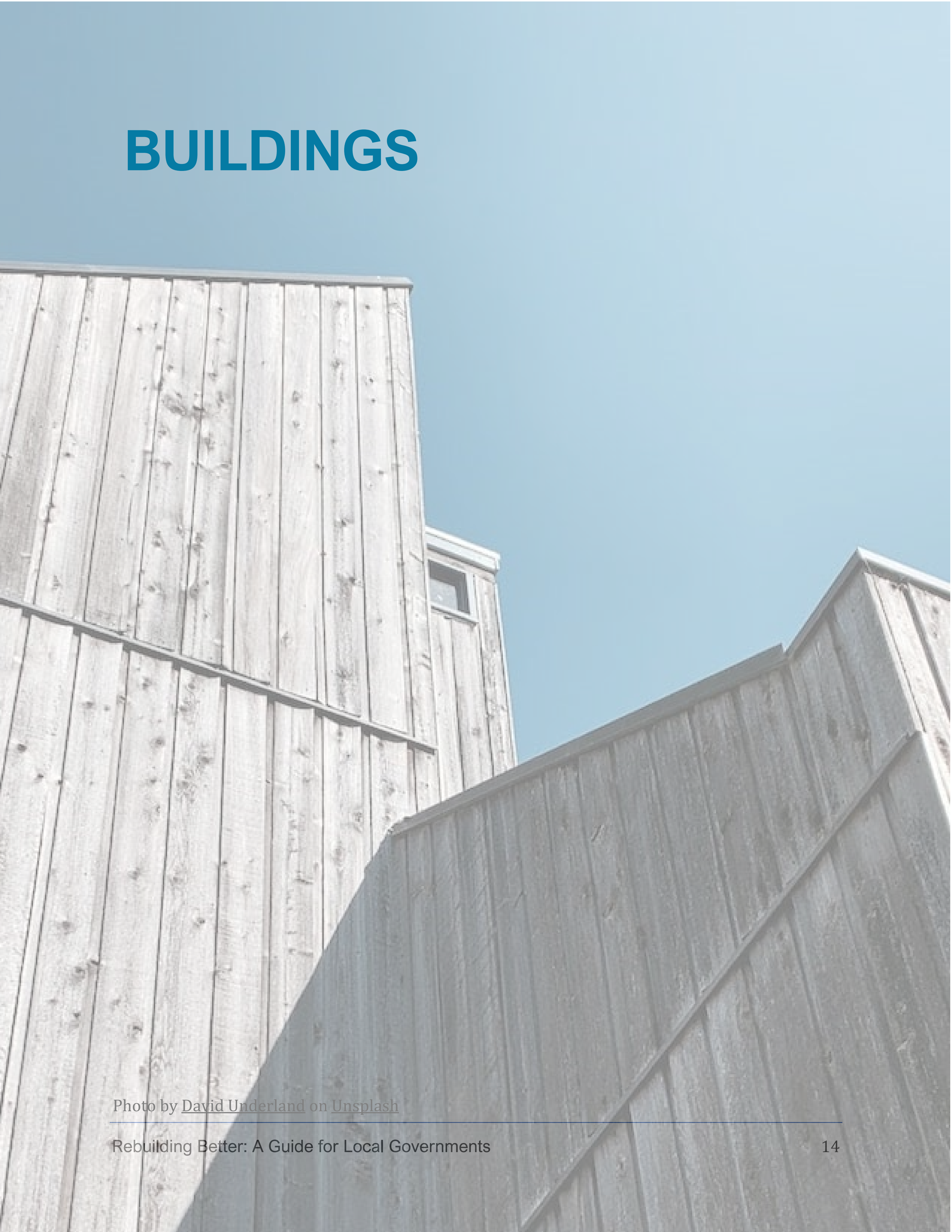


Photo by David Underland on Unsplash

BUILDINGS

When a building is designed resiliently, buildings provide shelter and a sense of safety during extreme weather events, which allow people to shelter in place.

INTRODUCTION

Buildings reflect our values and are central to human civilization. When a building is designed resiliently, buildings provide shelter and a sense of safety during extreme weather events, which allow people to shelter in place. Local governments are responsible for public buildings, which can act as emergency shelters during extreme weather and house critical infrastructure key to maintaining core services residents need. Residents also look to local governments for advice on what to during extreme weather events and rely on local jurisdictions to guide them during rebuilding or relocation scenarios.

A key concept in resilient building design is Passive Survivability, which is about "maintaining liveable conditions in the event of extended loss of power or interruptions in heating fuel".[22] This is useful during an extreme weather event since it allows people to shelter in place. Designing homes for passive survivability during a rebuilding scenario increases resilience to future weather events.

CHALLENGES

Much of the current building stock is not designed for extreme weather events, which can adversely affect the occupants' health and wellbeing. In British Columbia alone, 619 people died due to causes attributable to the 2021 heat dome, and many of the people who died were found in their homes without proper ventilation and cooling[23]. Extreme weather disproportionately affects vulnerable people, such as children, the elderly, and people with disabilities – these groups also tend to live in buildings with the least sustainability and resiliency features (passive cooling, air sealing, adequate ventilation, sump pumps, etc.).

Some of the challenges facing today's buildings as a result of changing climate conditions are:

- Increased energy demand during hot and cold weather events can lead to power outages, making buildings unoccupiable and potentially life threatening
- Overheating during heat waves leads to health, comfort, and safety impacts to occupants
- Air quality issues during fire and smoke events; inadequate ventilation
- Groundwater infiltration affecting foundations
- Increased numbers of pests as habitable seasons extend, natural habitats are lost, and extreme weather drives them to seek shelter

[22] Green Building Advisor. 2008. Making houses resilient to power outages. https://www.greenbuildingadvisor.com/article/making-houses-resilient-to-power-outages

[23] BC Coroners Service. 2022. *Extreme heat and human mortality: A review of heat-related deaths in B.C. in Summer 2021* https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/extreme_heat_death_review_panel_report.pdf

Two interviewees noted that damaged buildings can also present additional health hazards. Some building materials release toxic fumes when they are burned in a fire. If an older building contains asbestos and is damaged in a disaster, the disturbance of those materials becomes a health issue.

Interviewees also noted the pressure following a disaster to rebuild quickly and 'resume life as before', although some interviewees also noted that if structural issues were a concern (such as being in a landslide prone area), not everyone wanted to rebuild in the same way or in the same place. Some interviewees noted a spirit of innovation in their community that encourages sustainable building, which could be harnessed to consider how to rebuild in a low carbon and resilient way through pre-disaster planning, or during post-disaster recovery if the community were willing to undertake that kind of process.

Most interviewees noted a low level of knowledge within their community regarding resilient buildings and infrastructure. One interviewee pointedly said that most homeowners would rather prioritize a kitchen renovation over resiliency measures. Changing these perceptions of value and priority is challenging at the best of times, but in some cases a disaster recovery scenario can be a conduit to explore new opportunities for a community, rather than a time of further entrenchment in old ways of thinking.

RECOMMENDATIONS

Homes, schools, public buildings, and neighbourhoods should be designed and built (or rebuilt) to serve as livable refuges in the event of crisis or breakdown of energy, water, and/or sewer systems - this is called Passive Survivability.

Climate change means that our buildings need to change. There are many ways to design buildings that are low carbon and resilient, and the most appropriate options are dependent on local circumstances. The key universal concepts are designing for optimal thermal comfort with reduced energy demand, while using healthy, low carbon materials.

Nearly all interviewees stated that they consider resilient buildings to be very important to the community. Buildings that can withstand more stress from extreme weather will fail less often. Building with climate change considerations as the top design priority is proactive and can save local governments from needing to complete more expensive and disruptive retrofits in the future.

Homes, schools, public buildings, and neighbourhoods should be designed and built (or rebuilt) to serve as livable refuges in the event of crisis or breakdown of energy, water, and/or sewer systems - this is called *Passive Survivability*. Power outages are common during disasters, either from storm disruptions or an overloaded electrical system during heat waves and cold spells, and a building without power can quickly become uninhabitable. However, energy efficient buildings experience less heat transfer during a power outage because they are better insulated, which means they can be occupiable for longer periods even without electricity.[24]

LEVERAGE EXISTING HIGH PERFORMANCE BUILDING EXPERTISE

A high-performance building is more resilient by design as they allow for passive survivability. It is important to note that high performance building design is not just about fancy mechanical equipment. Through passive cooling design, high performance buildings can eliminate the need for air conditioning using thermal mass, shading, and natural ventilation.

The Province of British Columbia is already creating design expertise in energy efficient building design through the implementation of the BC Energy Step Code. Organizations such as Passive House Canada, the Carbon Leadership Forum, and the Zero Energy Building Exchange are also increasing industry capacity and knowledge related to energy efficiency, low carbon operations, reducing embodied carbon, and integrating resiliency.

Many local governments in BC have already adopted the Energy Step Code, which is a section of the BC Building Code that local governments may use to require or incentivize better-than-code energy performance in new construction, and all local governments will be required to reference the lower steps (minimum 20% more efficient than the building code) by the end of 2022. Local governments can use the BC Energy Step Code to ensure new buildings are energy efficient, while pairing it with policies that reduce or eliminate emissions from space and water heating. The Climate Leaders Playbook discusses building retrofits and the Energy Step Code in further detail and provides excellent examples for strategies and policy inspiration.

Local governments can leverage high-performance building expertise by:

- ☐ Adopting higher steps of the BC Energy Step Code in their community.
- ☐ Waiving or reducing building permit fees for high performance buildings.
- ☐ Encouraging a transition to outcome-based energy targets such as Energy Use Intensity (EUI).
- ☐ Instituting a special property tax rate for buildings that achieve a certain EUI rating over a given period.
- ☐ Promoting passively designed buildings that prioritize natural ventilation.

Resources on Leveraging High Performance Building Expertise

Mobilizing Building Adaptation and Resilience

Mobilizing Building Adaptation and Resilience is a multi-year, multi-stakeholder knowledge and capacity building project led by BC Housing, with participation and contribution from over 30 organizations, including: national, provincial, and local agencies; and industry partners.

[24] Urban Green Council. 2014. *Baby It's Cold Inside* https://www.urbangreencouncil.org/babyitscoldinside

BC Energy Step Code

The BC Energy Step Code website is a resource that helps local governments, industry, and other stakeholders more effectively use the BC Energy Step Code. It is hosted by the Province of British Columbia, with support from the Energy Step Code Council.

Zero Energy Building Exchange

The Zero Energy Building Exchange provides educational resources for building industry professionals to rapidly accelerate the knowledge, capacity, and passion for zero emission buildings. Many members either work with or for local governments and are knowledgeable in policy design.

Low Carbon Building Policy Toolkit

The Low Carbon Building Policy Toolkit report provides local governments with specific recommended policies, guidelines, and bylaws to support the transition to low carbon buildings in their communities as soon as possible.

Greensburg, KS (See Appendix D)

After being struck by a tornado in 2007, the town of Greensburg decided to rebuild "green" and chose to construct all public buildings to LEED Platinum, leading to 42% reduction in energy. The case study summarizes some of the strategies used in the buildings to achieve high performance.

PROMOTE RESILIENT RETROFITS

It is often noted that the greenest building is the one that is already built[25] as the carbon required to develop the building has already been expended. Local governments can increase resiliency in their community by promoting resiliency retrofits to existing buildings, which enable passive survivability.

One interviewee noted that most people associate resiliency with energy efficiency. Although energy efficiency plays an important role in climate mitigation, there are other options to consider in making an existing building more resilient, which are listed below, along with some examples:

1. Structure hardening which mitigates property damage, injury and system outages in the event of disaster
    a. Seismic retrofits
    b. Wind resistant roofs and windows
    c. Flood mitigation

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[25] Carl Elefante. 2012. *"The Greenest Building Is… One That is Already Built"* https://www.researchgate.net/publication/265833292_The_Greenest_Building_Is_One_That_Is_Already_Built

2. Resource conservation, which reduces the energy and water demands of a building, which increases the amount of time it can operate on backup power and reduces the impact of disruptions
    a. Efficient lighting, heating, ventilation, and air conditioning
    b. Water efficiency measures
    c. Building envelope improvements (increased airtightness and insulation)
3. Energy supply, which ensures that critical building systems can continue operating during a grid of fuel supply interruption.
    a. Renewable energy
    b. Combined heat and power
    c. Batter storage
    d. Backup generation
    e. Microgrids[26]

A study done by the Insurance Bureau of Canada recommends creating a "ResiliGuide" home resilience rating system and certification program that expands on the existing EnerGuide label, which many policymakers and homeowners are familiar with.[27] Checklists and information about these types of measures can be provided in the meantime while a program is under development.

Local Governments can promote resilient retrofits through the following policy recommendations:

- ☐ Expedite building permits for buildings that pursue resilient retrofits
- ☐ Advocate for the creation of a resiliency guide program equivalent to EnerGuide
- ☐ Provide a clear pathway for homeowners to make their homes more energy efficient and resilient. One interviewee noted that many homeowners are aware of energy efficiency grants but do not seek them out because they are time consuming to find and apply for.
- ☐ Consider concierge-style program offerings to assist residents and businesses in taking the steps needed to undertake resiliency retrofits, while also increasing industry capacity to do so
- ☐ Require that resiliency measures are installed during maintenance or renovation projects in community-owned buildings

Resources on Promoting Resilient Retrofits

Zoning for Coastal Flood Resiliency – New York

New York City implemented zoning changes known as the Zoning for Coastal Flood Resiliency amendment, which provides enhanced flexibility on allowable height increases, placement of mechanical systems, allowed streetscape improvements, and other design features, and expands the areas covered by flexible rules from the

[26] Urban Land Institute. 2022. *Resilient Retrofits: Climate Upgrades for Existing Buildings* https://knowledge.uli.org/-/media/files/research-reports/2022/resilient-retrofits-climate-upgrades-for-existing-buildings.pdf?rev=36e6e8d45f0e452a868fa3855431f0e0&hash=45C38A1E9B8BA9D74A2B7632E066D16E
[27] IBC. 2020. *Task force for a resilient recovery.* *https://www.recoverytaskforce.ca/wp-content/uploads/2020/08/IBC-Resilient-Retrofit-Proposal_2pgr_17Aug-2020.pdf*

100-year/1 percent annual chance to the 500- year/0.2 percent annual chance floodplain.

Coastal Flood Resilience Overlay District

In 2021, Boston adopted a Coastal Flood Resilience Overlay District, which: requires buildings that already require development review to also undergo a resilience review if located in a specified floodplain; relaxes requirements on height, floor area, and access features similar to New York's ordinance; and requires buildings to follow the City's Coastal Flood Resilience Design Guidelines, which specify appropriate retrofit strategies for flooding and call out co-benefits for mitigating other risks.

Energiesprong Net-Zero Retrofit Kit

An innovative program run by housing authorities in the Netherlands offers "kits" to retrofit low-income housing to zero carbon status. This program's unique financial aspect is that the renters of these low-income housing would pay the housing authority (who is paying for the retrofit process) the same amount they would be paying to the utility companies, about $2,200 per year. Thus, these houses' renters and tenants pay no more per year but end up with a completely renovated, lower carbon emission home.

Resilient Retrofits: Climate Upgrades for Existing Buildings by Urban Land Institute

The report provides design strategies, policy recommendations and financial solutions for resilient retrofits with many case studies and examples.

Federal Emergemency Management Agency (FEMA) Natural Hazard Retrofit Program Toolkit

The Natural Hazard Retrofit Program Toolkit to help state, local, tribal and territorial jurisdictions shape a retrofit program that meets their specific needs.

