Systems Based Approaches for Climate Resilient Infrastructure

Part 1: Literature Review for the Canadian Context

Submitted to BC Ministry of Transportation and Infrastructure
by IBI Group and Ramboll
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Executive Summary

This report contains a review of systems-based approaches that could be applied in Canada to improve the resiliency of infrastructure to climate change. It contains examples of scalable (multi-level) and flexible (multi-context) systems-based approaches which cover the lifecycle of climate related events: from pre-event preparation, through initial response, to post-event recovery and the eventual rebuild.

This report was prepared to inform the work of the Committee of Deputy Ministers on Rebuilding of Public Infrastructure and to assist in the development of a National Adaptation Strategy (NAS) by Infrastructure Canada. It contains a review of systems-based approaches for climate resilient infrastructure, with the aim of identifying scalable solutions that could be delivered as part of the NAS, and which support BC's infrastructure rebuild program.

Our approach began with an international review of literature to identify examples of best practice, focusing on the use of systems-based approaches to adapt to climate change, case studies that describe the response to specific extreme weather or climate events with potential to impact Canada, and content relating to climate preparedness, response, recovery and rebuild.

An initial set of over a hundred documents was reduced to a shortlist of twenty, comprising a mixture of technical reports, frameworks, and case studies. Each shortlisted document was then 'synthesised' to capture relevant information, and extract it to a new report using a common framework, structured around the themes used by the Resilient Natural and Built Infrastructure Advisory Table (i.e. technical, financial, policy & legal, socio-economic, governance & institutions).

Each synthesis ends with a short summary, noting the main conclusions and key takeaways, and including any interesting information that doesn't fit into the framework provided. A full set of twenty synthesis reports is included as an Appendix to this document; the main body of this report contains relevant examples and notable findings from the review.

As a goal of this project is to identify best practices and determine their applicability and relevance to Canada; we elected to define 'System Functions' by using two-word phrases that reduce complex concepts into simpler expressions to describe components of a system.

Our initial analysis produced a sample-set of almost fifty examples of potential System Functions, shown below. Our intention is to expand on these initial findings, incorporating any feedback; and to further refine the System Functions in order to connect examples of international best practices back to the Canadian National Adaptation Strategy.

1 Introduction

This assessment of **systems-based approaches for climate resilient infrastructure** is to inform the work of the Committee of Deputy Ministers on Rebuilding of Public Infrastructure, and assist the development of a National Adaptation Strategy (NAS) by Infrastructure Canada. Additionally, this report will inform the province of British Columbia, through the BC Ministry of Transportation and Infrastructure (BC MOTI), of the opportunities to leverage these approaches in the rebuild efforts after the 2021 flooding events. The findings of this and the subsequent Phase 2 report will include recommendations that are scalable and flexible for systems-based approaches for climate resilient infrastructure that could be delivered as part of the NAS, and which support BC's infrastructure rebuild program.

The vision for this project is:

> *To make recommendations of systems-based approaches for climate resilient infrastructure for the Canadian National Adaptation Strategy (NAS) that is scalable for Canadian Provinces and Territories.*

Our recommendations will focus on systems-based approaches for climate resilient infrastructure, and the project vision will be delivered in two phases, or missions.

MISSION	MISSION STATEMENT	DEADLINE
Phase 1	• Research best practices from around the world regarding climate change preparedness, disaster response, disaster recovery, and rebuilding. • Synthesize relevant documents and reports in a common framework to communicate global practices and actions to a broad array of stakeholders.	May 10, 2022
Phase 2	• Use the results from Phase 1 to develop recommendations for systems-based approaches for climate resilience in Canada. • Consider factors including planning, design, construction, operation, maintenance, disaster response, disaster recovery and rebuilding.	June 30, 2022

This report contains the output from Phase 1, and provides examples of system based tools and techniques that are (or could be) deployed to increase the resiliency of infrastructure assets in the face of a changing climate.

Our literature review included frameworks describing the approach to planning and preparing for events before they occur; reports evaluating the initial response to and recovery from a specific climate-related event; and case studies assessing the effectiveness of any rebuilding program.

As the goal was to identify examples of good practices deployed elsewhere, and determine their applicability and relevance to Canada, our scope included reports written at the entire country level; as well as those focused on a particular region, state or province; and examples from large cities; to ensure any findings would be scalable. The report is structured as follows:

Section 2 provides a brief background to this project, outlining its relevance to Canada's National Adaptation Strategy. **Section 3** describes the approach and methodology taken by the project team to fulfil the above noted missions.

Section 4 provides an overview of the documents included in the literature review, grouped by geography. **Section 5** contains a similar overview of the case studies selected. These sections highlight key, relevant, or otherwise interesting material from the source documents. They are intended to act as a signpost, helping the reader to locate the content of most interest to them.

Section 6 provides an initial functional analysis of the references and case studies included in this review. **Section 7** contains conclusions and suggested next steps. **Section 8** provides a bibliography with a link to the original reference documents. A full set of all synthesised reports is included as **Appendix A,** a full list of all source materials is provided at **Appendix B.**

2 Background and Context

According to a report by Environment and Climate Change Canada (ECC), Canada is warming at **twice the rate of the global average**. The effects of this warming have resulted in more frequent and severe extreme weather events, with costly consequences for infrastructure systems. In response to this, Canada is in the process of developing its first National Adaptation Strategy (NAS) which will provide a national framework for action on Climate Adaptation.

The NAS is being informed by five advisory tables, one of which is the **Resilient Natural and Built Infrastructure Advisory Table** led by Infrastructure Canada. Their mandate includes defining the transformational goal (by 2050) and the supporting interim objectives (by 2030) needed to embed resilient infrastructure in the NAS.

A January 2022 report[1] defines the transformational goal as follows:

> *"By 2050, infrastructure systems in Canada are climate resilient and continue to intentionally be adapted to a changing climate to deliver reliable, equitable, and sustainable services to all of society, including First Nations, Métis Nation, Inuit, and urban and off-reserve Indigenous peoples"*

This goal is supported by five interim objectives, each with a target date of 2030, defined below. For consistency, we adopted the same five themes to capture key information as part of our literature review:

THEME	OBJECTIVE: BY 2030…
Technical	Technical standards have been raised for easier adoption and climate change resilience is skillfully embedded in all decisions to locate, plan, design, manage, adapt, operate, and maintain infrastructure systems across their lifecycle
Financial	A robust investment framework is in place to purposefully guide the allocation of sufficient public and private funds towards low-carbon climate-resilient infrastructure, maximizing the long-term benefits of infrastructure investments
Policy & Legal	All levels of government utilize a coherent and integrated, community-informed policy and regulatory framework to drive resilience in public and private infrastructure decision-making
Socio-Economic	Climate-resilient infrastructure systems support the health and well-being in communities and secure economies, with a particular emphasis on prioritizing benefits and eliminating funding gaps for marginalized populations and those in high-risk areas
Governance & Institutional	There are clear and coordinated responsibilities within and between jurisdictions, including with Indigenous communities, to effectively and cooperatively implement climate adaptation best practices and solutions that account for the unique needs and context across the country

The development of the NAS provides an opportunity to evolve from traditional asset-based approaches for resilience to **systems-based approaches (SBAs),** which recognize the services that infrastructure provides and the systems in which infrastructure functions, and accounts for interdependencies, cascading impacts, and multiple scales (from jurisdictions to ecosystems).

[1] "In support of the development of a National Adaptation Strategy Phase 1"
- Environment and Climate Change Canada's Advisory Table on Resilient Natural and Built Infrastructure; Fall 2021.

3 Approach and Methodology

The approach taken by the Project Team to compile this report is described briefly below.

3.1 Stage 1: Nominate Reports

All Project Team members were asked to identify potential documents for inclusion using the consideration factors below, and to nominate candidate documents under one of three categories:

- Examples of SBAs that demonstrate climate change resilience
- Case studies describing specific extreme weather or climate events
- General literature on climate preparedness, response, recovery and rebuilding.

Each team member was asked to provide a brief synopsis of their nominated report(s) and describe why they believe it is a good candidate for further review. A total of 102 documents were nominated, and their key details (title, author, date, length, type, region covered) were captured on a tracking spreadsheet, together with a one-paragraph summary, and a unique reference ID, retained throughout. The list of nominated references is included in Appendix B.