CONSIDER RESILIENCY WHEN SITING BUILDINGS

Building orientation can help reduce both energy use and greenhouse emissions. Local conditions, including sun, wind, natural features, and topography can influence the energy performance of buildings. A building that is thoughtfully situated in its environment and designed to harness natural conditions such as wind and sun through passive means is more energy efficient and resilient.

Local governments can encourage appropriately-sited building design by:

- ☐ Identify south-facing development sites that have minimal obstruction blocking access to sunlight and provide opportunities for planting trees and shrubs to control solar gain
- ☐ Design subdivisions that cluster buildings, retain existing vegetation and natural areas – for carbon storage and GHG reduction – and maximize infrastructure use.
- ☐ Locate important buildings on higher ground away from flood-prone zones
- ☐ Orient buildings towards prevailing winds to maximize natural ventilation. This must be balanced against solar gains.

Solar and wind orientation play an important role in passive design; some specific passive design implementation strategies for consideration include:

- Orient buildings towards the south, with the longer axis running east-west. A southern building orientation is ideally achieved on south-facing lots with minimal obstructions that can block solar access (sun/shade analysis can identify the impact of obstructions)
- Consider subdivision layouts that optimize solar gain for each building
- Locate windows for optimum daylighting, solar gains, and natural ventilation
    - Locate windows on the south-facing facade for maximum winter solar gain and natural light
    - Minimize windows on north facade to limit heat loss
    - Locate operable windows to maximize natural ventilation, ideally on opposing or adjacent walls, to create cross-breezes
    - Orient primary building facades towards prevailing breezes to maximize passive ventilation and passive cooling (consider possible conflict with orientation for solar gain and optimize accordingly)
    - Use deep window overhangs and/or fixed adjustable external shades on south-facing facades that can block out high-angle summer sun and allow entry of low-angle winter sun
- Design and orient south-facing roofs and walls to maximize passive solar gain and create opportunities for solar energy collection
- Vary height, rooflines, and massing to reduce shade on neighbouring buildings and optimize sun exposure for heat gain and daylight
- Use building shapes that minimize adverse wind effects and optimize conditions for passive ventilation and cooling

LOW CARBON MATERIALS

Material selection plays an important role in rebuilding after a disaster, both from a climate mitigation and climate adaptation perspective. Depending on the severity of a disaster, rebuilding efforts are characterized by a large volume and quantity of construction materials, which contribute to the embodied carbon of a building. Embodied carbon, which is defined as the carbon produced from the sourcing, manufacturing, and transportation of building materials, as well as the energy expended during construction, represent a significant portion of a building's emissions throughout its lifecycle.

Embodied carbon is measured through a Life Cycle Assessment, which is an accounting system for environmental impacts. The embodied carbon of insulation becomes significant when using foam insulations such as XPS, EPS, and spray foam, which contain harmful hydrofluorocarbons that damage the ozone layer.

Biogenic materials, which are derived from organic materials such as plants, capture carbon as CO_2 from the atmosphere through photosynthesis. Biogenic materials such as hemp also have fire resistant qualities. These materials must be protected against moisture, such as by enclosing wood or applying a water-resistant scratch coat for hemp. It is generally recommended to prioritize the reduction of interior finishes to reduce the use of materials and allow for ease of maintenance; however, biogenic materials are suitable where interior finishes are required, such as for acoustics.

The seemingly contradictory recommendations of building out of durable, resistant materials, such as concrete, aluminum, and brick but also seeking to avoid those types of materials given their carbon intensity, can be balanced with incorporating more natural, biogenic materials that act as carbon sinks. No material is inherently "all good" or "all bad"; the way a material is used and where it is located play a significant role in creating a resilient building. Newer concrete mixtures, for example, have a greatly reduced carbon intensity and can be easily substituted into design.

The geography and weather of a site also influence the material selection. Rain-screened assemblies – which allow for drainage and evaporation of water through an air cavity behind the cladding - are suitable in coastal climates and regions that see a lot of precipitation, whereas face-sealed assemblies, such as stucco, are better suited to drier regions.

For more information on material selection, refer to the 2030 Palette website, referenced in the resources below.

Local governments can support the incorporation of low carbon materials by implementing policies that:

- ☐ Encourage materials which are sourced close to the site of construction. This has the added benefits of supporting the local economy and reducing transportation emissions
- ☐ Promote carbon-storing materials and strategies that contribute even further to meeting carbon-neutral goals by 2030
- ☐ Require rain-screened assemblies for regions that see high precipitation
- ☐ Support manufacturing practices that promote the production of new region-specific biogenic materials (e.g., fiber and purposefully-grown materials)

- ☐ Facilitate economic opportunity zones pairing agriculture residue products with materials manufacturing

Resources on Low Carbon Materials

City of Vancouver Embodied Carbon Policy

In 2019, Vancouver City Council set a goal of reducing embodied carbon from construction by 40% by 2030, compared to 2018 baseline standards. The policy enables reporting of embodied carbon impacts and sets the first limit by setting a requirement in the by-law. This will help prepare designers for future reduction requirements in 2025.

Green Building Policy for Rezonings

In July 2010, Council approved the Green Buildings Policy for Rezonings setting out requirements for all applicable developments applying for rezoning to help transition industry toward more sustainable building practices. A future amendment to the policy requires that a Life Cycle Assessment is completed for all new rezoning projects.

The policy applies to Part 3 buildings and outlines requirements for:

- Resilient buildings planning
- Energy and emissions performance limits
- Embodied carbon limits
- Integrated rainwater management and green infrastructure
- Energy system submetering

Carbon Leadership Forum

The Carbon Leadership Forum accelerates the transformation of the building sector to radically reduce the embodied carbon in building materials and construction through collective action.

Architecture 2030

Architecture 2030's mission is to rapidly transform the built environment from the major contributor of greenhouse gas emissions to a central solution to the climate crisis. They created the Architecture 2030 Challenge and many resources such as the 2030 Palette, which highlights low embodied carbon materials and design.

2030 Palette

The website contains resources and tools to promote low embodied carbon design and material selection through the Carbon Smart Materials Palette.

[Low Carbon Building Policy Toolkit]

The Low Carbon Building Policy Toolkit report provides local governments with specific recommended policies, guidelines, and bylaws to support the transition to low carbon buildings in their communities as soon as possible.

[Carbon Storing Materials Summary Report by the Carbon Leadership Forum]

The report investigates the potential of using low-carbon and carbon-storing materials in new construction. The project focused on carbon-intensive hotspot materials (e.g., concrete foundations and slab floors, insulated roof and wall panels, and structural framing) in light industrial buildings.

DESIGN FOR EASE OF REPAIRS

A resilient building is easy to maintain and repair following an extreme weather event, and this is facilitated by materials and design layouts that promote ease of repairs. The guidance in this section is particularly applicable to flooding and storms.

There are two types of floodproofing: wet floodproofing – where water is allowed to enter and leave the building; and dry floodproofing – where water is diverted away or prevented from entering the building.[28] Water resistant materials (such as concrete, brick, and aluminum) prevent damage, are easier to clean and easier to dry. These materials can also be energy intensive to produce so their use is recommended to be limited to areas that are most likely to be impacted by storms and floods.

One interviewee noted that drywall became in short supply when their region was affected by a disaster. While it is challenging to predict how the supply chain will be affected by disasters, it is important to consider that some materials may not be as readily available as required. Organizations such as the International Living Future Institute provide points to buildings that have exposed finishes and seek to meet the Living Building Challenge criteria. Exposed finishes also have the added benefit of being easier to maintain and clean. As such, this type of design feature could be considered as standard/preferred practice for areas rebuilding or completing resiliency retrofits.

[28] Andrew Marriott. 2020. *Clean, Resilient Flood Technology Options in Canada* https://act-adapt.org/wp-content/uploads/2020/07/ECCC_Flood-Tech_2020_WEB.pdf

Local governments can promote ease of repairs in buildings by requiring both new construction and 'substantial improvement' projects to:

- ☐ Be constructed with materials and utility equipment resistant to flood damage, using methods and practices that minimize flood damage
- ☐ Elevate the lowest floor, including the basement, two feet above the base flood elevation, and two feet above the highest adjacent grade for certain high-risk zones
- ☐ Floodproof nonresidential construction two feet above the base flood elevation so that the structure is watertight, with structural components capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy
- ☐ Design fully enclosed, non-basement areas below the lowest floor used solely for vehicle parking, building access, or storage and that are subject to flooding to automatically equalize hydrostatic flood forces on exterior walls by allowing the entry and exit of floodwater[29]

Resources on Promoting Ease of Repairs

Resilient Retrofits: Climate Upgrades for Existing Buildings by Urban Land Institute

The report provides design strategies, policy recommendations and financial solutions for resilient retrofits with many case studies and examples.

Clean, Resilient Flood Technology Options in Canada by SFU ACT (Adaptation to Climate Change Team)

Summarizes existing literature and information on promising existing and emerging clean technologies or climate change adaptation in Canada in the context of urban planning and water resource management, specifically in terms of their climate resilience and cost and implementation barriers for wider adoption.

CONSIDER WATER DESIGN AS A RESILIENCY MEASURE

Other building standards such as the Living Building Challenge (LBC) go beyond designing for thermal comfort in an outage event by considering aspects such as net positive water design. Under the LBC, buildings meeting the Water Imperative must incorporate a resilience strategy to provide drinking water for at least a week for all regular building occupants through water storage onsite.[30] In a study regarding the cost feasibility of Living Building Challenge buildings, it was found that rainwater harvesting, storage, and greywater reuse systems increase the costs of construction of

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[29] Urban Land Institute. 2022. Resilient Retrofits: Climate Upgrades for Existing Buildings https://knowledge.uli.org/-/media/files/research-reports/2022/resilient-retrofits-climate-upgrades-for-existing-buildings.pdf?rev=36e6e8d45f0e452a868fa3855431f0e0&hash=45C38A1E9B8BA9D74A2B7632E066D16E

[30] International Living Future Institute. 2022. *Living Building Challenge Guidelines* https://living-future.org/lbc/

1% to 3% and dramatically reduce the water needs and waste water discharge of the buildings (reductions of 45-60%). In the aftermath of a disaster, this type of design consideration can be a gamechanger for communities.

Local governments can encourage resilient water systems by:

- ☐ Creating incentives and removing barriers for relatively low-cost, but high-impact water efficiency and net zero water strategies
- ☐ Promote the use of lower-technology and lower-cost but high-benefit strategies like greywater reuse, rainwater capture, and high water efficiency fixtures whenever possible
- ☐ Consider incentives for mixed-use buildings and neighbourhoods that can balance greywater creation and use

Resources on Considering Water Design as a Resiliency Measure

The International Living Future Institute

The Living Building Challenge (LBC) is managed by the International Living Future Institute, which is a global network dedicated to creating a healthy future for all. One of the seven petals of the LBC is water, which challenges buildings to become water-independent through responsible water use and net positive water design. The website has examples of various projects that have met the standards of the Water Petal that could be a good resource for communities who are interested in become more resilient to drought events.

Omega Center for Sustainable Living (OCSL) (See Appendix C)

The Omega Center for Sustainable Living (OCSL) is a **purposeful building and site**, designed to **clean water**, **return the clean water** to the local systems, and **educate** users about the process.

PLAN FOR ALTERNATE USE CASES FOR EXISTING PUBLIC BUILDINGS

Many public buildings can also be used as either emergency or summer-long cooling centers or resilience hubs. Community centers and libraries are often well suited for this purpose as they are already heavily used by the public, have staff who are used to assisting the public, and are locations that are already well known to community members. Schools are also often considered temporary shelter locations for emergency situations and may be appropriate when additional capacity is needed for cooling locations during extreme weather events. These public buildings can all be outfitted with emergency backup power to ensure indoor cooling is consistent even in the event of an energy grid disruption.

Here are some implementation strategies that local government staff can keep in mind for planning alternate use cases for public buildings:

- ☐ Considering how existing public building stock can functionally operate in an emergency. Some examples of this are:
  - Arenas can function as emergency shelters
  - The fire station/city hall can house an emergency operations centre
  - Libraries can function as cooling centers in heat event (many local governments already do this)
- ☐ Ensure that the designated emergency-use area has capacity for additional heat/cool/water demands when volumes of people increase
- ☐ Consider installing a large kitchen in public buildings to serve an increased number of people
- ☐ Conduct emergency scenario planning when designing a new building. Some examples are:
  - Make sure critical IT infrastructure is not located in a basement in a flood-prone area
  - Design a fire-proofed part of the building that keeps important records/sets of keys etc.
- ☐ Create a plan for how donations will be received, sorted, and stored
- ☐ Ensure there is enough storage for emergency needs or consider which rooms can serve as storage spaces

SUPPORT ADOPTION OF INNOVATIVE MATERIALS AND CONSTRUCTION METHODS

The building industry is dynamic, and sustainability and resilience are the main focus of many emerging construction industry trends. Innovations in prefabricated construction, robotic manufacturing and building materials can expedite construction in a rebuilding scenario.

Local governments can promote the implementation of innovative materials and construction methods by:

- ☐ Considering building demonstration projects for affordable housing and community center structures
- ☐ Prioritize permitting for impactful prototype projects

Resources on Supporting Innovation

Kanaka Bar Resilient Housing Solutions

The Kanaka Bar Indian Band, SAIT, Okanagan College, Foresight Canada and Seko Construction partnered to launch the Kanaka Bar Resilient Housing Challenge, an Innovation Challenge to help the communities of Lytton, BC and Kanaka Bar rebuild sustainably after the wildfires of 2021. They are currently constructing four pilot houses at Kanaka Bar that will be assessed for their performance under extreme weather and fire conditions.

INFRASTRUCTURE

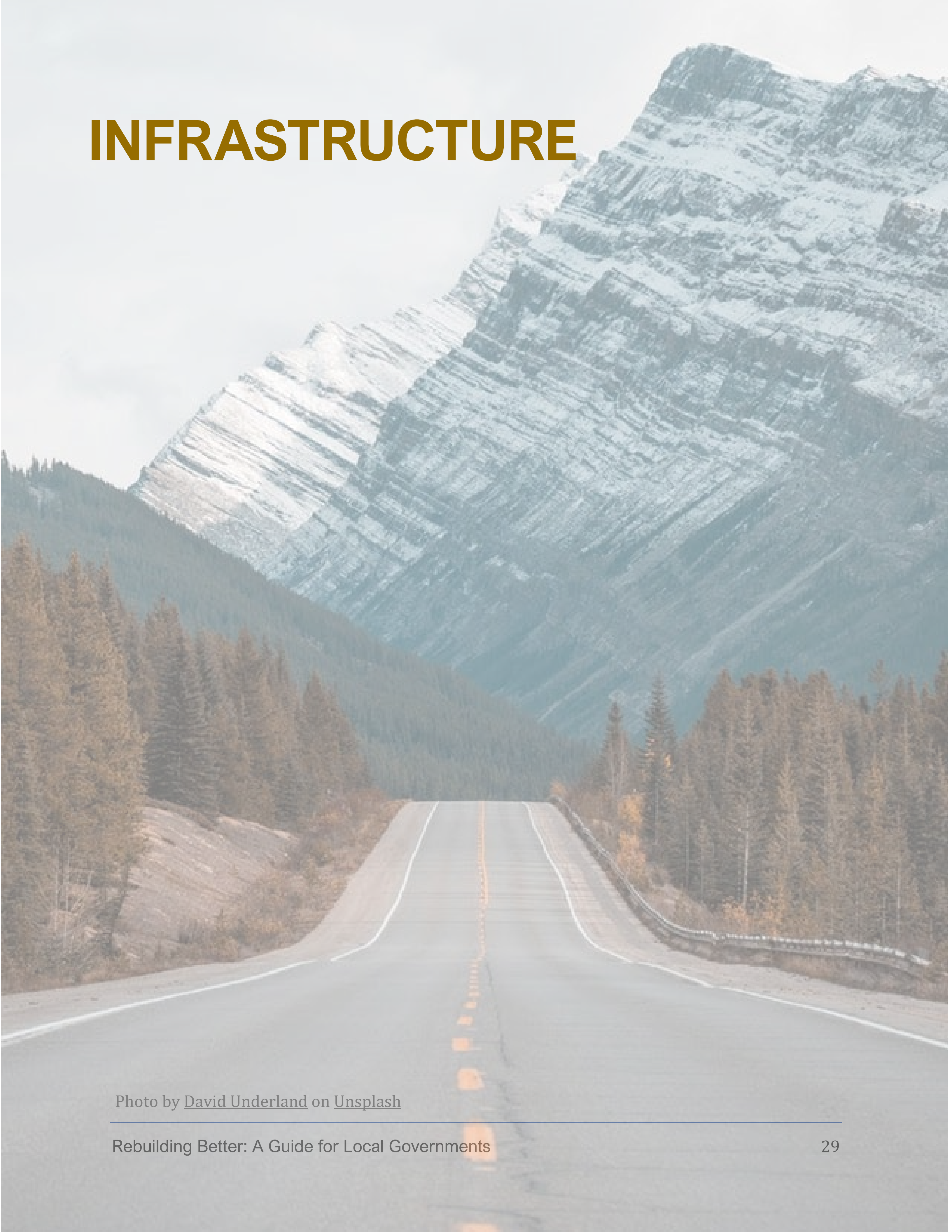

Photo by David Underland on Unsplash

INFRASTRUCTURE

Community infrastructure is often at the forefront of damages during extreme weather events such as storms, floods, and wildfires – which are all expected to increase in duration and intensity and frequency in the coming years.

INTRODUCTION

Infrastructure facilitates the delivery of public services, and its design and location has a significant effect on a region's economic growth, community livability, affordability, and overall health.[31] Ensuring infrastructure is actively maintained, replaced as necessary (due to age, climate, population, or service level changes), and that the services they provide are improved upon plays an important role in creating resilient communities.

CHALLENGES

Community infrastructure is often at the forefront of damages during extreme weather events such as storms, floods, and wildfires – which are all expected to increase in duration and intensity and frequency in the coming years. Earthquakes also carry a significant impact, although they occur less often and affect only certain areas of the province. Although disasters impact a variety of local government infrastructure, including roads, sidewalks/trails, electrical systems, and bridges, this guide focuses on impacts to water, stormwater, and wastewater systems.

Some of the challenges facing a local government's infrastructure as a result of changing climate conditions include:

- Overwhelmed pump stations
- Sewage systems becoming backed up if the wastewater infrastructure is overloaded
- Sediment or debris flows may block or damage systems
- Damaged/failed flood mitigation measures, such as breached or overflowing dikes
- Cumulative impacts from aging infrastructure and disasters; if an asset has issues to begin with or is nearing end of life, it could be made worse or pushed to failure by a disaster

RECOMMENDATIONS

There are a number of strategies to integrating low carbon resilience in infrastructure: reducing the demand on the system, increasing the capacity of the system to higher loads, considering nature based solutions or hybrid solutions, decreasing the amount of embodied carbon through material or design choices, and reducing operational carbon through design options such as site layout or

[31] Traditional infrastructure (not including natural assets such as wetlands, trees, etc.) makes up approximately 60% of a local government's asset ownership. https://fcm.ca/en/focus-areas/infrastructure

orientation. This can involve a combination of 'hard' and 'soft' approaches as discussed further below.

UNDERSTAND THE RISKS

Local governments can make informed decisions by looking to future climate data to understand the expected risks facing infrastructure systems. It is recommended that local governments take the following steps to understand risks facing infrastructure:

- ☐ Update flood maps to reflect 1:200-year flood events
- ☐ Take steps to understand and plan for regular asset replacement and renewal cycles
- ☐ Re-examine the engineering thresholds for hard infrastructure systems to assess their points of failure in future climate scenarios, and prioritize their upgrade/maintenance accordingly
- ☐ Consider looking into historical data to map hidden waterways such as creeks, which could be daylit to provide flood protection

LEVERAGE NATURAL ASSETS AND INCORPORATE GREEN INFRASTRUCTURE

Natural assets such as parks and wetlands can provide protection against damages from storms and floods by slowing water and storing it, reducing loads on hard stormwater systems and reducing risks of downstream flooding. Implementing green infrastructure solutions builds resiliency to disasters. Green stormwater infrastructure must be designed for regional geographic and climate contexts. While green stormwater was first popularized for its flood reduction benefits, it also provides the co-benefit of heat reduction through urban greening and increasing pedestrian thermal comfort through evapotranspiration, both of which are helpful during heat events.

Here are some examples of green stormwater infrastructure:

- Bioretention cells (e.g., rain garden)
- Rainwater tree trenches
- Subsurface infiltration
- Large scale projects such as engineering wetlands

The City of Vancouver Rain City Strategy (summarized in Appendix E) provides helpful strategies, policy changes and design examples of green infrastructure.

Local governments can leverage natural assets and incorporate green infrastructure by:

- ☐ Set up performance objectives for improving the resilience of infrastructure systems, rather than taking a prescriptive approach.
- ☐ Consider delivering services such as wastewater treatment through engineered wetlands that can also treat wastewater. See the Omega Center for Sustainable Living Case Study in Appendix C.
- ☐ Designing parks, bioswales, and permeable pavement/sidewalks to act as bioretention areas during heavy rain events.

- ☐ Adding to the urban forest (treed ecosystems within urban areas) by creating or expanding wooded areas and parks and planting street trees. Enhance the natural green network by increasing the quantity, density and diversity of trees.
- ☐ Planting trees in trenches rather than in large underground containers so trees live longer and grow larger as they mature.

CONSIDER ALL ASPECTS OF SITE DESIGN IN INFRASTRUCTURE PLANNING

The built and natural infrastructure that surrounds a building play an important role in creating a comfortable thermal environment for occupants and mitigating risks from extreme weather.[32] Natural features such as trees and shrubs increase resiliency by providing shade and increasing evapotranspiration during heat events, in addition to acting like sponges during floods and heavy storms. Trees store carbon, reduce water run-off during heavy rains, improve air quality (e.g., from wildfire smoke), buffer windstorms, and mitigate summer heating impacts.

Hard infrastructure such as parking lots can contribute to water pooling and heat island effects if not shaded adequately with runoff design considerations. Benches and seating areas without shading on the south side of a building may not be useable in the hottest part of the day. Fencing can be useful in preventing debris movement in windstorms but can also create access issues in an emergency if openings are not provided. By considering the climate conditions and extreme weather impacts that infrastructure will face during site layout and design, an area will be safer, more fully utilized, and more resilient.

Here are some implementation strategies that local government staff can keep in mind for resilient site design utilizing natural assets:

- ☐ Understand the local conditions of a place by looking at natural phenomena such as wind direction, local plants, sun exposure, etc.. to inform the site layout.
- ☐ Orient buildings towards the south, with the longer axis running east-west. A southern building orientation is ideally achieved on south-facing lots with minimal obstructions that can block solar access (sun/shade analysis can identify the impact of obstructions).
- ☐ Use deciduous trees on the southern and western-facing side of a building to maximize the warming effect of solar radiation in winter months and the cooling effect of shade in summer months.
- ☐ Locate coniferous trees so they block winter winds without blocking solar gain. The north face of the building is particularly suitable for this.
- ☐ Avoid storm damage to buildings and structures by planting low, shrub-like trees or hedges near buildings and taller trees farther away.

[32] Nowak et al. 2016. *Residential building energy conservation and avoided power plantemissions by urban and community trees in the United States* https://www.nrs.fs.fed.us/pubs/53420

Resources on Infrastructure

Rain City Strategy (see Appendix E)

The strategy reimagines and transforms how we manage rainwater with the goals of improving water quality, resilience, and livability through creating healthy urban ecosystems.

The strategy will implement sustainable rainwater management across the city with a goal of using rainwater as a resource rather than a waste product.

See Appendix E for the summary and see link above for access to full report.

Rain City Strategy Policy Examples

The Strategy sets the following performance targets by 2050:

- **90%** of Vancouver's average annual rainfall will be captured and treated close to where it lands;
- **48 mm** of rainwater per day will be managed by sites and GRI assets;
- **40%** of Vancouver's impervious areas will manage rainwater volume and water quality through new development, capital projects and strategic retrofits.

Planning for Urban Heat Resilience Report by the American Planning Association

The report lays out a framework for addressing urban heat, which requires setting clear urban heat planning goals and developing associated metrics for success; building a comprehensive "fact base" of information on heat risks; developing a diverse portfolio of heat mitigation and management strategies; managing uncertainty; coordinating across planning efforts; ensuring inclusive participation in planning processes; and effectively implementing, monitoring, and evaluating urban heat resilience efforts.

LAND USE

Photo by Cagatay Orhan on Unsplash

LAND USE

The decisions local governments make and influence as it relates to the physical characteristics of a building – or groups of buildings – and their siting are amongst the most powerful levers available to apply in both planning for and responding to climate-related emergencies.

INTRODUCTION

Land use is the human use of land—the management, conservation, and change of natural environments, built environments, and semi-natural areas—to support settlement and communities. *Sustainable land use* goes one step further by enabling humans to thrive within nature's limits. It integrates social, environmental, economic, and cultural objectives into policy and practice for the long-term well-being of communities and ecosystems.[33]

The decisions local governments make and influence as it relates to the physical characteristics of a building, or groups of buildings, and their siting are amongst the most powerful levers available to apply in both planning for and responding to climate-related emergencies. By discouraging development close to flood prone areas and wildland interfaces, local governments reduce disaster risk.

Where a building is situated greatly influences its material and energy consumption, its risk exposure to climate events, as well as that of the supporting infrastructure required such as roads, sewer, energy systems, etc. A building's location, as well as its relationship with other buildings and the overall landscape, play an important role in a community's resilience.

CHALLENGES

The relationship between land use and the climate is complex. In the past, land was often cleared and flattened to make way for various human activities; however, changes in land cover impact local and global weather by altering the flow of thermal energy, water, and greenhouse gases between the land and the atmosphere. The combined effects of increased pollutants and natural systems loss make a region more vulnerable to extreme weather and influence the ability of a site to recover from a natural disaster.

Current land use planning practices and the infrastructure threshold calculations that support them have largely not been designed with future climate data in mind; this has left communities less prepared and therefore less resilient when responding to a disaster.

There are also the cumulative effects of double disasters, such as floods that follow a wildfire due to increased runoff after intense rainfall or rapid snowmelt. This can leave communities in a state of

[33] Organization for Economic Co-operation and Development. 2020. *Towards Sustainable Land Use* https://www.oecd.org/environment/towards-sustainable-land-use-3809b6a1-en.htm

constant recovery. Disasters such as wildfires and floods also impact economic sectors such as forestry and agriculture by damaging existing stock, causing further harm and disruption to an area already coping with the physical effects of the event.

During an emergency, people typically either shelter in place or relocate to safer areas. One interviewee noted that their community is a hub for receiving residents from disaster affected regions, and that when people relocate it can overwhelm their region's existing infrastructure by creating additional demand that was not anticipated or planned for. When relocations become long term or permanent in an area that was not appropriately planned for, that can put people's safety, health, and wellbeing at risk because their needs are not being met. As one interviewee noted, short term solutions are not appropriate for the long term.

RECOMMENDATIONS

When it comes to rebuilding and recovery, communities face two primary choices regarding their buildings and infrastructure – build back in the same location or relocate. Some insurance policies might mandate rebuilding in the same location or other practicalities may require it (a port must be on the waterfront, for example). Relocation also presents challenges such as selecting an appropriate area to relocate to and acquiring the land.

The following sections highlight recommendations of what to consider in both scenarios, written with a Low Carbon Resilience perspective. The Room for the River case study (see Appendix F) is a good example from the Netherlands of addressing flooding with the aim to improve safety and spatial planning and utilizing a variety of hard and soft approaches to increase resilience.

UNDERSTAND THE RISKS

Geotechnical, Flood, and Fire Mapping

Understanding the risks by looking to future climate data is an important step before implementing resiliency strategies. One way to understand risks is by mapping areas that are prone to landslides, floods, and fires through geospatial data and satellite technology.

Resources for Understanding Risks

City of North Vancouver Geotechnical Mapping

The City of North Vancouver was impacted by several landslides in the early 2000's, one of which resulted in the death of one resident. The City worked with geotechnical engineers to conduct slope stability assessment and map the landslide risk of the region, which it used to strategically implement slope stability measures over the years.

[Grand Forks Relocation]

The 2018 flood in Grand Forks prompted a strategic managed retreat and buyback program. The document outlines how the City increased resilience to riverine flooding and made informed decisions using climate data.

[Western University Flood Impact Map]

A Western University flood-control expert has developed the first Canada-wide maps showing how floodplains – including low-lying areas of major cities like Vancouver and Montreal – may become inundated in the next 80 years under various climate change scenarios.

IMPLEMENT STRATEGIES FOR INCREASING RESILIENCE TO DISASTER THROUGH LAND USE

Note that following strategies are not mutually exclusive and should be considered in tandem and holistically.

ZONING FOR COMPACT COMMUNITIES

Compact building design is about using the least amount of land for development of buildings and infrastructure that is reasonable under the circumstances. This approach allows communities to be designed in a way that preserves open space and efficiently uses land and resources, minimizes risk by reducing the number of fail points in a system, and can also help with emergency response efforts by limiting the range of travel required, minimizing the number of locations for supply distribution, etc.

Local governments can increase resilience to disasters through zoning by implementing the following:

- ☐ Increasing density in areas that are less prone to natural disasters
- ☐ Increase zoning for mixed use development, which increases walkability, access to amenities and diverse transportation modes such as cycling (reducing vulnerabilities if roads are cut off, fuel supplies are low, etc.)
- ☐ Encourage densifying single family lots by removing barriers to constructing duplexes and laneway homes
- ☐ Implement setback relaxations for buildings that have thicker, more insulated walls
- ☐ Concentrate growth in small areas to reduce the impact on existing natural areas and reduce servicing costs (consider reducing DCCs).
- ☐ Encourage the use of small lots where single-family developments are being considered
- ☐ Create/ update existing policies that support compact subdivision development.

Resources on Zoning for Compact Communities

City of Grand Forks

The City of Grand Forks removed building permit and development fees for accessory dwellings in residential properties following massive flooding in 2018 that also involved managed retreat from flood-prone areas.

PROTECT NATURAL ASSETS & PROMOTE CREATION OF NEW NATURAL AREAS

Managed land conservation sustains natural assets such as forests, wetlands, and rivers, which provide long term protection against natural disasters and reduce the short-term impacts of climate events. In the case of relocation, which is discussed on another section, a two-pronged approach of moving to a new area while returning the old habitation to its natural state is recommended in order to maintain a balance of natural area availability.