3.2 Stage 2: Select Reports

Each nominated report was scored against three criteria:

- Relevance to Canada
- Relevance to SBAs
- Quality of Source

Scores were assigned to each report against each of these criteria, using a five-point scale. The Project Team collectively reviewed the weighted scores to develop a shortlist of highly ranked reports that provided a good geographic spread, and which covered a range of climate disasters without obvious repetition or duplication. This resulted in the subset of twenty documents that are presented in this report; which is made up of fifteen technical reports, and five case studies.

The final list of documents selected is intended to be representative, not exhaustive. The examples were selected because they contained information that was perceived to be relevant to the Canadian environment, based on recent events, had direct applicability, or which otherwise fit the selection criteria.

3.3 Stage 3: Synthesize Reports

Once the shortlist of twenty documents was established and agreed, each was assigned to a team member tasked with preparing a ‘synthesis’ of the document: extracting the key information and relevant points into a short summary. The initial draft was then peer-reviewed.

Each synthesis follows a common framework, starting with an opening section that briefly sets out the fundamentals of the report being synthesised, such as the title, author and date.

Relevant information from the original document was then added to the synthesis, grouped under one of the four phases of disaster management / event response:

PHASE	DESCRIPTION
Prepare	Covering the period prior to extreme weather events, including pre-existing climate adaptation strategies
Respond	Covering the period during the event, including quality of response plans and how they were deployed.
Recover	Covering the period in the immediate aftermath of the event, getting critical infrastructure and services back online.

Rebuild	Covering the post-event period to restore level of service, and to mitigate future risk by improving the resiliency of the infrastructure

Within each of these four phases, useful or interesting content identified from the source material was recorded using the same five headings as the Resilient Natural and Built Infrastructure Advisory Table' report, described in Section 2 and shown below.

Given the wide range in focus of the different reports, it is to be expected that the level of detail varies enormously between the documents. To address this, reviewers / synthesisers were issued with the following list of key words, phrases and concepts to help them identify the material of greatest interest, and record it under the appropriate heading. If a report did not have any relevant content for a particular section, that part of the synthesis should be left blank.

HEADING	EXAMPLES OF KEY WORDS / CONCEPTS OF INTEREST
Technical	• Future-looking data • Standardized climate risk assessments • Use of protocols • Qualifications • Nature-based Solutions (NbS) • Research & Innovation
Financial	• Applying a climate lens to inform and prioritize investments • Climate-related financial disclosure of risk to operations and maintenance • Adequate and sustainable investment including in low-carbon technology • Research & development
Policy & Legal	• New construction standards and updated codes • Regulations that facilitate the uptake of low-carbon climate resilient infrastructure • Mainstreaming climate-resilient decision-making
Socio-Economic	• Equity-informed approaches that consider differential and intersectional impacts • Changes in behavioural patterns associated with the use of infrastructure • Community Empowerment • Learning from community input • Indigenous Knowledge
Governance & Institutions	• Coordination across communities, sectors, and jurisdictions • Clarity of roles and responsibilities • Flexibility in approaches for the unique needs and contexts across the country

Each synthesis ends with a short summary, highlighting the main conclusions and key takeaways, and including any noteworthy information that doesn't fit into the framework provided. This final section also provides the author of the synthesis with an opportunity to flag any material they believe is important for readers of the document to consider.

A full set of all twenty synthesised documents are collated, and included as Appendix A to this report. The following sections contain an overview of the fifteen main reports (in Section 4), and of the five case studies (in Section 5), to highlight material of the greatest relevance or interest.

4 Literature Review Highlights

This section provides a brief extract of key material from each of the 15 reports, organised by geographic region. The purpose of this section is to act as a signpost, highlighting parts of the original document which have particular relevance to systems-based approaches, or have direct applicability to Canada, and helping the reader to decide whether they should invest the time required to either read the synthesis provided in Appendix A, or to review the entire original report.

4.1 Reports with Global focus

In this context, the term 'global' was used to encompass reports where the focus is not tied to a single country, or for examples of research performed by international organisations, such as the World Bank, the United Nations, and the OECD.

4.1.1 World Bank

The World Bank has assessed that the cost of building additional resilience into systems is typically equivalent to 3% of the total investment, but can lead to significantly fewer disruptions and outages. In some countries, they estimate $4 is returned for every dollar invested. In **Reference ID #05: *"Lifelines: The Resilient Infrastructure Opportunity"***, they assess the cost of infrastructure disruptions, and the economic benefits of investing in resilient infrastructure. The report lays out ways to invest capital dollars more wisely that can be applied in any country.

The report is structured in three main parts. It starts with a problem statement: highlighting how a lack of resilient infrastructure harms both people and businesses. This is supported with evidence-based, concrete examples of ways in which disruption can lead to higher costs & lower productivity, or can impact health and wellbeing, or reduce income; and argues that natural shocks are a leading cause of infrastructure disruption & damage, and that local disruptions translate into macro-economic impacts. Key findings include:

- Infrastructure disruptions cost businesses more than $300 billion per year
- Infrastructure disruptions' direct impact on people are worth at least $90 billion per year
- Natural shocks are among the leading causes of infrastructure disruptions.

The second part of the report makes the case for more resilient infrastructure on grounds of cost effectiveness, arguing that investing in greater resiliency is both urgent and profitable, as more resilient infrastructure assets – particularly in exposed areas - pay for themselves by creating more resilient infrastructure services that lead to more resilient users and economies.

The final part of the report outlines a potential way forward, by taking five perceived obstacles to creating more resilient infrastructure, and recommending potential solutions to each of them, as summarized below.

OBSTACLE	RECOMMENDATION
Many infrastructure systems are poorly designed, operated or maintained	**Get the basics right** • Enforce regulations, construction codes, and procurement rules • Create systems for appropriate infrastructure operation, maintenance, and post-incident response. • Provide funding / financing for infrastructure planning, construction, and maintenance
Multiple political challenges and coordination failures impede public action on resilience	**Build institutions for resilience** • Implement a 'whole of government' approach to infrastructure resilience, built on existing regulations. • Identify critical infrastructure. Define acceptable and intolerable risk levels. • Ensure equitable access to resilient infrastructure

Infrastructure providers lack incentives to avoid disruption and strengthen resilience	**Include resilience in regulation and incentives** • Include resilience objectives in master plans, standards, and regulations, and regularly review & update • Incentivize service providers to promote resilient infrastructure services. • Ensure regulations are consistent with risk-informed land use plans
Public and private actors lack data, models, and capacity	**Improve decision making** • Invest in freely accessible natural hazard and climate change data. • Make decisions that minimize potential for regret and catastrophic failures. • Mobilize the know-how of the private sector to build data-sets and models.
The infrastructure sector faces affordability and financing constraints	**Provide financing** • Provide funding for risk assessments early in the project design. • Set up a financial protection strategy & contingency plan. • Promote transparency to better inform investors and decision makers

The concepts introduced in this report may help decision-makers at all levels of government in Canada think about infrastructure provision and resilience in new ways, with consideration given to both the direct and indirect costs and losses that are associated with infrastructure failures, and suggested methods to overcome common obstacles and barriers.

One topic that is experiencing a recent growth in interest concerns Nature-based Solutions (NbS) which uses natural approaches to create climate resilient infrastructure that can prove to be cheaper than traditional methods. The World Bank's portfolio of NbS investments for disaster risk management and climate resilience amounted to almost $5 billion USD by 2020.

In 2021, the World Bank, together with the Global Facility for Disaster Reduction and Recovery, published **Reference ID #71: "*A Catalogue of Nature-based Solutions for Urban Resilience"*** as a resource for those aiming to shape urban resilience with nature, sharing good practice examples, design, benefits, and implementation considerations. The aim is to provide insight to the suitability of NbS within an urban landscape, and their effectiveness for climate resilience.

The report describes performance insights and potential benefits of 14 different NbS typologies (or families), each with information on functionality, costs and benefits, and real-world examples.

- Urban forest
- Terrace and slopes
- River and stream renaturation
- Building solutions
- Open green spaces
- Green corridors
- Urban farming
- Bioretention areas
- Natural inland wetlands
- Constructed inland wetlands
- River floodplains
- Mangrove forest
- Salt marshes
- Sandy shores

There is a comprehensive presentation of each typology, diving into design, benefits, and implementation considerations, accompanied by visualizations, graphics, key facts and case studies. It acknowledges that NbS are often most effective when approached and planned in an integrated or holistic manner, especially in complex urban environments; and recommends first taking a system-based approach to address resilience and biodiversity challenges, and then seeking practical ways to integrate NbS into policies, plans, programs, and projects.

The catalogue provides examples at three different spatial scales (river basin, city, neighbourhood) and includes guidance around upfront and whole life costs, meaning that the material within this report could be used to help identify scalable opportunities to implement resilience through NbS.

4.1.2 The United Nations

The United Nations Development Programme compiled **Reference ID #93: "*Global Compendium of Good Practices on Post Disaster Recovery*"** to highlight examples of best

practices applying disaster recovery processes at the local, regional and national level across Africa, Asia, East Europe, Latin America and the Caribbean. The factors the UN used to determine good practice, and to select the examples for inclusion in the compendium are:

CRITERIA	KEY ISSUE TO DETERMINE ELIGIBILITY
Universality / Transferability	Can the identified practice be applied in another region/country?
Applicability	Is the application appropriate for the post disaster context?
Expandability	Can the small-scale activities that typify the practice be expanded, or replicated, throughout the same sectors / areas?
Orientation / Focus	Is the practice focused on reducing the overall level of risk from the pre-disaster situation? Are the concepts of Building Back Better included in the practice?
Assimilation / Integrability	Can the practice identified be incorporated, or assimilated into, other development or risk reduction practices?
Impact / Effectiveness	What effect does the practice have on accelerating and/or efficiently implementing recovery activities?

The report has details of 25 case studies or initiatives, drawn from 23 different countries, and uses them to present several key findings relating to both the preventative elements of disaster risk reduction (DRR), and to post disaster needs assessment (PDNA). The overall recommendation is that recovery needs should be undertaken based on the impact analysis, using the opportunity to build back better wherever possible to maximise future resiliency.

The report contains examples of systems-based approaches that encourage the use of new and emerging technology such as digital tools, web-based applications, remote sensing, or drones to support recovery efforts; and suggests governments should work with the private sector to establish whether recent developments in fields like 3D printing, artificial intelligence, and geospatial and satellite imagery could be utilised to further increase resilience.

The compendium also suggests that new funding mechanisms are needed that utilise public and private means of finance to unlock investments in climate adaptation and mitigation initiatives, through loans, equity, guarantees and grants; and that all parties work towards climate risk related Sustainable Development Goals (SDGs) to ensure those outcomes are sustainable.

4.1.3 Organisation for Economic Co-operation and Development

The Organisation for Economic Co-operation and Development (OECD) is an international body that works with governments and policy makers to find solutions to a range of environmental challenges using evidence-based international standards. **Reference ID #69: *"Climate-resilient infrastructure"*** is a 2018 policy paper aimed at encouraging climate resiliency in the development and planning of infrastructure projects, and the inclusion of climate risks in financial decision making.

The paper highlights emerging good practices across OECD and G20 countries, and provides non-prescriptive guidance to countries seeking to enhance their own resiliency. With its broader international focus, the report does not contain an in-depth analysis of any specific projects, but does provide many illustrative examples, with suggestions on ways to apply the lessons learned from one location in another environment.

Within the main body of the report there are often links to further reading or more detailed analysis, and this information is conveniently summarised near the end of the report, with sections that include links to useful tools and websites, and to other relevant OECD reports.

The report contains many possible adaptation measures, grouped as either Structural or Management, addressing the following ideas and concepts:

- Using a sector-based approach to assess the impacts of climate change
- Calculating the macro-economic impact of flooding using modelling
- Engaging stakeholders via communication tools that accurately describe climate risks
- Improving decision making through shared resources and tools
- Promoting regional ecosystem-based adaptation ideas
- Financing the investments needed in new/upgraded climate-resilient infrastructure
- Identifying and pricing financial risks of climate change
- Integrating climate risks into public infrastructure planning
- Integrating climate resilience into public-private partnerships (PPP).

The report includes links to a number of sustainability rating tools to help decision makers assess their options, as well as examples of frameworks that have been developed and used to assess climate risks, and tools to perform cost-benefit analysis; while noting that given the context-specific nature of climate adaptation, the outcomes of any measures used will vary widely between locations.

4.2 North America

4.2.1 Canada

The Canadian Climate Change Adaptation Project (CCAP) was created to identify practical and cost-effective adaptation solutions to the most challenging impacts of climate change facing Canada. It considered climate impacts to industry sectors such as mining, banking and telecoms; and to non-industry or public sectors such as freshwater resources, biodiversity, and human heath impacts. It also treated the property and casualty sectors separately, due to the high level of perceived challenge presented to this sector.

Their approach was designed to identify tailored courses of action that could be deployed to mitigate the impacts of climate change on the affected sectors. Subject matter experts were tasked with articulating the challenges they face in each sector, and recommending actions to address those challenges.

Reference ID #18: ***"Climate Change Adaptation - A Priorities Plan for Canada"*** builds upon earlier work on climate adaptation for Canada identified by the CCAP Adaptation Advisory Committee to consider the financial risk implications of climate change, and help to ensure insurance coverage and pricing aligns with climate change risk, to promote modified building codes, and to develop tools to promote climate change adaptation.

The report responds to around a dozen original adaptation recommendations, grouped by sector, and with proposed solutions and suggested next steps. They include the following:

SECTOR	POSSIBLE NEXT STEPS
City Infrastructure	• Estimate remaining service life of infrastructure v climate thresholds • Use vulnerability & risk assessments to prioritize the implementation of adaptation measures in areas at greatest risk • Incorporate adaptation into city planning policies
Biodiversity	• Use modelling to prioritize changes within bioclimatic envelopes • Identify bioclimatic zones with greatest need of adaptive measures • Increase habitat connectivity in human-dominated settled landscapes • Manage exotic/invasive species
Freshwater	• Preserve or restore critical wetlands • Redesign human infrastructure to conserve water quantity & quality • Move population and water-intensive industry to water (not vice versa) • Integrate water uses at watershed scales

Aboriginal Communities	• Redesign & relocate climate stressed communities • Factor traditional knowledge into adaptation plans • Integrate resiliency into community access / transportation
Agriculture	• Develop agriculture-relevant information materials to engage stakeholders • Incorporate climate change concepts into planning decisions
New Homes	• Modify the national building code process for new home builds • Identify highest priority future risk locations
Existing Homes	• Incorporate pre- and post- disaster improvements to mitigate future loss • Adopt fire management techniques for urban floods & winds • Introduce collaborative disaster mitigation assistance programs
Insurance Pricing	• Perform attribution analysis to identify factors affecting weather-related losses

This report also provides an extensive summary of the climate change models developed as part of step 1 of the CCAP, and discusses their effectiveness. Although some of the material that was originally produced under CCAP is now more than a decade old, many of the underlying ideas and principles provide a sound basis on which to build.

A more recent report, with a focus on disaster management practices applied in Canada, **Reference ID #07: "*Systems Approach to Management of Disasters – A Missed Opportunity?*"** looks at how knowledge and systems science can be deployed to improve disaster management in the face of rapid climate destabilization, and the potential to deploy systems approaches for effective disaster management that are based on simulation, optimization, and multi-objective analyses.

The paper claims the institutional context means the Canadian approach for disaster management is "*decentralized, fragmented and subject to incremental lawmaking. This makes it difficult to address serious disaster management decisions in a comprehensive, holistic (systematic) fashion",* and goes on to discuss how systems approaches can be leveraged to improve disaster management, recognising that disasters often result from failures within one or more of the following three major systems:

- The physical environment
- The social and demographic characteristics of the communities that experience them
- Buildings, roads, bridges, and other components of the constructed environment.

The report outlines strategies and tools that include:

- Pooling interdisciplinary resources more efficiently to boost emergency responses
- Eliminating ineffective siloed approaches and considering the interrelationships between the different systems
- Looking at disasters through a regional lens
- Increasing stakeholder engagement
- Applying the broadest range of risk mitigation measures
- Accounting for all costs and benefits.

The paper includes several case studies to show how system approaches have been used in disaster preparedness and modelling, and concludes with recommendations on how these can contribute towards creating a national disaster management strategy.