Local Governments can improve their natural assets and reduce risk to disasters by:

- ☐ Establish urban growth boundaries to maintain land conservation
- ☐ Naturalize rivers and streams to increase resilience to floods and heat events
- ☐ Construct inland wetlands, bioswales, and urban watersheds to slow down stormwater
- ☐ Encourage climate-appropriate and fire-smart vegetation to reduce water use and the possibility of additional fuels
- ☐ Consider possibility of using a constructed wetland to treat wastewater, which might be a suitable solution for a small community. See Omega Center for Sustainable Living case study (see Appendix C), which recycles about 19 000 000 L (approximately 5 million gallons) of wastewater per year.

Resources on Protecting Natural Assets and Promoting Creation of New Natural Areas

Municipal Natural Assets Institute

Organizations such as the Municipal Natural Assets Institute (MNAI) work with municipalities to count nature in delivering everyday services, increasing the quality and resilience of infrastructure at lower costs and reduced risk.

City of North Vancouver – Streamside Development Permit Areas

The City's Official Community Plan and associated bylaws establish Development Permit Areas for Streamside Protection and Enhancement. The City's approach to streamside protection has been designed to meet Provincial regulations to protect fish habitat in an urban environment and reduce flood risk, while providing certainty for homeowners and developers.

Nature-Based Solutions Report

This report analyses the current state of knowledge regarding the role of Nature-based Solutions (NbS) in climate change mitigation. It shows that in order to keep temperature rising to 1.5 degrees and achieve net zero by 2050 a significant contribution from NbS is both necessary and possible, provided the necessary finance is made available. It assesses the role that carbon offsets can play in the overall finance package.

A Catalogue of Nature-based Solutions for Urban Resilience by World Bank Group

The Catalogue of Nature-based Solutions for Urban Resilience has been developed as a guidance document to support the growing demand for NBS by enabling an initial identification of potential investments in nature-based solutions.

Consolidating insights of the performance and benefits into 14 NBS typologies which intends to support policy makers, project developers, development professionals, urban planners, and engineers with the identification of potential NBS investments, and to start a policy dialogue on NBS in cities.

INCREASE TREE COVER AND GREEN SPACES IN URBAN AREAS

Trees and green spaces are increasingly becoming recognized as valuable assets for local governments because they alter the local climates by producing shade, blocking winds, and reducing air temperatures through evaporation of water from leaves. Several studies demonstrate that these ecosystem services can reduce cooling demand from buildings in the summer.[34] Large deciduous trees are especially advantageous around buildings as they allow sunlight to penetrate through during winter months, allowing the building to benefit from natural heating from the sun.[35]

In addition to these benefits, increasing tree cover and green spaces in urban areas can also mitigate stormwater surcharge during storms and floods. One interviewee recommended considering what type of urban tree cover to put in following a disaster as that it is a good time to take actions affecting the long-range vision of recovery. Public gathering spaces that also provide cooling benefits can help to address issues of social connectivity, health, and wellbeing.

For communities living in wildfire interface areas, increasing tree cover must be balanced against FireSmart strategies. This can be accomplished through species selection, pruning programs, and public education and engagement.

Local governments can increase tree cover by implementing the following policies:

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[34] Nowak et al. 2016. *Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States* https://www.nrs.fs.fed.us/pubs/53420
[35] Green Blue Urban. 2017. *How Urban Trees Reduce Energy Costs* https://greenblue.com/ce/urban-trees-reduce-energy-costs/

- ☐ Preserve and increase urban tree canopies and green spaces to reduce ambient temperatures and provide air filtration
- ☐ Increase park designations and dedications, maintain wildlife and greenspace corridors, and ensure access to shaded natural outdoor spaces in all parts of the community
- ☐ Create naturalized pollinator meadows on managed lands
- ☐ Educate residents on benefits of 'xeriscaping' or low water use landscaping techniques to minimize and/or eventually eliminate the need for irrigation.
- ☐ Lead by example by planting native or naturalized species and drought resistant plants on community-owned buildings
- ☐ Use low-maintenance, salt-tolerant species along streets, sidewalks, and other public spaces

Resources on Increasing Tree Cover and Green Spaces in Urban Areas

City of Colwood, Urban Forest Bylaw

The Urban Forest Bylaw was adopted to preserve trees on both private and public property and to assist in growing the City's urban forest. If you wish to cut or remove a tree on your property, you may require a permit. When trees are removed, replacement trees must be planted in order to maintain and enhance the urban forest.

City of Phoenix Tree and Shade Master Plan

The Tree and Shade Master Plan is a roadmap for creating a healthier, more livable and prosperous 21st Century desert city. Implementing the plan will help the City and its residents save millions of dollars, while tackling important environmental and social challenges.

City of Vancouver Green Streets Program and Boulevard Gardening Guidelines

Green Streets gardens not only enhance public space, they help manage rainwater, provide habitat for wildlife, and add a touch more green space to the communities where people live, work, and play.

INCREASE RESILIENCE TO FIRES

Reducing wildfire risk through landscape management often means removing dry vegetation that can fuel fires. This can be done through prescribed burning, which removes dry vegetation and is typically carried out in the spring and fall. Prescribed burning also has the added benefits of increased biodiversity and reduction of invasive species. Alternatively, dry vegetation can also be removed and may be possible to be turned into a renewable energy source or into pulp and paper products.

Establishing fire breaks, following Fire Smart Principles and situating communities strategically in relation to water sources also increase resilience to fires.

Local governments can support wildfire prevention through the following policies:

- ☐ Proactively reduce wildfire risk in publicly-owned interface areas through fuel removal and/or prescribed burning programs
- ☐ Leverage existing grants to restore forests proactively following a wildfire
- ☐ Support efforts that promote using forest byproducts
- ☐ Reduce barriers to prescribed burning permits

Resources on Increasing Resilience to Fires

Elephant Hill Fire Recovery Case Study (see Appendix G)

The case study highlights the Secwépemc community's and provincial government's objectives and outcomes of the Elephant Hill wildfire and the joint leadership approach to wildfire recovery.

Fire Smart BC

FireSmart BC is a program that supports wildfire preparedness, prevention, and mitigation in BC. The website has educational resources for homeowners, local governments, First Nations, local FireSmart representatives and fire departments.

Wildfire Preparedness Guide by Government of Canada

This guide will help you prepare your household, protect your property and learn what to do if a wildfire is close to your community.

INCREASE RESILIENCE TO FLOODS

Canadian communities and infrastructure are vulnerable to coastal and riverine flood hazards. The risks associated with coastal and river flooding are increasing due to development in river floodplains and coastal zones, as well as the effects of climate change on flood and erosion hazards.[36] There is growing interest in the potential for Nature-based Solutions to play a role in managing these risks, which slow down the floodwaters, and therefore their impact, through natural means.

[36] CSA Group. 2021. *Nature-Based Solutions for Coastal and Riverine Flood and Erosion Risk Management* https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-Nature-Based-Solutions-for-Coastal-and-Riverine-Flood-and-Erosion-Risk-Management.pdf

Some examples of Nature-based Solutions are:

- Coastal regions – beaches/dunes, reefs, and wetlands provide buffers against wave action, storm surges, and erosion;
- River watersheds – wetlands, reconnected floodplain areas, and restored river channels enhance groundwater infiltration, reduce or delay runoff, and attenuate peak flood flows and water levels; and
- Estuaries – marsh and wetland systems can be preserved, expanded, or restored to provide additional hydraulic storage and attenuate waves.

Natural systems typically span multiple jurisdictions or regulatory boundaries, particularly in Canada where flood risk management responsibilities are shared by federal, provincial/territorial, municipal/regional, and Indigenous governments. To be most effective, flood resilience strategies must be applied across the whole system, which necessitates collaboration between different departments and levels of government.[37]

Local governments can promote the use of Nature-based Solutions for flood mitigation through implementing policy that:

- ☐ Renaturalizes shorelines and floodplains in areas where development has already occurred
- ☐ Prioritizes interconnected natural water infiltration and attenuation systems over hard infrastructure, and/or considers hybrid solutions
- ☐ Provides for multi-purpose spaces, whereby overland waterflows can purposefully be directed to a natural area during peak times, and recede leaving a park area available for community use
- ☐ Increases urban green spaces and tree cover
- ☐ Streamlines permitting processes for Nature-based Solutions so that projects are considered and prioritized over engineered-asset approaches
- ☐ Limits steep slope development and minimizes risk of landslides following heavy rainfall or snowmelt by planting stabilizing species of trees, redirecting waterflows, etc.

Resources for Increasing Resilience to Floods

Municipal Natural Assets Institute

Organizations such as the Municipal Natural Assets Institute (MNAI) work with municipalities to count nature in delivering everyday services, increasing the quality and resilience of infrastructure at lower costs and reduced risk.

[37] World Bank Group. 2021. A Catalogue of Nature-based Solutions for Urban Resilience https://openknowledge.worldbank.org/handle/10986/36507

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Nature-Based Solutions for Coastal and Riverine Flood and Erosion Risk Management by CSA Group

This report assesses how NbS can be used to manage flood and erosion risks in coastal and riverine environments in Canada and determines what kind of policies and standards would support deployment of NbS to reduce coastal and riverine flooding and erosion risks.

Room for the River Case Study (See Appendix F)

The Room for the River case study discusses how 9 key strategies were utilized in 34 different areas of the Netherlands to improve the safety and spatial quality of the river region. The strategies are a combination of Nature-based Solutions (i.e., green infrastructure) and hard engineering approaches (grey infrastructure) and showcases how these approaches can work together to reduce flood risk.

Green Shores Program

The Green Shores© program, run by the Stewardship Centre for British Columbia, encourages the preservation, management, and restoration of shorelines for public and private properties, with ecosystem sustainability at the forefront. The program is based on voluntary credits and ratings system, modelled after the widely adopted LEED™ program for green buildings.

TransCoastal Adaptations

TransCoastal Adaptations is a Centre for Nature-Based Solutions at Saint Mary's University that engages in research and partnerships that promote and undertake projects related to climate change adaptation. Their framework for implementing Nature-based Solutions guides coastal adaptations and helps create resilience to climate change impacts.

Engineering with Nature Program

In the United States, the U.S. Army Corps of Engineers is revising policies, guidance, and regulations to enable implementation of Nature-Based Solutions through the Engineering With Nature™ program, which could be a model for change in Canada.

RELOCATION

Sometimes moving buildings and infrastructure is the best option, especially when a disaster-impacted region is deemed unsafe to rebuild in, or future risk to repeated extreme weather events presents greater costs, hazards, and challenges than relocating. Local governments may identify areas within their community that are at higher risk of natural disasters such as flooding or wildfires (particularly under future climate conditions) and choose to proactively designate other parts of the community for immediate relocation or for rebuilding purposes should the need arise.

When moving buildings or infrastructure to a new area, it is important to balance competing interests for land conservation with safer ground by designing compact, complete communities. Refer to the *Zoning for Compact Communities section* for further detail.

Local governments can consider the following policy suggestions during a relocation:

- ☐ Move smallest homes for lighter footprint on infrastructure.
- ☐ Consider deep energy retrofits for houses that are moved. For example, investing in an insulated foundation can lead to significant energy savings for homeowners.
- ☐ Consider district energy use such as geothermal heat pumps, which are more applicable in a larger, district wide setting.
- ☐ Locate important buildings on higher ground away from flood-prone zones.

Resources on Relocation

City of Phoenix Tree and Shade Master Plan
The Tree and Shade Master Plan is a roadmap for creating a healthier, more livable and prosperous 21st Century desert city. Implementing the plan will help the City and its residents save millions of dollars, while tackling important environmental and social challenges.

Grand Forks Relocation

The 2018 flood in Grand Forks prompted a strategic managed retreat and buyback program. The document outlines how the City increased resilience to riverine flooding, using a combination of actions, such as relocating single family dwellings, drainage enhancement and non-structural approaches.

Room for the River Case Study – See Appendix F

The Room for the River case study discusses how 9 key strategies were utilized in 34 different areas of the Netherlands to improve the safety and spatial quality of the river region. The strategies are a combination of Nature-based Solutions (i.e., green infrastructure) and hard engineering approaches (grey infrastructure) and showcases how these approaches can work together to reduce flood risk.

Planning for Urban Heat Resilience Report by the American Planning Association

The report lays out a framework for addressing urban heat, which requires setting clear urban heat planning goals and developing associated metrics for success; building a comprehensive “fact base” of information on heat risks; developing a diverse portfolio of heat mitigation and management strategies; managing uncertainty; coordinating across planning efforts; ensuring inclusive participation in planning processes; and effectively implementing, monitoring, and evaluating urban heat resilience efforts.

Development Permit Areas for Climate Action by the Ministry of Community, Sport and Cultural Development

The purpose of this guide is to help local governments use their DPA authority to conserve energy, conserve water and/or reduce GHG emissions. The guide is intended primarily for local governments and their planning staff. The content of the guide may also benefit others involved in land-use planning and development, including developers, builders, architects, landscape architects and planning consultants.

PEOPLE

Photo by Shane Rounce on Unsplash

PEOPLE

INTRODUCTION

There is no doubt that disasters have severe social impacts that can last long after the event itself passes. Cities, towns, and communities are a product of the people who live in the region and the cultural values they share. Buildings – and the built environment as a whole – reflect these values and contribute to a certain way of life. When this way of life becomes disrupted from a disaster, people often start to act out of fear, which can negatively impact their health, safety, and creativity.

This section is based on the information gathered during stakeholder interviews, as investigating the social aspects of rebuilding were originally not in scope for this research project. During the course of the project, it became apparent how central this topic is to the issue of rebuilding and as such it was added for completeness; however, this section is by no means exhaustive and the author recommends further work be done to build out the recommendations for communities based on a fulsome literature review and further research.

CHALLENGES

The main social impacts of recovering from disaster, as mentioned during the interviews, center around governance, communication, equity, and mental health. The interviewees highlighted several of the many social challenges that arise when dealing with disasters:

- Governance
    - Duplication of efforts resulting from unclear governance structures
    - Elected officials are judged harshly for "not spending the right way." During a disaster, previously approved budgets can be significantly affected.
    - Government responses can be seen as paternalistic and risk averse. Governments may want to be *part* of the solution, not *the* solution.
    - Staff turnover for local governments can be high following a disaster, leading to difficulties implementing the strategies and solutions decision-makers have established.
- Communication
    - When residents disperse to other communities following an evacuation, reaching them and communicating becomes difficult.
    - How the connection of community is supported is very important. A community can be ruined by not helping maintain and grow social connections.
    - When strategic connections and community members aren't checked in with regularly, communication becomes transactional, weakening relationships and trust.
    - There is a sense of frustration when community members are told that they can't help in recovery efforts. Allowing them the opportunity to contribute where practical is important.

    - In emergency situations people are almost always looking for someone to blame or to place their fears and frustrations on to. How and when communities communicate to residents during this time is critically important to maintaining trust and confidence.
- Equity
    - The most vulnerable people in a community (i.e., income, ability, access to transportation, stable/quality housing, etc.) are often the most severely affected.
- Mental Health
    - Disasters can impound challenges that are already prevalent. Some communities saw an increase in domestic violence following a disaster in their area.
    - Recovering when the labour force is chronically fatigued and traumatized often leads to impaired decision making because people are inclined to jump to things without fully considering them as they would in 'normal' times. This applies for both the decision-makers and front-line staff, presenting both governance-level and safety challenges.

RECOMMENDATIONS

The following list describes some of the recommendations provided by interviewees, many of whom had firsthand experience in dealing with the above-mentioned challenges.