Case studies analysed within the report include the following:

CASE STUDY THEME / TOPIC	AUTHORS	YEAR
Use of a systems approach in disaster management	Atlay & Green	2006
Model of patient movements through a hospital ER department	Lane et al	2000

'Shared vision' model of hospital ER to understand patient wait times	Lane et al	2003
Model of casualty treatment following a large-scale disaster, used as a tool for planning disaster response strategies	Fawett & Oliveria	2000
Flood evacuation simulation for the Manitoba Red River basin, to evaluate different emergency management procedures.	Simonovic & Ahmad	2005
Optimization model to minimize recovery time and allocate resources.	Chen et al	2009

For the Canadian context, the author makes the following three recommendations to leverage a systems approach to improve disaster management:

- **Improved data availability**: Use common platforms to seamlessly share disaster related information across and between government institutions and agencies, with analytics to support data-driven decision making, planning and forecasting, and to educate the public on the consequences of their behaviour
- **Modelling and simulation**: Deploy standardized tools and simulation models to improve disaster-related decision-making at all levels of government
- **Organizational change:** Build a community of people with a shared vision that use systems thinking and approaches to create more realistic disaster management policies.

4.2.2 United States

In 2013, the state of New York established a dedicated Governor's Office of Storm Recovery (GOSR) in response to a series of major events that included Hurricane Irene and Superstorm Sandy. Tasked with identifying innovative solutions to make New York's infrastructure and critical systems more resilient, GOSR managed the NY Rising program which focused on housing recovery, small business, community reconstruction, and infrastructure; and coordinated with the Rebuild by Design competition to develop innovative green infrastructure solutions to mitigate the impacts of climate change on coastal communities.

A key innovation of the NY Rising Program was involving local communities in a participatory planning process to identify how funding should be distributed among implementation actions within each community**. Reference ID #21: "*A Managed-Participatory Approach to Community Resiliency"*** provides an overview of efforts to help communities recover from disasters, and identifies ways to reduce vulnerability to future events. It argues that the best approach to identify disaster recovery and climate change adaptation strategies must involve the local community using both **horizontal mechanisms** (among community stakeholders) and **vertical ones** (between political institutions and local communities).

> *"...both horizontal and vertical engagement are necessary for effective community planning because communities with a low degree of horizontal integration have difficulty organizing for collective action, and those with a low degree of vertical integration may have weak ties with central authorities and thus face problems in taking ownership of eternal programs in their communities"*

The program provided funding for a total of 66 Community Reconstruction Plans, each one developed by Planning Committees consisting of local residents, business owners, and civic leaders, with the assistance of New York Rising Community Reconstruction (NYRCR) program staff, who used an approach designed to balance limited government resources with the local population's knowledge to develop the best solutions while building consensus.

The New York Rising was largely a reactive program, with most initiatives relating to reconstruction plans following major events; but the way the program was designed to include the horizontal-vertical model of managed-participatory approach provides an innovative strategy

for creating a policy framework that empowers local communities to direct funding within that framework, and which could be adapted for use elsewhere.

For an example of a more pro-active approach, the state of California is required by law to issue a statewide climate adaptation strategy every three years. The latest edition of **Reference ID #23: "*California Climate Adaptation Strategy: Priorities, Goals and Actions"*** reflects nearly two decades of evolution and revisions, and is based around six climate resilience priorities:

- Strengthen protections for climate vulnerable communities.
- Bolster public heath and safety to protect against increasing climate risks.
- Build a climate resilient economy.
- Accelerate nature-based solutions (NbS), strengthen resilience of natural systems.
- Make decisions based on the best available climate science.
- Partner and collaborate to leverage resources.

The 2021 Strategy attempts to draw connections between different sectors, aiming to provide flexibility as climate change impacts the conditions on the ground. This version gathers together initiatives that range from statewide climate action plans, to sector-based and regionally focused strategies, and contains nearly 150 actions selected based on their ability to achieve the six priorities above. The document is organised around intended outcomes, rather than on sector-specific actions, in order to break down silos and consider the impacts and benefits of climate adaption initiatives in a more unified way, and the report is supported by a website (https://climateresilience.ca.gov/) that allows users to explore actions by Priority or Region.

Every action is linked to a specific goal, tied to one of the six priorities, and accompanied by success metrics, delivery timescales, and the details of the agency responsible.

One of California's priority objectives relates to increasing protections for climate vulnerable communities, recognising there is a need to improve the understanding of factors that drive vulnerability by gathering input from communities to help guide decision-making, together with the use of more traditional risk assessments and the latest climate science to help ensure a fair distribution of the state's resources.

Another example of a program that has deployed a community-based approach, but with a more targeted focus comes from the state of Louisiana. When the Disaster Recovery unit of the Louisiana Office of Community Development created the LA SAFE program, they decided to adopt a community-driven regional approach to ensure the equitable distribution of $40 million of federal funding designated for coastal resilience projects.

Reference ID #24: "*Our Land and Water: A Regional Approach to Adaptation*" describes how the program was structured around five goals, each supported by actionable strategies:

- Manage flooding and subsidence
- Plan for safe and affordable development
- Improve mobility throughout the region
- Diversify educational & employment opportunities to strengthen the regional economy
- Support healthy communities, regional culture, and recreational access to nature.

One of the strategies being discussed involved managed retreat: an extremely sensitive topic within coastal communities. To build consensus (and ultimately acceptance) around some initially controversial concepts, LA SAFE applied a community-based approach, holding five rounds of public meetings over the course of eight months, working with the affected communities to identify challenges and priorities, locate areas of opportunity and evaluate the community vision, define strategies and identify project partners, and finally to evaluate the demonstration projects.

Contributions from the public were supplemented by the latest data about climate change and sea level rise, with scientific research about land loss, storm surge, geology, ecology, and

climate; and with plans developed by other state and regional agencies throughout Louisiana. This led to the production of a Regional Strategy that outlines the high-level program and policy recommendations, which is supported by six Parish Strategies that each describe specific projects in support of the wider program goals.

The consensus-building, community-led approach meant that local populations are able to plan with their own priorities in mind, within a framework that helps to ensure that all of the local plans support regional and/or national goals. In turn, local plans may then be eligible to receive regional or national funding, because they align with or contribute towards broader objectives.

4.3 Europe

4.3.1 United Kingdom

The UK Government established the National Infrastructure Commission (NIC) to provide independent, impartial advice on coping with long term infrastructure challenges, supporting sustainable economic growth that helps to improve the quality of life.

The NIC's remit covers 'economic infrastructure', meaning energy, transport, water and wastewater (drainage and sewerage), waste, flood risk management and digital communications; and the NIC produces regular national assessments, with a series of recommendations for government to act on, supported by an annual monitoring report to track progress against objectives.

All investment recommendations from the NIC must:

- be accommodated within pre-set annual spending levels (as a % of GDP)
- include cost-impact assessments on businesses, consumers, and other end users
- consider the role of the UK's economic regulators in regulating infrastructure providers
- align with the government's legal obligations, e.g. meeting emissions reduction targets
- comply with any statutory obligations, e.g. environmental impact assessments.

In their report **Reference ID #40: "*Anticipate, React, Recover: Resilient Infrastructure Systems"*** the NIC uses a six-part framework for considering resilience in terms of how a shock would impact infrastructure systems over time, with recommendations in each stage:

STAGE	DESCRIPTION	RECOMMENDATION
Anticipate	Before any disruption, operators can anticipate shocks and be prepared	Government sets resilience standards
Resist	Systems can resist shocks and stresses to prevent an impact on infrastructure services	Regulators oversee regular stress testing Infrastructure operators address vulnerabilities
Absorb	Systems can absorb shocks and stresses to minimise the impact on services	
Recover	After the shock, actions help quickly restore expected levels of service	
Adapt	Longer-term, to be better prepared next time, systems may need to either: • adapt, or • transform.	Infrastructure operators produce long term resilience strategies.
Transform		Regulators value resilience in decisions to support investment

A major element of preparedness identified in this framework is the need for a common set of standards that define the understanding between each Infrastructure Operator, their Regulator, and the Government. Standards should identify the types of disruption or failure that could happen, and the response needed by each party to protect the public, should that disruption occur, in order to reflect the level of service that customers or the public can expect.

Using techniques from other sectors, standards for resiliency are presented in the form of Recovery Point Objectives, which define the levels of service that must be delivered when recovering from an outage (e.g. X% of customers to have service levels fully restored within Y time period).

The NIC recommends the following principles are adopted when setting service levels, to ensure a balance between costs, impacts, and expectations:

- minimise costs & risks for potentially catastrophic events
- use a wide range of methods to understand consumer views on disruption
- consider the widest possible range of impacts of any potential disruptions or failures
- assess the costs and benefits of resilience, especially where changes are irreversible.
- consider wider social impacts and impacts on dependent sectors.

The NIC also recommends that systems are stress tested, as a means of enabling Infrastructure Operators to demonstrate their effectiveness at providing resilience to a major event, to identify and address vulnerabilities, and to give assurance to the Regulators and to Government that the resilience standards can be met. Using best practices established by the Financial Services sector, the report suggests that Regulators should set out scenarios and scope for stress tests, provide guidance for developing bespoke tests (frequency, common scenarios, etc.), and oversee the stress tests, scrutinising the outcomes. Regulators must ensure investment can be made to enable government's resilience standards to be met, while also scrutinising companies' resilience bids to ensure they are proportionate, and consumers will not be paying for excess resilience (i.e. avoid 'gold plating').

As the Operators will remain responsible for developing and implementing the plans needed to remedy any vulnerabilities identified as part of the stress tests, they must develop appropriate strategies to do so. Implementing these strategies effectively require strong governance and clearly identified decision points, a role that Regulators are well placed to support via oversight and guidance.

However, since the Operators do not always have the right incentives or correct assumptions when it comes to long term resilience planning, the industry Regulators have a role to:

- require Infrastructure Operators to produce long term resilience strategies;
- produce guidance on developing those strategies to ensure a proportionate approach;
- scrutinise those strategies, to develop a sector wide view of resilience
- share best practice from within the sector, and facilitate expert reviews
- ensure a proportionate approach, and provide guidance on the appropriate time horizon

The report contains the following core recommendations, which are generic enough to be applied to the Canadian environment:

- Government to publish clear, proportionate and realistic standards for the resiliency of infrastructure services, and regularly review/update these standards
- Regulators to require infrastructure operators to enact a system of regular stress testing to ensure their systems and decision-making can credibly meet resilience standards, and to require remedial action in case of failure.
- Operators to develop and maintain longer term strategies to ensure infrastructure services can continue to meet the agreed resilience standards.

The main report is accompanied by several technical annexes that contain practical guidance on the application of these recommendations, covering the following topics:

- Setting Service Levels
- Expected Costs and their Impacts
- Case Studies & Examples of Good Practice

4.3.2 Netherlands

Building on more than a decade of climate adaptation policy in the Netherlands, **Reference ID #44: *"National Climate Adaptation Strategy: "Adapt with ambition"*** (NAS) is part of the Dutch response to the European Commission's call to adopt a climate adaptation strategy.

After providing some insight into the main effects of climate change, the report focuses on the actions needed to ensure that the Netherlands is structurally less vulnerable to climate change by 2050; considering the impact of four potential scenarios (warmer, wetter, drier, rising sea levels) across nine industry sectors.

The NAS highlights six problems that require urgent attention:

1. More heat stress due to extreme weather: more sick people, hospitalizations, deaths, and reduced work performance/increase in absenteeism.
2. More frequent failure of parts of vital and vulnerable functions due to extreme weather: energy, telecom, IT facilities and main infrastructure.
3. More frequent crop damage and other damage in agriculture and horticulture due to extreme weather: reduced crop yields, damage to means of production.
4. Shifting of climatic zones, meaning the flora and fauna cannot move sufficiently with the shifting climate due to a lack of international spatial cohesion in nature.
5. Loss of health, loss of work and costs due to a possible increase in infections, allergies such as hay fever, or other respiratory complaints.
6. Cumulative effects where failure in one sector or at one location has consequences for other sectors and/or other locations.

Longer term concerns identified in the report include the failure of parts of the electricity network or large IT outages due to extreme weather, limitation of shipping due to changing sea levels, loss of species and habitats, or damage to buildings and infrastructure due to subsidence, safety risks caused by the rupture of pipes, and extra CO2 emissions due to peat oxidation. The NAS contains a visualization tool that helps to show the potential effects of climate trends on different sectors: https://nas-adaptatietool.nl/

Once the Strategy is set nationally, the central government encourages its implementation by:

- raising awareness of the need for climate adaptation
- stimulating the implementation of climate adaptation
- utilizing and expanding the knowledge base
- addressing urgent climate risks
- embedding climate adaptation in policy, legislation, and regulations
- monitoring progress and effectiveness of the adaptation policy.

Introducing climate adaptation techniques rapidly can prove particularly challenging, but by focusing on, and highlighting small wins, the NAS team were able to showcase meaningful steps that led to positive results, encouraging others to move towards the goal of climate adaptation. A 2020 evaluation of the implementation program made the following three recommendations:

- Resolve the most urgent risks: on heat, built environment and infrastructure.
- Connect with other transitions and social challenges.
- Invest in a long-term knowledge and monitoring system.

4.3.3 France

Reference ID #57: "*Plan National D'Adaptation au Changement Climatique"* presents the French National Adaptation Plan for Climate Change. It covers the actions deemed necessary to reduce greenhouse gas emissions, limit the rise in average global temperatures to no more than 2°C; and to adapt to the expected climate change impacts at a regional level, by 2050.

The plan forms an essential component of France's climate change mitigation policy, which aims to achieve carbon neutrality while avoiding contradictions between the various adaptation and environmental protection actions. It contains 56 actions, grouped across the six thematic areas shown in the table below.

THEME	TYPE OF ACTION
Governance	• Define roles and responsibilities at national/territorial level • Specify a coherent approach between climate adaptation and mitigation • Reinforce judicial and legislative frames around climate adaptation
Prevention / Resilience	• Develop early warning systems • Introduce long-term land-use strategies • Climate proof cultural / heritage assets
Nature & Environment	• Deploy nature-based responses that respect ecosystems and biodiversity • Use better water resource management, preserve aquatic ecosystems • Coastline adaptation, Forest preservation, Biodiversity protection
Economic	• Identify vulnerabilities of economic actors, climate-proof investments • Focus on sustainable eco-tourism, transition towards agro-ecology • Create favourable conditions to invest in France
Knowledge & Information	• Build strong scientific knowledge • Educate the public of the need to fight against climate change and adapt to it.
International	• Encourage international collaboration to learn from other countries • Disseminate best practices from France worldwide.

The report applies a climate lens to inform and prioritize investments: calling for a framework to evaluate the economical, socioeconomic and environmental aspects of investments, develop specific criteria for climate projects to avoid investments that could be affected by climate change, and create conditions for investors to finance climate adaptation projects that fully take risks into account. It proposes collaboration with the Insurance sector, to ensure that risks are properly priced.

It also recommends that socioeconomic factors are properly considered, with climate justice at the heart of multi-level governance; so that actions at local, municipal, national, European and international levels are well-coordinated, and reinforced through the use of communal policies (i.e. flood directives, common agriculture policy, biodiversity strategy, development aid) and, where relevant, a harmonized approach to risk management.

4.3.4 Denmark

As a response to multiple extreme rainfall events in the summer of 2011, the City of Copenhagen published **Reference ID #54: *"Cloudburst Management Plan"*** which proposes a series of measures that enables extreme rainfall to drain into the sea, preventing water damage to public and private assets within the city. The plan explores opportunities of implementing Blue-Green Infrastructure (BGI) for storing rainwater and acknowledges the need for underground grey infrastructure (large pipes). Additionally, existing urban infrastructure such as roads and parking lots, are considered for water storage during extreme events.

Based on future weather projections, the Masterplan contains an analysis of flood-proofing needs in Copenhagen, and proposes an outline of realistic solutions to be deployed over a specified time horizon. A data-driven approach to assess risk and determine vulnerability drives a prioritization methodology that allows decision-makers to establish the best course of action.

Implementing the plan required changes to existing legislation that enabled utility companies to invest in climate adaptation solutions, and to provide greater clarity on the key roles and responsibilities used when allocating funding. Governance between the utility companies, public

institutions and private owners is structured based on asset jurisdiction and functionality, with a clearly defined public-private partnership between the city, the utility companies, and the private property owners; and three potential methods of funding: private financing, funding by charge revenue, and taxation.