- Governance
    - It is important for local governments and people in positions of power to understand what is happening to the community, specifically how residents and their families are affected. One interviewee recommended "a listening tour" early in the recovery process.
    - A clear governance structure outlining who is responsible for what aspects of response and recovery is important to avoid duplication of efforts.
    - To combat fatigue within city staff, bring in an external (e.g., four-person) team to lead recovery while staff, many of whom are directly impacted by the disaster, have a chance to recover.
    - Regarding creative problem solving:
        - There is more than one right way to recover. It is more important to iterate rather than following a linear process.
        - Iterating through the creation of prototypes and monitoring user feedback regarding what works and what doesn't is an effective process.
        - Use design thinking type processes and workshops, which is a creative problem-solving approach that emphasizes engagement, dialogue, and learning in a collaborative environment.
        - Create plans and vision statements about where community wants to land following the disaster recovery, and then implement the vision.

- Communication
  - Transparency is key! Understand the scope of problem and communicate the plan so people have confidence in the government.
  - People are very likely to accept solutions that make their community safer, and communications with the community should highlight safety benefits.
  - Coordinate disaster recovery with neighbouring towns/regions and look for opportunities for resource sharing.
    - For example, Community B can have digital backups of important documents of Community A, who is situated in a wildfire interface area/flood plain and is at higher risk of disaster.
  - Make bylaws easy to understand for residents by creating additional information sheets that communicate the impacts (including cost) using clear language and graphics.
  - Share what works and what doesn't with other communities & ask other communities for advice.
- Equity
  - Think about intersectionality and how vulnerable people are accessing resources. Intersectionality refers to the interconnected nature of social categorizations such as race, class, and gender as they apply to a given individual or group, regarded as creating overlapping and interdependent systems of discrimination or disadvantage.
  - Consider affordable access to resources and ways of building.
- Mental health
  - Trauma-informed practices are kinder to people. Traumatized people need to vent and talk about the problem to make sense of it. Build in flexible processes so they include time for reflection, venting.
  - Assign case managers that help connect people with resources, such as financial planning, mental health help, etc. The interviewee recommended assigning case managers to a community for at least two years following the disaster.

REFERENCES

American Institute of Architects. (2009, May 1). *Omega Center for Sustainable Living*. Omega Center for Sustainable Living | AIA Top Ten. Retrieved August 4, 2022, from https://www.aiatopten.org/node/109

American Planning Association. (2022). *Planning for Urban Heat Resilience*. American Planning Association. Retrieved May 28, 2022, from https://www.planning.org/pas/reports/

B.C Coroner's Report. (2022, June 7). *Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021* . Government of Canada. Retrieved August 9, 2022, from https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/extreme_heat_death_review_panel_report.pdf

Berkebile Nelson Immenschuh McDowell (BNIM) Architects. (2022, April 19). *Omega Center for Sustainable Living*. BNIM. Retrieved August 4, 2022, from https://www.bnim.com/project/omega-center-sustainable-living

Berkebile Nelson Immenschuh McDowell, Inc. (2010). *Flow: The Making of the Omega Center for Sustainable Living*. Kansas City, KS; BNIM Architects. Retrieved August 3, 2022, from https://issuu.com/bnim/docs/flow_0.

The Canadian Press. (2022, May 13). *$416 million in disaster funding comes through for homes lost in B.C wildfires*. Vancouver Sun. Retrieved June 9, 2022, from https://vancouversun.com/news/local-news/disaster-funding-for-homes-lost-in-bc-wildfires

CBC News. (2022, June 14). *Abbotsford approves proposal to overhaul flood mitigation systems in City*. CBC News. Retrieved July 12, 2022, from https://www.cbc.ca/news/canada/british-columbia/abbotsford-council-flood-mitigation-plans-1.6487753

City of Vancouver. (2019). (rep.). *Rain City Strategy*. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/rain-city-strategy.pdf.

City of Vancouver. (2019). *Appendix C - IRMP Report Card*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/irmp-report-card.pdf

City of Vancouver. (2019, November 5). *Appendix B - GRI Typologies*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-gri-typologies.pdf

City of Vancouver. (2019, November 5). *Appendix D - Watershed Characterization*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-watershed-characterization.pdf

City of Vancouver. (2019, November 5). *Appendix E - Engagement Summary*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-engagement-summary.pdf

City of Vancouver. (2019, November 5). *Appendix F - Transformative Directions and Action Plans*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-action-plans.pdf

CSA Group. (2021). (rep.). *Nature-Based Solutions for Coastal and Riverine Flood and Erosion Risk Management*. Retrieved May 15, 2022, from https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-Nature-Based-Solutions-for-Coastal-and-Riverine-Flood-and-Erosion-Risk-Management.pdf.

Deloitte Access Economics. (2016). *The economic cost of the social impact of natural disasters*. Australian Business Round Table. Retrieved August 9, 2022, from http://australianbusinessroundtable.com.au/assets/documents/Report%20-%20Social%20costs/Report%20-%20The%20economic%20cost%20of%20the%20social%20impact%20of%20natural%20disasters.pdf

Dickson Hoyle, S., & John, C. (2021). (rep.). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery*. Secwepemcú l̓ecw Restoration and Stewardship Society. Retrieved June 12, 2022, from https://www.srssociety.com/docs/elephant_hill_-_secw%C3%A9pemc_leadership_and_lessons_learned.pdf.

Elefante, C. (2012). *The Greenest Building is the one that is already built*. The Greenest Building Is The One That Is Already Built | Bennington College. Retrieved July 10, 2022, from https://www.bennington.edu/bennington-magazine/greenest-building-one-already-built

Federal Emergency Management Agency. (2020). *Natural hazards retrofit program toolkit - FEMA*. FEMA. Retrieved August 11, 2022, from https://www.fema.gov/sites/default/files/documents/fema_natural-hazards-retrofit-program-tookit.pdf

Foresight Canada. (2022, May 27). *Kanaka Bar Resilient Housing Solutions Challenge Results*. Foresight CAC. Retrieved June 10, 2022, from https://foresightcac.com/learn/kanaka-bar-resilient-housing-solutions-challenge-results/#:~:text=May%2027%2C%202022%3A%20In%20February,after%20the%20devastating%20wildfires%20of

Gowen, A. (2020, October 23). The town that built back green. *Washington Post*. Retrieved May 28, 2022, from https://www.washingtonpost.com/climate-solutions/2020/10/22/greensburg-kansas-wind-power-carbon-emissions/.

GreenBlue Urban. (2017, June 1). *How urban trees reduce energy costs*. GreenBlue Urban. Retrieved July 11, 2022, from https://greenblue.com/ce/urban-trees-reduce-energy-costs/

Hoekstra, G. (2021, November 27). *B.C. needs billions in dike upgrades to prepare for climate change*. Vancouver Sun. Retrieved July 18, 2022, from https://vancouversun.com/news/b-c-needs-billions-in-dike-upgrades-to-prepare-for-climate-change

Insurance Bureau Canada. (2020, August 17). *Task Force for a resilient recovery* . Retrieved July 22, 2022, from https://www.recoverytaskforce.ca/wp-content/uploads/2020/08/IBC-Resilient-Retrofit-Proposal_2pgr_17Aug-2020.pdf

International Living Future Institute. (2022, July 22). *Living Building Challenge*. International Living Future Institute. Retrieved June 10, 2022, from https://living-future.org/lbc/

International Panel on Climate Change. (2014). *Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* . IPCC. Retrieved July 9, 2022, from https://www.ipcc.ch/report/ar5/syr/

Kriegh, J., Magwood, C., & Srubar, W. (2021, February). *Carbon-storing materials: Summary Report*. Carbon Leadership Forum. Retrieved July 10, 2022, from https://carbonleadershipforum.org/carbon-storing-materials/

Lightbody, L., & Fuchs, M. (2018, January 11). *Every $1 invested in disaster mitigation saves $6*. The Pew Charitable Trusts. Retrieved July 31, 2022, from https://www.pewtrusts.org/en/research-and-analysis/articles/2018/01/11/every-$1-invested-in-disaster-mitigation-saves-$6

Marriott, A. (2020). (rep.). *Clean, Resilient Flood Technology Options in Canada*. Retrieved May 23, 2022, from https://act-adapt.org/wp-content/uploads/2020/07/ECCC_Flood-Tech_2020_WEB.pdf.

Met Andere Woorden. (2006). *Spatial Planning Key Decision 'Room for the River': Investing in the safety and vitality of the Dutch river basin region*. Arnhem, Netherlands; Ministry of Transport, Public Works and Water Management (V&W).

Ministry of Community, Sport and Cultural Development. (2011). (rep.). *Development Permit Areas for Climate Action*. Retrieved May 30, 2022, from https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/local-governments/planning-land-use/development_permit_areas_climate_action_guide.pdf.

Natural Resources Canada. (2021, April 6). *Cost of wildland fire protection*. Natural Resources Canada. Retrieved July 22, 2022, from https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/forest-change-indicators/cost-fire-protection/17783

OECD. (2020). (rep.). *Towards Sustainable Land Use: Aligning Biodiversity, Climate and Food Policies*. Retrieved July 23, 2020, from https://doi.org/10.1787/3809b6a1-en.

Omega Institute. (2019). *Project Fact Sheet: Omega Center for Sustainable Living (OCSL)*. Rhinebeck, NY; Omega Institute. Retrieved August 4, 2022, from https://www.eomega.org/sites/default/files/documents/ocsl-fact-sheet.pdf.

Pinna Sustainability. (2020, February). *Climate projections for the Okanagan Region*. Regional District Okanagan Similkameen. Retrieved May 14, 2022, from https://www.rdos.bc.ca/assets/PLANNING/AreaX/2020/ClimateProjections/FinalReport.pdf

Quinn, P. (2013, April 13). After devastating tornado, town is reborn 'green'. Retrieved May 18, 2022, from https://www.usatoday.com/story/news/greenhouse/2013/04/13/greensburg-kansas/2078901/.

RDH Building Science Inc. (2021). (rep.). Climate Change for Resilient Buildings. BC Housing. Retrieved May 16, 2022, from https://www.rdh.com/wp-content/uploads/2021/07/Climate-Change-Resilience-for-Buildings-Primer.pdf.

Stowa. (n.d) *Room for the River*. Retrieved August 3, 2022, from https://www.stowa.nl/deltafacts/waterveiligheid/waterveiligheidsbeleid-en-regelgeving/room-river#1572

SWCA Environmental Consultants. (2017, November 15). *After the storm: The environmental impacts of natural disasters*. SWCA. Retrieved July 18, 2022, from https://www.swca.com/news/2017/11/after-the-storm-the-environmental-impacts-of-natural-disasters#:~:text=Pollutants%20from%20flooded%20industrial%20sites,of%20structural%20changes%20to%20ecosystems.

Tehan, B. (2018, March 14). *The social impact of natural disasters – at what cost?* VCOSS. Retrieved July 22, 2022, from https://vcoss.org.au/emergency-management/2016/03/the-social-impact-of-natural-disasters-at-what-cost/

Urban Green Council. (2014, February 4). *Baby it's Cold inside*. Issuu. Retrieved July 10, 2022, from https://issuu.com/urbangreen/docs/baby_it_s_cold_inside

Urban Land Institute. (2022). *Resilient Retrofits: Climate Upgrades for Existing Buildings* . Retrieved August 11, 2022, from https://knowledge.uli.org/-/media/files/research-reports/2022/resilient-retrofits-climate-upgrades-for-existing-buildings.pdf?rev=36e6e8d45f0e452a868fa3855431f0e0&hash=45C38A1E9B8BA9D74A2B7632E066D16E

US Climate Resilience Toolkit. (n.d.). Following a Devastating Tornado, Town and Hospital Rebuild to Harness Wind Energy [web log]. Retrieved May 28, 2022, from https://toolkit.climate.gov/case-studies/following-devastating-tornado-town-and-hospital-rebuild-harness-wind-energy.

US Department of Energy. (2012). *Rebuilding it Better: Greensburg, Kansas - High Performance Buildings Meeting Energy Savings Goals*. National Renewable Energy Laboratory. Retrieved May 27, 2022, from https://www.nrel.gov/buildings/assets/pdfs/53539.pdf.

World Bank Group. (2021). (rep.). *A Catalogue of Nature-Based Solutions for Urban Resilience*. Retrieved May 15, 2022, from https://openknowledge.worldbank.org/handle/10986/36507.

Zevenbergen C., et al. . (2013). (rep.). *Tailor made collaboration: A clever combination of process and content.* . UNESCO-IHE. Retrieved June 10, 2022, from https://www.un-ihe.org/sites/default/files/13270-rvdr-brochure-governance-engels_def-pdf-a.pdf.

APPENDICES

APPENDIX A – ACKNOWLEDGEMENTS

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Kari Tyler	User Engagement and Training Specialist at Pacific Climate Impacts Consortium
Patrick Michell	Former Chief of Kanaka Bar Band
Richard Walton	Former Mayor of District of North Vancouver
Skip Backus	Chief Executive Officer at Omega Institute
Steven Rice	Director at Thompson-Nicola Regional District
Tanya Spooner	Emergency Programs Manager at the City of Prince George

APPENDIX B – INTERVIEW QUESTIONS

Interview Questions:

1. Tell me a bit about you – your position, responsibilities, background as it relates to this topic. *
2. Have you been directly involved in the planning / post-recovery efforts of rebuilding after a natural disaster? *

If yes to question 2, ask following questions:

3. Please tell me more about what happened (dates/disaster type/damages to infrastructure/ buildings). *
4. What process are you following / did you follow to recover and rebuild? What ideas/solutions were implemented?
5. What would you say is most important when thinking about recovery and rebuilding? (Time, resiliency, safety, financial/mental health supports, other…?) *
6. When it comes to rebuilding efforts, how important are resilient buildings/infrastructure to the community?

   We define resilient buildings as designing for increased longevity with the use of sustainable materials, withstanding extreme weather brought on by climate change, and having a more positive impact on the environment.

7. Is/was there pressure to rebuild the exact same way you built before?
8. What level of knowledge do you think individuals within the community currently have on resilient buildings/infrastructure?
9. Did you set performance targets for recovery or rebuilding?
   a. If yes, how did you measure them?
10. In your experience with rebuilding and recovery, what worked well or would you consider a success? *
11. What are/were the major challenges faced (technical, financial, institutional, etc.)? *
12. In your opinion, what would have helped, or would help to overcome the challenges faced? *
13. Please describe any lessons learned from your experience as it relates to rebuilding and recovery.
14. Please share your thoughts on the future of disaster mitigation and recovery in your region, and/or the province.
    a. What would be the ideal end goal?

If no, to question 2, ask following questions:

3. Please tell us about your impressions of / indirect experience with disaster mitigation and recovery?
4. What would you say is most important when thinking about recovery and rebuilding? (Time, resiliency, safety, financial/mental health supports, other…?) *
5. When it comes to rebuilding efforts, how important are resilient buildings/infrastructure to the community?

   We define resilient buildings as designing for increased longevity with the use of sustainable materials, withstanding extreme weather brought on by climate change, and having a more positive impact on the environment.

6. What level of knowledge do you think individuals within the community currently have on resilient buildings/infrastructure?
7. Please share your thoughts on the future of disaster mitigation and recovery in your region, and/or the province.
   a. What would be the ideal end goal?