STAKEHOLDER	RESPONSIBLE FOR…	FINANCING METHOD
Property Owners	Flood-proofing property above ground level	Privately financed
Utility Companies	Assuring the drainage system capacity meets service level Implementing adaptive measures in accordance with the risk dimensioning	Majority of adaptive measures financed by charge revenue
City Administration	Coordinate with urban planning on climate adaptation and redirection of water courses.	Municipal tax to cover the costs for adaptive measures at ground level. Solutions combine flood proofing with green / recreational solutions

The document also calls for an intermediary plan that will help to mitigate risks to the city while longer term solutions are being applied, together with a permanent response strategy as a safeguard against unforeseen events.

The City of Copenhagen Masterplan was the main inspiration behind the New York Cloudburst Adaptation Plan, and has been used as a tool to promote climate adaptation solutions more generally.

4.4 Asia & Oceania

4.4.1 Australia

The Australian Government has prepared a handbook to guide emergency management activities. **Reference ID #102: *"The Australian Emergency Management Arrangements Handbook"*** describes roles and responsibilities for all levels of government, as well as non-government organisations, businesses, communities and individuals within Australia, and its states and territories.

The guidance covers each stage of the emergency management cycle: Prevention, Preparedness, Response, and Recovery; and aims to provide a high-level, scalable overview of how Australia addresses the risks and impacts of hazards through a collaborative approach to the prevention of, preparedness for, response to, and recovery from emergencies.

The purpose of the handbook is to provide a single, trusted source of emergency management knowledge that establishes nationally agreed principles, identifies and promotes good practice, and builds interoperability between stakeholders. It does not aim to dictate how any one event or disaster should be responded to, but instead provides a context to guide the approach to these situations that shares best practice and ensures local responses are aligned at the regional and national level.

The main body of the handbook is structured into six chapters. The first five are applicable to all types of emergency, with a separate sixth chapter focused on catastrophic events, noting they often require greater levels of coordination and strategic leadership.

Recognising that the first response to an emergency is often provided by the local community, the material includes specific commitments for the state and territory governments to work on strengthening partnerships with local, aboriginal, and indigenous communities: encouraging their

participation in risk assessments to better understand the problem, or providing tools that enable the community to better protect themselves.

The handbook demonstrates Australia's strong focus on shared responsibilities, providing clarity on the roles of the different actors impacted before, during, and after a major event. It also provides a good overview of the legal and administrative framework for disaster resilience planning and disaster management, with the responsibilities of key stakeholders within a multi-level governance model clearly defined. These same principles and structures are also used to support Australians affected by emergencies overseas, and to allow the Australian government to assist foreign governments affected by emergencies.

4.4.2 Singapore

The city of Singapore established their Garden City vision shortly after gaining independence in 1967. What initially began as an effort to sanitize and 'green' the city landscape has since evolved into a world-leading example of applied sustainability and resilience principles in action. **Reference ID #74*: "Preparing for a Climate Resilient Singapore"*** describes how Singapore has transformed in terms of climate resilience, looks at its current and future vulnerabilities, and proposes new adaptation strategies to further improve resiliency.

This document presents an integrated strategy that reveals how good correlation between Dynamic Governance and Integrated Master Planning result in a flexible and efficient application of climate change strategies. Collaboration across areas of governance and active engagement of stakeholders produces a multitude of system-based strategies that break down into sector specific actions and frameworks.

Within Singapore, climate change action is overseen by an inter-ministerial committee and executive, supported by three working groups that focus on:

- long term emissions & mitigation
- resilience
- international negotiations.

The overarching goal has three principles: high quality of life, competitive economy, and sustainable development. Their approach uses Integrated Master Planning to maximize efficiency across the energy, water and building sectors by considering carbon emission reduction, climate change safe proofing, flood protection, food security and ecology.

Given Singapore's size and geography, there is a strong interest in promoting international collaboration to build capabilities and develop cross-border solutions with neighbouring jurisdictions, and to enter regional agreements with other southeast Asian countries.

Culturally, there is an emphasis placed on a 'whole-of-society' effort: one that combines government-led policies and infrastructure investments with citizen-initiated community-owned programmes and initiatives.

The dynamic governance model deployed in Singapore is built upon decades of experience in addressing climate related issues, with significant value attributed to scientific research and innovation. Governance structures are set up to monitor progress using data gathering, with analysis performed to confirm that current activities (e.g. to create a national climate model) remain relevant, or to deliver improved performance through the use of emerging technology.

5 Case Study Report Highlights

5.1 Fort McMurray Wildfire, Canada

Wildfires in northeastern Alberta in the summer of 2016 caused Fort McMurray, the largest community in northern Canada, to be cut off for one month. An estimated 88,000 people were evacuated; and more than 2500 homes and other structures were destroyed by fire. The estimated financial impact of the fire was CAD $8.9 billion.

Written three years after one of the most significant wildfire events ever to occur in Canada, **Reference ID #86: *"Fort McMurray Wildfire – Learning from Canada's costliest disaster"*** is a comprehensive review of all stages of the 2016 disaster that offers many insights into the actions and decisions taken at the time, and discusses the investments required to reduce damage and losses in future wildfires.

The assessment builds on previous research from the Institute for Catastrophic Loss Reduction (ICLR). While it found that many lessons learnt in previous disasters were successfully applied in the management of the wildfire, and the subsequent community rebuild, there are opportunities to improve resiliency in future.

The report begins with an overview of the fire and how it grew, with a timeline of the event, before presenting fire behaviour and risk models to explain how wildfires can ignite homes. There are separate sections discussing ways of strengthening disaster risk governance, investments in disaster risk reduction, and building resilience in recovery, followed by chapters describing the lessons learned and providing recommendations.

The report contains many practical examples and actions that can be used to build resilience and reduce risk, which have been grouped into four 'clusters':

- Prevent creation of new risk in the community through local planning regulations
- Build resilient new structures with codes and standards for design and construction
- Protect existing buildings with protective retrofits for local hazards
- Invest in protective infrastructure including natural and physical protection.

The case study concludes that damage from the fire would have been much more extensive but for the courageous efforts of those involved in the response, and for the actions taken prior to the wildfire that enhanced the resilience of the community.

Although the recovery following the fire has strengthened the community's resilience to loss and damage from future hazards, lessons learned can be articulated using the four 'priorities for action' defined by the Sendai Framework for Disaster Risk Reduction, and the report provides several recommendations under each of the following themes:

- Understanding disaster risk
- Strengthening disaster risk governance
- Investing in disaster risk reduction
- Building resilience in recovery

5.2 Calgary Floods, Canada

In June 2013, Calgary was hit by the most destructive flood in recent memory, costing the city over half a billion dollars in flood repair expenses. With the Bow and Elbow rivers peaking at 1 in 100 and 1 in 500-year flow rates, the massive response and recovery effort tested authorities to their limit.

During the 2013 flood, the Calgary Emergency Management Agency (CEMA) coordinated and oversaw the efforts of 10,000 city staff, and managed the evacuation of 32 communities representing 80,000 citizens within a 15 hour period. **Reference ID #87: *"Forewarned and Forearmed - The Calgary Emergency Management Agency and the 2013 Flood"*** contains an independent review of the performance of CEMA, and the city's Emergency Operations Centre, during this emergency.

To compile the report, the authors evaluated Calgary's performance using three methods:

- A comparison with the responses to other large-scale emergencies, such as hurricanes Katrina & Sandy
- An assessment of whether the city's own recommendations from previous floods had been followed
- Interviews with those involved in the response – from public, private and non-governmental organisations.

The report contains an assessment of CEMA's performance which is structured around the following five topics, each of which contains some lessons learned and recommendations:

- Emergency Operations Centre / Incident Command System
- Crisis Communications
- Social Media
- Volunteerism
- Preparedness & Resilience

This case study provides an interesting contrast – combining a factual, data-driven evaluation of the emergency response, with the personal views of people who experienced the event. The interviewees spoke about intangibles that are harder to measure, but important to capture, such as civic pride, volunteering spirit, and a strong work ethos.

Some key takeaways include:

- Efforts are most effective when guided, informed, and supported by established frameworks, structures, and plans.
- Using a pre-established, standardized incident management approach ensures that people, resources, and facilities are incorporated in an organized manner, helping to reduce response times and eliminate miscommunication.
- Social media is an indispensable tool used when it comes to recovery, as it can be used to provide direction, organize volunteers, and help the city rally together.
- Empowering citizens by giving them the knowledge and authority to perform self-assessments of their properties reduced the amount of inspections required, and expedited the time in which people could re-enter their homes.
- Volunteers are a valuable, but fragile, resource.

5.3 Pacific Northwest Heatwave, Canada/USA

In June 2021, the Pacific Northwest experienced an unprecedented heatwave. The village of Lytton, B.C. recorded the highest ever temperature in Canada at 49.6°C, which melted power cables and caused roads to buckle. In total, US and Canadian officials attributed over a thousand deaths to the excess heat.

Reference ID #28: "*Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada in June 2021*" contains an assessment of the role of human-induced climate change in the likelihood and intensity of the June 2021 heatwave.

Their analysis used weather observations and modeling from an area that includes the cities of Vancouver, Seattle and Portland, and found that the occurrence of a heatwave of the intensity experienced in that area would have been virtually impossible without human-caused climate change. Such an event – one that would have been expected to occur once every thousand years in the current climate – can be expected to happen once per decade, or more frequently if the world reaches two degrees of global warming.

They conclude that deaths from extreme heat can be dramatically reduced with adequate preparedness action, but that adaptation measures need to be much more ambitious if they are to take account of the rising risk of heatwaves around the world.

Their recommendations include:

- Improving heatwave early warning systems through tailoring messages to inform and motivate vulnerable groups.
- Using tiered warnings that take into account vulnerable groups may have lower thresholds for risk.
- Conducting stress testing of early warning systems to evaluate their robustness to temperature extremes beyond recent experience.
- Updating warning systems to ensure their continued effectiveness in a changing climate.

The 2003 European heatwave which caused the deaths of more than 30,000 people in total, and the subsequent measures take by France in response, are used as a basis for comparison.

After the August 2003 extreme heat event, which is estimated to have caused approximately 15,000 deaths in France, the government adopted a National Heatwave Plan to better prepare the population for future extreme heatwaves. Some of the measures introduced have been praised for preventing health complications among vulnerable populations, but critics point to other impacts of extreme heat that are not addressed by the plan, such as strained electrical grids, poor air quality, transit delays, emergency room capacity, and risks to outdoor workers.

Despite experiencing even more extreme heatwaves in recent years, the number of deaths has never risen to the levels seen during the 2003 event, and studies have attributed these improved outcomes to the adaptation measures applied in the years since.

The plan contains some specific measures to protect vulnerable citizens, such as requiring Town Halls to maintain a register of senior citizens so that health workers can check on them. France has also implemented a 'Heat Tax', the proceeds of which are used to fund programs that protect at-risk people, such as installing air-conditioning in health establishments, or requiring dedicated 'Blue Plans' for all residential establishments which ensure there is a specific person at each site with responsibility for the elderly residents.

The French system uses the same four levels of preparedness across national, regional, and local stakeholders:

LEVEL	COLOUR	TITLE	NOTES
1	Green	Seasonal Monitoring	• Maintain operational systems, e.g. national telephone platform • Implement meteorological and health surveillance system
2	Yellow	Heat Warning	• Heightened monitoring in preparation for increased load. • Targeted communications
3	Orange	Heat Wave Alert	• Preventative actions implemented by government agencies, • Communication of targeted actions to mitigate heat impacts
4	Red	Maximum Mobilization	• Activated for exceptional, intense, long-lasting heatwave with collateral effects on various sectors. • Triggers the Inter-ministerial Crisis Unit (CIC)

A National Heatwave Plan similar to the one used in France could be replicated in Canada. One key lesson from their experience is that success is heavily dependent on coordination between the national government, regional/local officials, and private institutions, as adoption relies on better public health education, and clear communication about extreme heat events.

5.4 Missouri River & North Central Flood, USA

In March 2019, higher than average rainfall intensified the snow melt in the Midwest USA, which led to the flooding of the Missouri River and the Upper Mississippi River Basin, causing an estimated $12.1 billion in damage over millions of acres affecting the states of Nebraska, Iowa, Missouri, North Dakota, South Dakota, Minnesota, Wisconsin, and Michigan.

In the aftermath of the 2019 flood, **Reference ID #30: "*Adapting to Climate Change in the Upper Mississippi River Basin: Exploring Stakeholder Perspectives on River System Management and Flood Risk Reduction*"** aimed to gather the views and perspectives of those engaged in flood management.

To compile this case study, researchers carried out interviews with a range of stakeholders that represent the Federal, State, and Local Government, as well as non-profit advocacy groups, community representatives and local leadership. From those interviews, five themes emerged:

- River flooding is a different experience than coastal flooding.
- River flooding is a regional experience that requires a regional response.
- Local actors face constrained resources for flood risk protection and recovery.
- Differentiated responsibility across levels of governments makes recovery and response difficult to navigate.
- Competing stakeholder goals challenge cooperative flood hazard management.

The study concludes that:

- Adaptation efforts that are either broadly dictated or locally fragmented are inadequate.
- Regional cooperation and collaboration are required to put adequate adaptation measures in place.
- River systems that cross local, county, and state borders require cooperative planning and decision-making.
- Hazard mitigation efforts in the region, including buyout programs, flood insurance, levees, retaining basins, wetland restoration, and flood resilient infrastructure have largely been implemented at the local level, with limited regional coordination.

While this paper largely focuses on actions that can be taken to mitigate flooding at the local level, it does note that this event impacted multiple states, and calls for future action to be considered based on the geographic boundaries created by river basins and watersheds, rather than administrative boundaries.

The report recognises that there is value in developing locally-driven flood and severe weather adaptation plans, but to be truly effective, these need to be coordinated at the regional level; which may require funding or other incentivization from state and regional agencies.

The interviewees also noted that unlike coastal floods, which tend to be more acute events; the slow-moving nature of rain and river flooding can create a lag in the declaration of a federal emergency, which in turn leads to a delay in the ability to deliver disaster aid. Federal government and state agencies should also consider the potential unintended consequences downriver when implementing flood mitigation measures upstream.

5.5 High Water Event, Netherlands

In July 2021, large areas of the Netherlands flooded after heavy rainfall, affecting more than 2500 homes and 600 businesses. Around 50,000 people were evacuated, with no loss of life – although the total cost of the damage is estimated at €350–600 million.

In the aftermath of the flood, the Dutch Expertise Network for Flood Protection commissioned a fact-finding project. **Reference ID #65: "*High Water 2021 – Facts & Interpretation"*** contains the results of their preliminary study, which not only considers the hydrological and civil engineering aspects of the flood, but also looked at the social consequences of flooding, including the crisis response and the health effects.

A broad consortium of knowledge institutes participated in the research, including universities, research institutes, consultancies, and government agencies. The regional water authority, and the Dutch Ministry of Infrastructure and Water Management also provided information, and participated in field visits and interviews.

The assessment included a review of the effectiveness of the flood defences, assessing the use of both permanent and temporary barriers, and of the various response plans and mitigation strategies that were enacted at the time.

It also included a review of the impact of the floods on transportation (including national and local roads, the rail network, and on shipping), interruptions to the power supply, and failures with the internet and telecommunications networks, and the linkages and co-dependencies between them. It notes, for example, how a power outage caused by a flooded electrical cabinet caused a telecoms outage, due to the lack of a backup battery or an emergency generator; or how a damaged bridge or displaced subsoil can affect the copper wires and fibre optic cables it carries.

The report also noted that emergency shelters were made available during the floods within facilities such as sports halls, but were rarely used. Most people demonstrated personal initiative and self-reliance to evacuate themselves to safety if necessary.

The authors concluded that this makes it essential for authorities to share accurate and reliable information about the real-time condition of the flood defences, so that people can make informed decisions.

As one example of this, they cite how additional sandbags were made available by the water board and municipalities and filled by local residents, then positioned on top of existing flood defences to increase their retaining height. Locals were able to use the publicly available, real-time water level measurements and forecasts to determine the most effective locations to deploy their limited resources.