Close-out Questions:

1. Do you have suggestions on specific case studies we could examine for this project? *
2. Are you aware of any bylaws, policies, or other guidance materials that would be of benefit to share with local governments for this purpose? *
3. Who else would you suggest we speak with about this topic? *
4. Do you any comments or suggestions you'd like to share that weren't covered in our discussion? *

** Questions followed by asterisk (*) are open-ended, trauma-informed questions asked to interviewees that have been personally affected by natural disasters.*

APPENDIX C – CASE STUDY 1: OMEGA CENTER FOR SUSTAINABLE LIVING

Inspiration behind the Omega Center for Sustainable Living

The Omega Institute is a nonprofit educational organization focused on holistic studies and provides workshops, retreats, conferences and professional trainings in its 250 acre campus. In 2005 Omega's aging septic system needed to be replaced to accommodate an organization that hosts up to ***20,000 users in its campus****.*

Instead of going the traditional route with chemicals, Omega wanted to create a ***natural water reclamation system, that would handle water not as waste, but as a precious resource.*** *Omega chose to build an Eco Machine™, a natural "wastewater" treatment system that cleans water by mimicking the systems of the natural world.*

Source: https://www.aiatopten.org/node/109

Inspiration Continued: *Part of the Eco Machine™ needed to be housed by a building. Omega also wanted the building to include a classroom, and be designed in a way that would allow the public to learn about the water reclamation process, witness the latest developments in regenerative design, and take courses that highlight their connection to nature and inspire greater sustainability in their own lives and communities.*

VISION

The Omega Center for Sustainable Living (OCSL) is a **purposeful building and site**, designed to **clean water**, **return the clean water** to the local systems, and **educate** users about the process.

KEY PARTNERSHIPS

Two partnerships played a key role in creating the OCSL. **John Todd Ecological Design** is the architecture firm that created the Eco Machine™ and **BNIM Architects** designed the building. The selected project team of engineering consultants also had experience working together on high performance building design.

The Omega Institute worked with State of **New York** and the **Department of Environmental Conservation (DEC)** to approve the project. When an endangered species was discovered on site, the **Federal Emergency Management Agency (FEMA)** was brought in. [5]

GENERATING LOCAL SUPPORT

The project was challenging from a legislative perspective because the project differs from current wastewater systems. A member of the project team highlighted how these challenges were overcome:

- Make partners out of people so they have a role in the project. Trust is earned by demystifying the process.
- Speak to people in their language by understanding what their concerns are (economically, technically, politically) and how you plan on addressing those concerns.
- Create a failsafe system by agreeing to do things the regular way if the innovative system doesn't work. [5]

OUTCOMES

This Project Fact Sheet outlines the Center's accomplishments and building performance from 2009-2019, some of which are summarized here.

- 100% of energy supplied by on-site renewable sources
- 100% of precipitation managed on-site
- 98% of building is daylit
- 78% of building is naturally ventilated, net zero energy, net zero water, and net zero waste [1]

LOW CARBON RESILIENT DESIGN

The project highlights how infrastructure and buildings can be designed resiliently. By creating a closed-loop system that recharges aquifers, the OCSL has **no impact on the water table** and ensures water sustainability for years to come.

- ***Flexibility***
  - The building is not only designed with sustainable materials and low energy, it can also be used as a classroom, event space, and yoga studio.
- ***Innovation***
  - The core of the facility is a 4,500-square-foot greenhouse containing a water filtration system called the Eco Machine™. **The Eco-Machine system mimics a natural and robust ecosystem, such as a wetland, that filters and recycles waste, nutrients, and contaminants**. The system is **chemical free**, **uses zero net energy**, and **creates a closed loop hydrological cycle.** The Eco Machine filters approximately **200,000**

L/day. Since inception, approximately **348 million liters of water** have been filtered without chemicals.

- ***Materials***
    - **Interior finishes are reduced or eliminated**, which reduces the embodied carbon and also minimizes off-gassing from various construction materials. Materials requiring **little or no maintenance** were used throughout the facility due to the harsh exterior and interior (greenhouse) environments. **Reclaimed materials** were used throughout the building, such as: dimensional lumber, plywood, interior doors, beech wood paneling, and toilet partitions. **Materials came from warehouses,**
    - **schools, office buildings, and other projects.** [1, 2, 4]

RECOMMENDATIONS

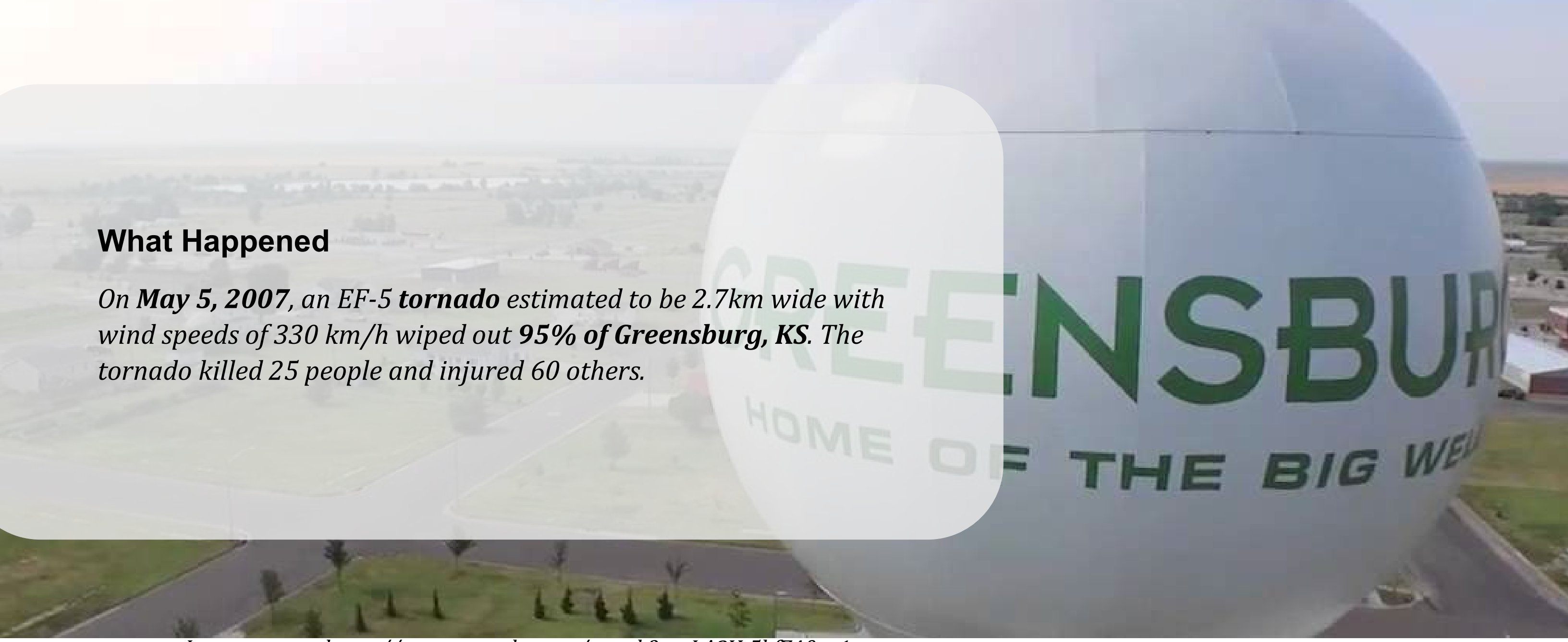
The following policy recommendations would help support projects like the OCSL:

- Increase transparency on permitting process to encourage projects like the OCSL
- Streamline municipal engineering costs, reduce duplicative efforts and the length of time to review the project for approval

RESOURCES

1. Berkebile Nelson Immenschuh McDowell (BNIM) Architects. (2009). *Omega Center for Sustainable Living*. BNIM. Retrieved August 4, 2022, from https://www.bnim.com/project/omega-center-sustainable-living
2. Berkebile B., McDowell S., Lesniewski L., (2010). *Flow: The Making of the Omega Center for Sustainable Living*. Kansas City, KS; Berkebile Nelson Immenschuh McDowell Architects Inc. Retrieved August 3, 2022, from https://issuu.com/bnim/docs/flow_0.
3. Omega Institute. (2019). *Project Fact Sheet: Omega Center for Sustainable Living (OCSL)*. Rhinebeck, NY; Omega Institute. Retrieved August 4, 2022, from https://www.eomega.org/sites/default/files/documents/ocsl-fact-sheet.pdf.
4. American Institute of Architects. (2009, May 1). *Omega Center for Sustainable Living*. Omega Center for Sustainable Living | AIA Top Ten. Retrieved August 4, 2022, from https://www.aiatopten.org/node/109

APPENDIX D – CASE STUDY 2: GREENSBURG, KS



What Happened

*On **May 5, 2007**, an EF-5 **tornado** estimated to be 2.7km wide with wind speeds of 330 km/h wiped out **95% of Greensburg, KS**. The tornado killed 25 people and injured 60 others.*

Image source: https://www.youtube.com/watch?v=cLA3V-5bfZ4&t=1s

VISION

The town decided to build back "green" and created a **Sustainable Comprehensive Master Plan** for the next 20 years that outlined their road to recovery.

OBJECTIVE

The town set the objective to convert to wind power electrical generation and rebuild sustainably as outlined in the Master Plan.

POLICY

Eight months after the tornado, the Greensburg City Council adopted a resolution:

> *"All large public buildings in Greensburg with a footprint exceeding 4,000 square feet must meet the LEED-platinum standards of the U.S. Green Building Council and utilize renewable energy sources."*

KEY PARTNERSHIPS

The town partnered with the **US Department of Energy (DOE)** and the **National Renewable Energy Laboratory (NREL)** to identify ways to incorporate energy efficiency and renewable energy technologies into new buildings

The architecture firm **BNIM** worked with the town to create the Greensburg Sustainable Comprehensive Master Plan.

Greensburg is a town with conservative values, so ***highlighting the economic benefits of going green*** was key to generating community support.

OUTCOMES

15 years after the tornado, Greensburg achieved the following objectives:

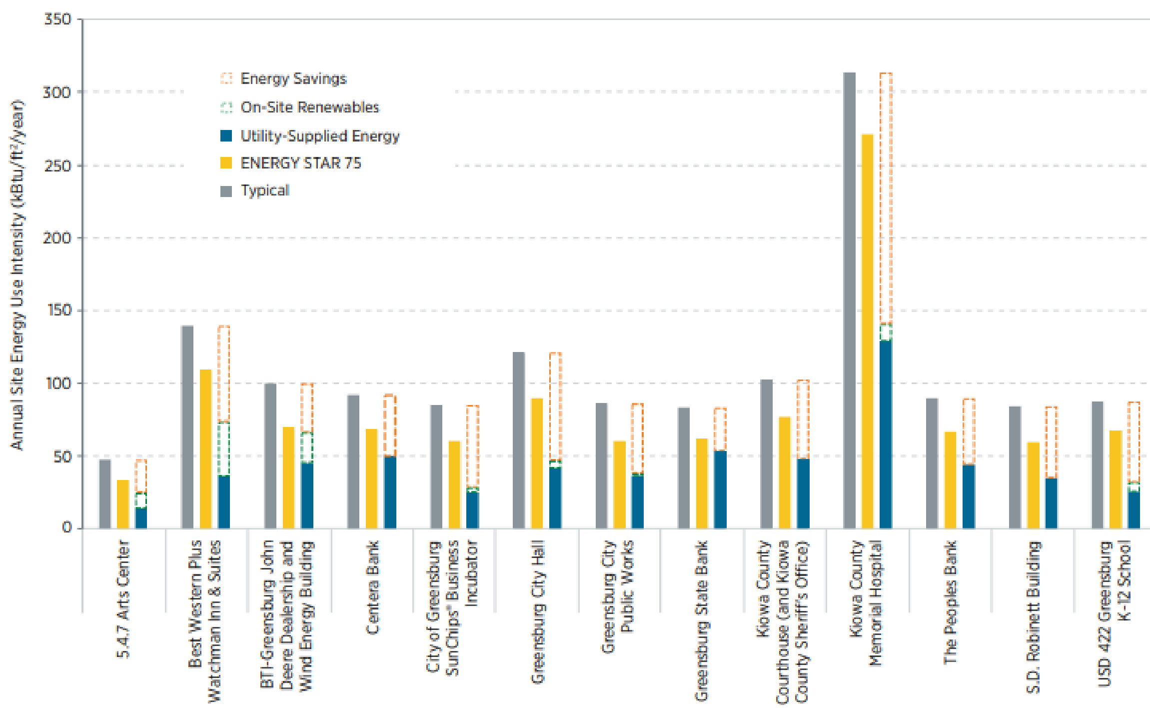
- The **Greensburg Wind Farm** includes ten 1.25-megawatt (MW) wind turbines that supply 12.5 MW of renewable power to the town, while also selling power to other Kansas municipalities.
- **13 public buildings designed to LEED Platinum**, leading to **$200,000 savings** in energy costs per year.
- Key buildings are clustered in **walkable blocks**.
- Building LEED Platinum led to a **20% increase** in construction costs.
- Residents formed a nonprofit organization, Greensburg GreenTown™, to provide resources and support as Greensburg rebuilt.
- The town built 400 modest homes with front porches.

LOW CARBON RESILIENT DESIGN

The town's regional characteristics made it suitable for wind power generation. The solutions used for the building designs were climate and region specific.

The [Rebuilding it Better: Greensburg, Kansas] document prepared by the US Department of Energy highlights design strategies used to achieve up to **42% energy reduction** in the 13 public buildings.

The following graphic highlights the energy savings and compares them against the typical and energy efficient code standards:



Source: NREL website

A few **design strategies** that were used across many of the buildings are listed below:

- **Energy** - Many projects incorporated solar panels, ground source heat pumps, and a vegetated roof to reduce heating and cooling needs.
- **Daylight** - Conserved energy by maximizing natural daylight. This was achieved through:
  - Optimizing south and north facing light
  - Incorporate skylights, tubular daylighting devices, clerestories, electric lighting systems such as LEDs
- **Water** – dual flush toilets and waterless urinals reduced water by more than 50%
- **Materials** – used local, reclaimed, and recycled content materials as much as possible, such as gypsum, window sills, countertops, and ceramic tiles.
- **Building envelope** – an airtight envelope and thermal insulation were used to heat in during cold months.
- **Air quality** – non-toxic, low VOC products were chosen for paint, adhesives, sealants, interior composite wood, and agrifiber items.

The guide also provides **operational strategies for ensuring the buildings operate efficiently**, such as:

- Placing daylighting sensors in all spaces that receive abundant daylight
- Placing occupancy sensors in locations with electrical lighting
- Lowering setpoints (when appropriate) for all building controls during times when the building is unoccupied
- Turning off all electronics and other plug loads at night to prevent energy waste
- Reviewing utility bills annually and comparing the energy consumption to past years. This will help ensure a high level of performance by indicating when maintenance is needed.

RESOURCES

1. US Department of Energy. (2012). *Rebuilding it Better: Greensburg, Kansas - High Performance Buildings Meeting Energy Savings Goals*. National Renewable Energy Laboratory. Retrieved May 27, 2022, from https://www.nrel.gov/buildings/assets/pdfs/53539.pdf.
2. Quinn, P. (2013, April 13). After devastating tornado, town is reborn 'green'. Retrieved May 18, 2022, from https://www.usatoday.com/story/news/greenhouse/2013/04/13/greensburg-kansas/2078901/.
3. US Climate Resilience Toolkit. (n.d.). Following a Devastating Tornado, Town and Hospital Rebuild to Harness Wind Energy [web log]. Retrieved May 28, 2022, from https://toolkit.climate.gov/case-studies/following-devastating-tornado-town-and-hospital-rebuild-harness-wind-energy.
4. Gowen, A. (2020, October 23). The town that built back green. *Washington Post*. Retrieved May 28, 2022, from https://www.washingtonpost.com/climate-solutions/2020/10/22/greensburg-kansas-wind-power-carbon-emissions/.

APPENDIX E – CASE STUDY 3: RAIN CITY STRATEGY

Inspiration behind the Rain City Strategy

In order to eliminate sewage overflows by 2050 and **improve water management holistically**, the Vancouver City Council unanimously approved an ambitious green rainwater infrastructure and urban rainwater management initiative called the ***Rain City Strategy***. [1]

Source: https://revitalization.org/article/vancouver-british-columbia-adopts-new-rain-city-strategy-to-restore-water-quality-regenerate-ecosystems-and-boost-climate-resilience/

Inspiration Continued: *The strategy and its action plans reimagine how the City can manage rainwater, representing a significant opportunity to take bold strides toward becoming a water-sensitive community.*

VISION

The Strategy's vision is that Vancouver's **rainwater is embraced as a valued resource for its communities and natural ecosystems.** The project aims to simultaneously improve water management and the community's engagement with water through **Green Rainwater Infrastructure (GRI)**.

The **benefits of GRI** are:

- Flood reduction
- Sustainable water management
- Improved water and air quality
- Reduces sewer infrastructure cost [1]

OBJECTIVES

The Strategy's goals and objectives are summarized in the graphic on the next page [1]:

Vision: Vancouver's rainwater is embraced as a valued resource for our communities and natural ecosystems

Goals:

- Improve and protect Vancouver's water quality
- Increase Vancouver's resilience through sustainable water management
- Enhance Vancouver's livability by improving natural and urban ecosystems

Objectives:

- Remove pollutants from water and air
- Reduce volume of rainwater entering pipe system
- Increase managed impermeable area that treats urban rainwater runoff
- Increase total green area that treats urban rainwater runoff
- Mitigate urban heat island effect
- Harvest and reuse water

POLICY

The Strategy sets the following performance targets by 2050:

- **90%** of Vancouver's average annual rainfall will be captured and treated close to where it lands;
- **48 mm** of rainwater per day will be managed by sites and GRI assets;
- **40%** of Vancouver's impervious areas will manage rainwater volume and water quality through new development, capital projects and strategic retrofits [1].

The Strategy reaffirms the previously adopted performance target to manage 90% of Vancouver's average annual rainfall, increases the design standard for the volume of rainwater to be managed by sites and GRI assets to 48 mm per day and establishes an ambitious implementation target to manage rainwater volume and water quality for 40% of Vancouver's impervious areas by 2050 through new development, capital projects and strategic retrofits.

KEY PARTNERSHIPS

To create the Strategy, the City of Vancouver consulted with a number of **consultants, non-profits and academic professionals**, some of which are listed below. See page two of the report for a full list:

- University of British Columbia
- Kwantlen Polytechnic University
- Simon Fraser University
- Kerr Wood Leidal
- Hapa Collaborative
- False Creek Watershed Society
- Still Moon Arts Society

LOW CARBON RESILIENT DESIGN

There are different types of green rainwater infrastructure incorporated in the Rain City Strategy, which are summarized and illustrated in the GRI Typologies document, some of which are also listed below:

- **Bioretention practices** are engineered landscapes designed to infiltrate and filter urban rainwater runoff
  - GRI types: bioswales, bioretention bulges and cells, rain gardens
- **Rainwater tree trench (RTT)**, which provides both storage for rainwater and support to street trees
  - GRI types: soil cells and structural soil
- **Resilient Roofs** can be designed to manage rainwater and support plant growth
  - GRI types: Green roofs (extensive and intensive), blue roofs, blue-green roofs, white roofs
- **Permeable pavement** allows rainfall to soak into an underlying reservoir base where it is either infiltrated to the ground or removed by a subsurface drain.

    - GRI types: Permeable concrete pavers, pervious concrete, porous asphalt, grass grid pavers/country lane, porous rubber, permeable epoxied gravel
- **Large scale practices** include a variety of tools that collect and manage large volumes of surface water
    - GRI types: Engineered wetlands, floodable spaces, stream daylighting
- **Non-potable systems** aim to collect, store, treat and supply non-potable water in buildings and facilities.
    - GRI types: Water harvest, re-use, and treatment
- **Subsurface Infiltration** use conventional grey rainwater infrastructure to collect and convey rainwater to areas where it can be stored and infiltrated.
    - GRI types: Infiltration trenches, dry wells, soakways, chambers, arches, modular systems
- **Absorbent landscapes** are vegetated areas designed to absorb and retain larger amounts of rainfall than conventional compacted landscapes without ponding.
- **Downspout disconnection** is the process of redirecting rainwater flowing from downspouts away from the sewer system to complementary rainwater management practices designed to use or absorb rainwater. It works in concert with other types of GRI mentioned above, such as bioretention, rainwater harvest and reuse.

OUTCOMES

A list of project examples implemented in Vancouver are listed below:

- Bioretention practices rain garden and bioswale– West 63rd and Yukon Street
- Rainwater tree trench at Quebec Street and 1st Avenue
- Green roof at VanDusen Botanical Gardens
- Permeable interlocking concrete pavers at Olympic Village on Athletes Way and Columbia Street
- Creek daylighting at Creekway Park
- Engineered wetland at Hinge Park, which collects and manages two thirds of the rainwater that runs off of roadways, plazas and other public spaces in Olympic Village
- On-site wastewater treatment plant and distribution system at the Vancouver Convention Center reduces water use by 38% or 300,000 toilet flushes per year
- Infiltration trench at Burrard Street and Cornwall Street captures more than 24mm of rainfall within 24 hours

RESOURCES

1. City of Vancouver. (2019). (rep.). *Rain City Strategy*. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/rain-city-strategy.pdf.
2. City of Vancouver. (2019, November 5). *Appendix B - GRI Typologies*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-gri-typologies.pdf
3. City of Vancouver. (2019). *Appendix C - IRMP Report Card*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/irmp-report-card.pdf

4. City of Vancouver. (2019, November 5). *Appendix D - Watershed Characterization*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-watershed-characterization.pdf
5. City of Vancouver. (2019, November 5). *Appendix E - Engagement Summary*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-engagement-summary.pdf
6. City of Vancouver. (2019, November 5). *Appendix F - Transformative Directions and Action Plans*. City of Vancouver. Retrieved May 24, 2022, from https://vancouver.ca/files/cov/one-water-action-plans.pdf

APPENDIX F – CASE STUDY 4: ROOM FOR THE RIVER

What Happened

*In 1993 and 1995, the water levels in the rivers of the Netherlands were dangerously high, resulting in floods. In the 1995 flood, **250,000 people and 1 million animals were evacuated**.*

Source: https://nlintheusa.com/room-for-the-river-waal/

Continued:** The Room for the River program was created to **address flooding with the aim of improving safety and spatial planning.** The key rationale for the project was that with every dike height increase, the flood risk also grows – water surges with greater force, resulting in a greater number of casualties and economic damage. The government implemented **34 different projects** to address flooding for both upstream and downstream considerations – originally 39 projects were planned, but 5 became unnecessary after applying vigorous implementation to certain projects. **Construction began in 2007 and finished in 2016**, with the total project cost coming to **2.2 billion Euros. [1]

VISION

The overall aim was water level reduction with safer and more attractive catchment areas. The rationale for improving the spatial quality was to improve urban and rural development, create more recreational areas, and strengthen the economy.[1]

OBJECTIVE

As a result of giving the rivers more room, the River Rhine can safely transport **16,000 m^3** of water per second to the sea. That is **1,000 metres per second (m^3/s)** more than is currently possible (equivalent to approximately 4,000 baths full of water).[1]

POLICY

In 2006, the Cabinet of the Netherlands drew up the **Spatial Planning Key Decision (SPKD)**[4] Room for the River, which has three objectives:

1. In 2015 the Rhine branches will safely cope with an outlet capacity of 16,000 m^3/s;
2. The measures implemented to achieve the above will also improve the quality of the environment of the river basin;
3. The rivers have adequate space to expand through the coming decades.

KEY PARTNERSHIPS

Collective leadership is one of the key cornerstones of Room for the River, which was made possible through partnerships with stakeholders. The stakeholders involved were: politicians, mayors, project leaders, contractors, nature conservation organizations, farmers, consultants, residents, and businesses.

The SPKD **linked local and regional ambitions to the flood protection issue**. The group who took on **leadership** of the planning phase was typically a **water board, province, or municipality**.

Given the scope of the program, Room for the River called for **multi-level water governance**. Different phases of the project demanded different expertise and approaches, and **adaptive management** which required collaboration between the program office and the region.[2]

There was a sense of urgency following the floods. The project initially aimed for completion in 2018. The Minister of Transport and Water Management assigned the **Elverding Commission**, which created a report that **accelerated the project completion from 2018 to 2015.**[1]

GENERATING LOCAL SUPPORT

One of the challenges of the project was **community buy-in from residents and business owners** who had to be relocated due to the river expansion. A total of **150 houses and 40 businesses** needed to be **relocated** to make room for the rivers.

Farmers partnered with the regional farmer's group to create a **mound plan** that relocated farms were placed on so that even if water levels rose again, the farms would be protected. The organization also coordinated support from the province. There was expedited permitting for the creation of polders (a tract of low land reclaimed from a body of water). Local support was earned through **empathy and transparency** by acknowledging a person's role and interests. There was continuous consultation with residents and farmers, sometimes discussing the project design with them in their home. A manager was tasked with responding to residents' questions.

PROJECT DELIVERY

A balance between directing and collaborating led to consistent management in projects. Milestones played a crucial role in project delivery.

Intensive cooperation between state and region led to **incorporating things like cycle paths early on because doing it later would be more costly.** This also created buy-in from the community.

Some projects had an **integration of land uses**, that combined farming with water management, nature conservation, and recreation. One example is that the IJsselland Foundation owns the nature reserve land that a local farmer uses. The Foundation reimburses the farmer for mowing and removing the grass as part of river management and their cows keep the grass short.[1]

The key behind the successful collaborations was creating a coherent programme with **customized projects that were tailored to what the community needed**. Focusing on shared interests and goals, rather than shared viewpoints, led to successful outcomes.

Stakeholders were involved in the design process through **workshops**. A coaching firm was brought in for simulation games. Bus trips to similar projects were organized as a way for people to get to know each other and find common ground.

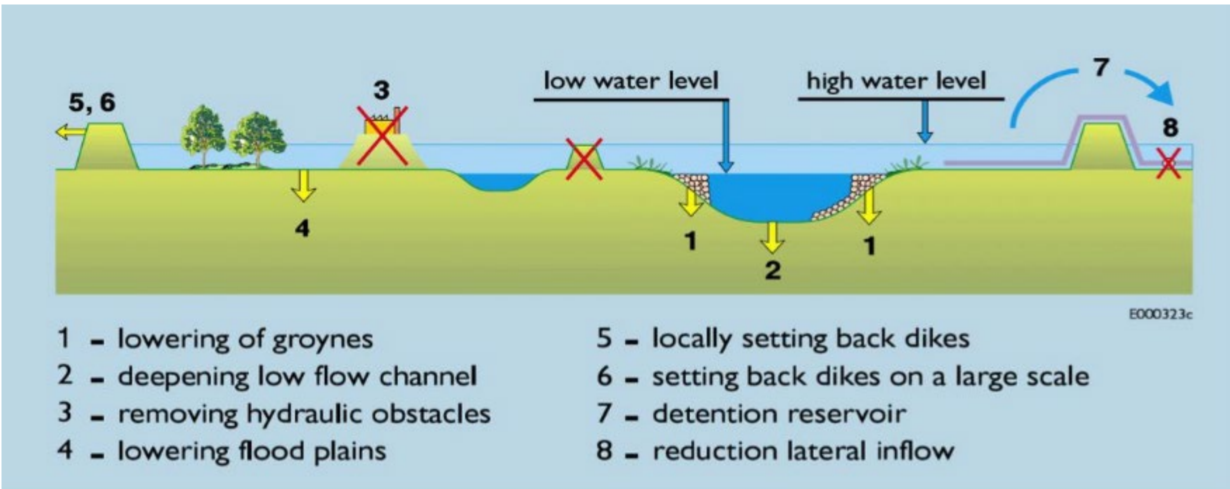
LOW CARBON RESILIENT DESIGN

The river region was considered as a whole – a one-system approach where the effectiveness of measures was seen in conjunction with one another. **The project encompasses natural areas, creating housing, businesses, and recreation.**

The design approach was to **"move with the water"** instead of fighting against it. The **design solutions were determined by water reduction levels**. The open-ended design outcomes helped create a culture of learning, where projects are "invented by those involved". Soft delta technology such as nature-based solutions were prioritized.

The **Building Blocks computer program** calculates the hydraulic results of a combination of river widening measures and supports the design and selection of measures. It also supported dialogue between participants and decision-making.

The Room for the River approach consists of a number of separately applicable measures. Eight measures are presented in the figure below.



Source (Silva et al, 2001)

The measures work as follows: [1]

1. Groynes stabilize the location of the river and ensure its correct depth. However, in a high-water situation, groynes may obstruct the flow to the river. Groynes reduce the inundation time duration, increasing floodplain resilience.
2. Excavating/deepening the surface of the riverbed creates more room for the river. Eco-engineering solutions can produce natural channel designs.
3. If feasible, removing or modifying obstacles in the riverbed will increase the floodplain discharge capacity.
4. Lowering/excavating part of the floodplain increases room for the river in high water situations
5. Relocating a dike inland widens the floodplain and increases room for the river
6. Relocating a dike inland on a large scale will widen the floodplain on a larger scale and will create more room for the river.

7. The dike on the riverside of a polder is lowered and relocated inland. This creates space for excess flows in extreme high-water situations.
8. Reducing the lateral inflow by measures in the field of land use. Retention will reduce peak water flows by storing the water upstream. Runoff production can be reduced by for example reforestation.

RECOMMENDATIONS FOR REBUILDING BETTER

A few regional examples are listed below. Each example highlights a low carbon resilience and/or implementation strategy that helped deliver the project on time and budget [1]:

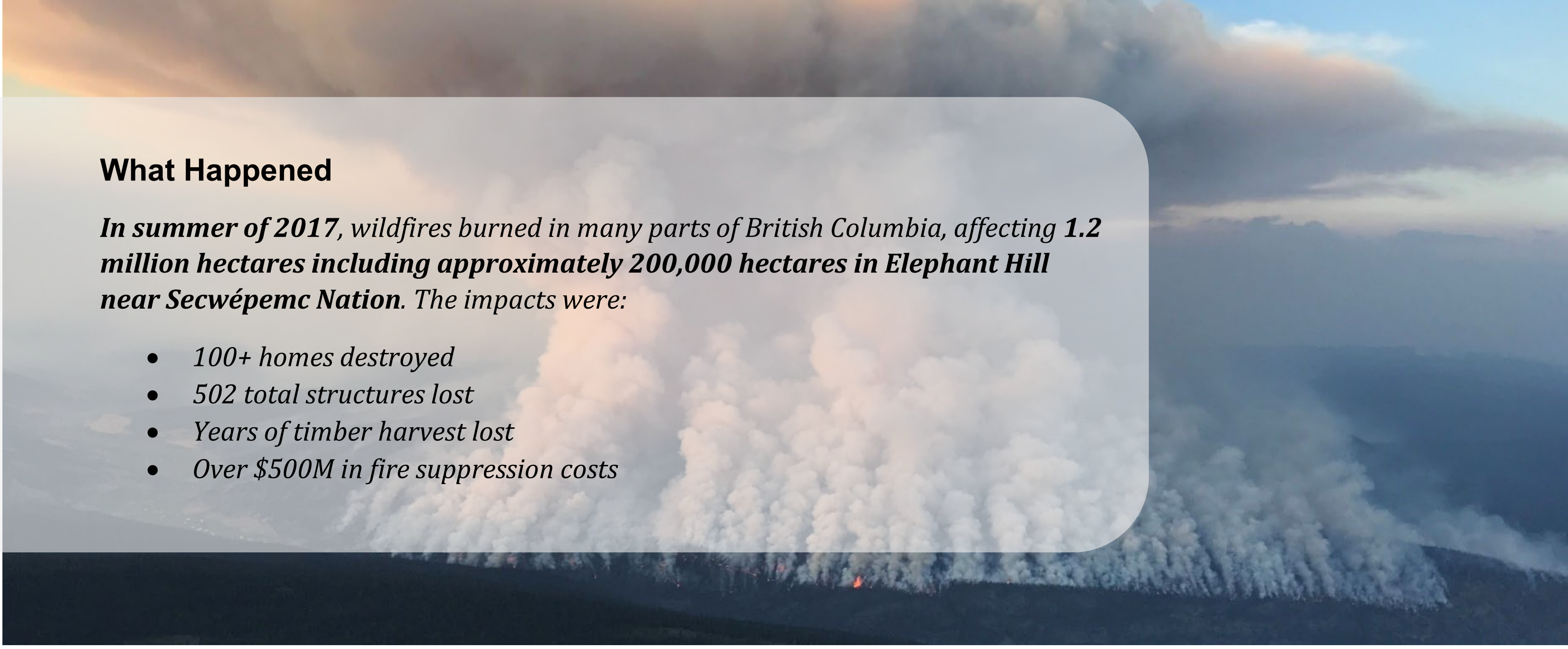
- Lower Rhine
    - 4 projects where planning and realization was the responsibility of one contractor
    - Faster excavation and implementation lead to reduced construction cost
- Overdiepse Polder
    - Local community participation with dairy farmers
    - Constructed mounds (terps) on top of which farmers could rebuild their farmhouses
    - Farmhouses relocated to 8 mounds – in the case of flooding, farms will still be on dry land
- Meinerswijk
    - Cycle lanes and footpaths partly financed by the Municipality created an opportunity to build a floodplain park
- Nijmegen
    - Dyke relocated 350m away which means that water levels will drop by as much as 35cm
    - Creation of river park for nature and recreational activities acted as catalyst for urban planning
- Avelingen – Municipality of Gorinchem
    - Creating channel deep enough for shipping and an extra container park
    - The project served as boost for sustainable river transport
- Munnikenland
    - Multi-functional river dyke with foot and cycle paths as well as lookout points
    - Soil is reused
    - Cattle keeps vegetation down
    - The project served as a stimulus for nature, culture and recreation
- Noordwaard
    - The area will be depoldered, which means that dykes will either be removed completely or moved inland. This means the area will be under water several times a year.
    - The rationale behind this was to allow the river to flow more quickly to the sea and provide flood protection downstream.
    - Farmers can continue to live and work by living on existing mounds and also by creating new ones. They will not need to move during depoldering works.
    - Evacuation plan is created to evacuate at times of dangerously high water levels.
    - Landscape will reverse to its original characteristics with sandbanks, reeds, shallow streams and wooded areas.
    - 47 bridges are built in the wetland area.

- IJsselsprongg project
    - A multidisciplinary project involving a county, 3 municipalities and water board which addressed two dyke replacements
    - Created one plan which encompasses housing, road infrastructure and a green buffer
- Veesen-Wapenvel project
    - Faced a lot of resistance initially from farmers.
    - The water board's management branch was very familiar with the farmers, the culture, the location specific issues, implementation aspects and agricultural matters, which allowed them to act on the interests of the farmers.
    - The board visited the farmers in their homes to discuss individual concerns, explain the project with drawings and clear language which plots the farmers would get, where drainage is installed, where a ditch had to be moved or a culvert ditch installed.

SOURCES AND FURTHER READING

1. Zevenbergen C., et al. (2013). *Tailor made collaboration: A clever combination of process and content*. [online] UNESCO-IHE Institute for Water Education, Available at: <https://www.un-ihe.org/sites/default/files/13270-rvdr-brochure-governance-engels_def-pdf-a.pdf> [Accessed 10 June 2022].
2. Tisma A. and Meijer J. (2018), *Lessons learned from spatial planning in the Netherlands. In support of integrated landscape initiatives, globally.* PBL Netherlands Environmental Assessment Agency, The Hague. Available at: <https://www.pbl.nl/en/publications/lessons-learned-from-spatial-planning-in-the-netherlands-in-support-of-integrated-landscape-initiatives-globally> [Accessed 11 June 2022].
3. Silva W., Klijn F., Dijkman, J.P.M (2001). *Room for the Rhine branches in The Netherlands: What the research has taught us.* TU Delft, Deltares (WL); RIZA. Available at: <https://repository.tudelft.nl/islandora/object/uuid%3A12b2ad06-3469-49ea-a280-78e1dcc2fcb9> [Accessed 03 August 2022].
4. Met Andere Woorden. (2006). *Spatial Planning Key Decision 'Room for the River': Investing in the safety and vitality of the Dutch river basin region*. Arnhem, Netherlands; Ministry of Transport, Public Works and Water Management (V&W).
5. Stowa. (n.d.). *Room for the River*. Retrieved August 3, 2022, from https://www.stowa.nl/deltafacts/waterveiligheid/waterveiligheidsbeleid-en-regelgeving/room-river#1572

APPENDIX G – CASE STUDY 5: ELEPHANT HILL FIRE RECOVERY



What Happened

In summer of 2017*, wildfires burned in many parts of British Columbia, affecting* ***1.2 million hectares including approximately 200,000 hectares in Elephant Hill near Secwépemc Nation****. The impacts were:*

- *100+ homes destroyed*
- *502 total structures lost*
- *Years of timber harvest lost*
- *Over $500M in fire suppression costs*

Source: https://news.ubc.ca/2021/12/06/review-of-elephant-hill-fire/

VISION

The scope and scale of the Elephant Hill wildfire, which crossed multiple jurisdictions and Indigenous territorial boundaries created an opportunity for **collaborative efforts to implement land-based recovery**. Addressing the wide-ranging impacts of this fire required drawing on multiple areas of expertise and bringing together industry, First Nations, and different levels of government.

OBJECTIVE

The three main objectives of the recovery, which were agreed on by all parties, were:

- **Salvage harvesting** to reduce the loss of timber supply
- **Fireguard rehabilitation** to remove fuel
- **Range recovery** (specifically rebuilding fences on Crown range land)

Archaeology formed a key piece underlying all three objectives to ensure that present artifacts or cultural sites were protected.

KEY PARTNERSHIPS/ GOVERNANCE

Secwépemc Chiefs strongly advocated for Secwépemc leadership in recovering and restoring their territories in the months, years, and decades to come. Recovery efforts led to forming the Secwepemcúl'ecw Restoration and Stewardship Society (SRSS), which was set up to receive and manage wildfire recovery funding and aid in coordinating collaborative projects and facilitating partnerships with provincial and federal agencies and external stakeholders.

The **Elephant Hill Joint Leadership Council (JLC)** and **Elephant Hill Joint Technical Committee (JTC)** were created to facilitate collaborative conversations and decision making at both strategic and operational levels of wildfire recovery. The JTC, which consisted of natural resource, cultural heritage, stewardship and other scientific/ research staff from Secwépemc communities; Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD); Regional Districts; and the BC Wildfire Society (BCWS), provided recommendations that were ratified by the JLC in a consensus-based manner.

Sub-committees were formed to create focused working groups. The groups and their goals are listed below:

- **Access managemen**t – Develop access management principles and road recovery strategies
- **Silviculture** – Develop silviculture principles to guide reforestation within the Elephant Hill wildfire area
- **Collaborative monitoring** – Identify potential funding for collaborative/ First Nation-led monitoring within the region and establish monitoring principles

POLICY/ GUIDANCE

A broader view of recovery was formalized into government when in 2018, BC became the first Canadian province to adopt the **Sendai Framework for Disaster Risk Reduction** and its principle of 'building back better'.

The JTC wrote the ***Declaration on the Understory within the forests of Secwepemcú́lecw,*** which supported the **Morel Permit Program**, a management strategy to mitigate ecological and human health impacts stemming from the commercial mushroom harvest in the Elephant Hill Fire. The Declaration and permitting program demonstrate an approach to implementing the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

The **Elephant Hill Wildfire Recovery Repor**t made **30 recommendations**, framed as "calls to action" that address critical needs and priorities for advancing First Nation engagement and leadership across all stages of wildfire management and upholding commitments to reconciliation.

The recommendations are categorized across the four pillars of emergency management: mitigation, preparation, response, and recovery.

LOW CARBON RESILIENCE

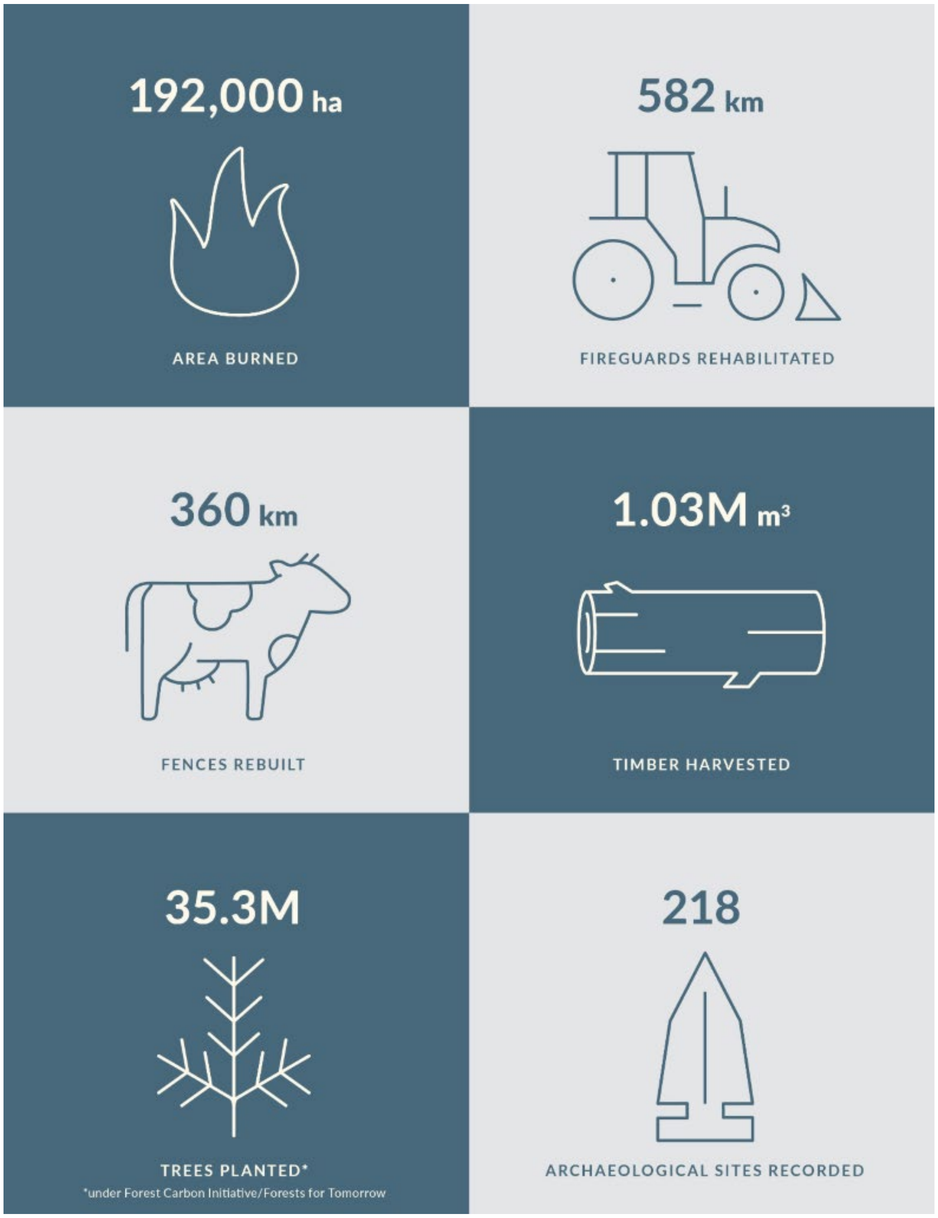
The three recovery objectives resulted in a series of co-benefits that helped to restore the area. Although the objectives were relatively short-term, they set a foundation for ongoing resilient wildfire recovery. One of the recommendations in the *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery* report is that long-term goals are just as important, if not more important, to ecosystem health than those short-term recovery-oriented objectives and should be prioritized accordingly.

- Harvesting burnt forests **reduced the loss of timber supply** and promoted **strategic retention of trees** in environmentally- and culturally-sensitive areas.
- Fireguard rehabilitation also **reduced the risk of landslides**, which are associated with increased runoff or other changed drainage patterns. It also **increased access for hunters** who are often on quads, thus **decreasing rehabilitation disturbance** in the affected areas from having proper access roads.

- Range recovery allowed for the **ecological recovery** of Crown rangeland in terms of the regeneration of forage species and the stabilization of soils as well as **rebuilding fences and range infrastructure** so cattle can roam safely.

OUTCOMES

The Secwépemc-led wildfire recovery achieved the following **quantifiable objectives**:



Source: 2021 Elephant Hill Report

In addition to the above-mentioned results, **additional tools and policies** were created to help wildfire recovery:

- Written report on lessons learned

- Implementation of motorized vehicle and ATV hunting closures
- Restriction in Limited Entry Hunting tags for moose
- Direct awarding archaeological work to First Nations
- Implementation of Secwépemc morel permit program
- Writing the Declaration of the Understory in the Forests

CHALLENGES AND NEXT STEPS

The Lessons Learned report highlights a number of recommendations for policy makers. Some of the challenges and recommendations for overcoming the challenges are listed here:

- Prioritize long term ecosystem health in addition to short term recovery efforts.
    - There were conflicting expectations for recovery amongst the JLC – immediate rebuilding vs. long term recovery.
- Reduce barriers to prescribed burning as a wildfire prevention method.
    - Prescribed/ cultural burning reduces risk associated with landscape and local-level hazards and regenerates ecosystems by reducing fuel loads. The practice is not currently recognized by government agencies and there are differing viewpoints on protecting life and structures vs. promoting the health of ecosystems. There are limited windows for doing prescribed burns (approximately 2-week windows in spring and fall), which makes permitting challenging. There are also concerns over insurance and liability in carrying out a prescribed burn.

RESOURCES

Dickson Hoyle, S., & John, C. (2021). (rep.). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery*. Secwepemcú ĺecw Restoration and Stewardship Society. Retrieved June 12, 2022, from https://www.srssociety.com/docs/elephant_hill_-_secw%C3%A9pemc_leadership_and_lessons_learned.pdf.

Dickson Hoyle, S., & John, C. (2021). (rep.). *Elephant Hill: Summary and Recommendations*. Secwepemcú ĺecw Restoration and Stewardship Society. Retrieved June 12, 2022, from https://www.srssociety.com/docs/elephant_hill_-_summary_and_recommendations.pdf