6 Functional Analysis

System Functions provide a mechanism to convey either a key concept from the reviewed references and case studies, or to highlight a notable component of a systems-based approach.

Each System Function is described using the 'action-object' naming convention to create a simple, two-word, verb-noun pair, and is accompanied by a brief explanation or description, and the source of the idea. An example is shown below.

SYSTEM FUNCTION	DESCRIPTION / EXPLANATION	SOURCE
Stress-test Systems	Use stress tests to demonstrate effectiveness at providing resilience to a major event, and to identify vulnerabilities	United Kingdom

Compiling System Functions in this way reduces complex concepts to simpler expressions that are more easily understood; which can then be more easily tailored to a particular environment. Conceptually, this can help to identify possible commonalities or themes between different systems which may not have obvious similarities; and will allow the Project Team to connect examples of international best practices back to the Canadian National Adaptation Strategy.

The following sections contain examples of some System Functions we identified as part of the literature review during Phase 1; the intention is to develop these further during Phase 2.

6.1 System Functions from Global reports

SYSTEM FUNCTION	DESCRIPTION / EXPLANATION	SOURCE
Understand Need	Acknowledge the disruption due to lack of resilient infrastructure can lead to higher costs, lower productivity, health and wellbeing impacts, and reduced incomes	World Bank
Regulate Resilience	Include resilience objectives in master plans, standards, and regulations, and regularly review & update.	World Bank
Leverage NbS	Adopt Nature based Solutions (NbS) typologies (or families) to maximise benefits	World Bank
Build-back-better Infrastructure	During recovery, take every opportunity to build back better to maximise future resiliency, based on an impact analysis	United Nations
Leverage Technology	Deploy emerging technology either to support recovery efforts (e.g. digital tools, web-based applications, remote sensing, and drones); or increase resilience (e.g. 3D printing, artificial intelligence, and geospatial and satellite imagery)	United Nations
Price Risks	Include climate risks in the financial decision making to account for the direct and indirect effects of climate change and climate variability	OECD

6.2 System Functions from North America

SYSTEM FUNCTION	DESCRIPTION / EXPLANATION	SOURCE
Modify Building codes	Modify building codes and to develop tools for climate change adaptation	Canada
Identify Risks	Use risk assessments to prioritize adaptation measures in areas at greatest risk	
Address Agriculture	Develop agriculture-relevant information to engage affected stakeholders	

Address Development	Identify the highest priority future risk locations	
Synergize Disciplines	Pool interdisciplinary resources to boost emergency responses, eliminate siloed approaches, consider interrelationships between systems, looking at disasters through a regional lens, and increase stakeholder engagement	
Optimize Data	Improve data availability, use common platforms to share disaster information. Use analytics to support data-driven decision making, planning, and forecasting; develop modelling and simulation for disaster-related decision-making	
Engage Locals	Involve the local community to identify disaster recovery and climate change adaptation strategies. Use horizontal and vertical mechanisms (among community stakeholders and political institutions).	New York
Engage Locals	Implement a community-led approach to encourage local populations to plan with their own priorities in mind	California
Renew Strategy	Mandate that climate adaptation strategies are regularly reviewed and updated to remain relevant.	
Sustain Science	Ensure decisions are based on the best available climate science	
Set Priorities	Focus on priorities for selecting sector-based and regional strategies and actions	
Measure Success	Link every action to a specific goal, tied to priorities, and accompanied by success metrics, delivery timescales, and the details of the agency responsible.	
Manage Retreat	Strategize retreat with coastal communities. Build consensus around concepts with community-based approach to identify challenges and priorities, locate areas of opportunity, evaluate the community vision, define strategies, identify project partners, and evaluate demonstration projects	Louisiana

6.3 System Functions from Europe

SYSTEM FUNCTION	DESCRIPTION / EXPLANATION	SOURCE
Measure Progress	Regularly assess performance against objectives, and against annual spending levels (as a % of GDP) with cost-impact assessments on businesses, consumers, and other end users	UK
Set Standards	Define relationships between Infrastructure Operators, Regulators, and Government. Identify the recovery point objectives when restoring service	
Stress-test Systems	Use stress-tests to demonstrate effectiveness at providing resilience to a major event, and to identify vulnerabilities	
Regulate Industry	Introduce regulations that require/incentivise infrastructure operators to produce long term resilience strategies, sharing guidance, scrutiny, and best practices from the sector	
Raise Awareness	Raise awareness of the need for climate adaptation with hard-to-reach or resistant communities	Netherlands
Set Policy	Embed climate adaptation in policy, legislation, and regulations at every level of government	

Measure Progress	Monitor the progress with, and effectiveness of, any adaptation policy	
Define Responsibilities	Define roles and responsibilities at national and territorial level	France
Regulate Land-use	Introduce long-term land-use strategies	
Build Knowledge	Build strong scientific knowledge and educate the public	
Engage Insurers	Collaborate with the insurance sector to ensure risks are properly priced	
Employ Grey-infrastructure	Use grey infrastructure (pipes, roads, parking lots etc.) to complement Blue-Green Infrastructure (rivers, canals, streams) to store extreme rainwater.	Denmark

6.4 System Functions from Asia & Oceania

SYSTEM FUNCTION	DESCRIPTION / EXPLANATION	SOURCE
Empower Locals	Involve local communities in risk assessments to better understand the problem. Provide tools for the community to protect themselves	Australia
Clarify Roles	Clarify the roles of the different actors impacted before, during, and after a major event. Define responsibilities of stakeholders and governance	Australia
Integrate Plans	Use Integrated Master Planning across sectors in consideration of carbon emission reduction, climate change safe proofing, flood protection, food security and ecology	Singapore
Promote Innovation	Value scientific research and innovation. Analyze progress to confirm emerging technologies deliver improved performance	Singapore

6.5 System Functions from Case Studies

SYSTEM FUNCTION	DESCRIPTION / EXPLANATION	CASE STUDY
Regulate Industries	Prevent risk through planning regulations. Build structures with codes and standards for resilience	Fort McMurray wildfire
Retrofit Infrastructure	Protect existing buildings with retrofits for local hazards	
Pre-establish Incident-management	Use a pre-established, standardized incident management approach that ensures people, resources, and facilities are organized to reduce response times and eliminate miscommunication	Calgary floods
Leverage Social-media	Leverage available social media platforms to provide direction, organize volunteers, and help rally together	
Engage Volunteers	Support and engage volunteers, recognising they are a valuable, but fragile, resource	
Establish Frameworks	Use established frameworks, structures, and plans to more effectively coordinate response.	
Recognize Challenges	Acknowledge that heat events expected once every thousand years may happen once per decade or more	

Register Senior-citizens	Maintain a register of senior citizens so health workers can check on them. Residential establishments can assign specific people the responsibilities to check on elderly residents	Pacific Northwest heatwave
Implement National-heatwave-plan	Coordinate between the national government, regional/local officials, and private institutions. Adoption relies on public health education and communication about extreme heat events	
Provide Warning-systems	Tailor messages on heatwave early warning systems to inform and motivate vulnerable groups; with tiered warnings for vulnerable groups with lower risk thresholds. Update warning systems to ensure effectiveness	
Expand Collaboration	Collaborate and act based on the geographic boundaries of river basins and watersheds - rather than administrative boundaries for rivers crossing local, county, and state borders. Consider consequences downriver when implementing flood mitigation measures upstream.	Missouri River flood
Provide Real-time-information	Share information of real-time condition of flood defences and forecasts for people to make informed decisions	Netherlands flood

7 Conclusions & Next Steps

This report summarizes the key findings from an international literature review to research the use of system-based approaches to mitigate the impacts of climate change. It includes a synthesis for each of the 20 documents reviewed in detail, a narrative highlighting some noteworthy content, and an initial functional analysis.

In selecting documents for the literature review, we chose to include examples that focused on single events, as well as more generic guidance and frameworks that describe an overall approach or methodology unconnected to any one incident. To reflect scalability, we sought to identify opportunities that could be applied at the city, region or national level; and which would be appropriate given the Canadian climate and environment.

In total, twenty documents were synthesised, with each one receiving a detailed write-up, using a common framework for consistency. Elements of the original report relevant to this project's scope were captured, and recorded within the synthesis in one of two ways; depending on whether the material relates to timing (phase) or the type of content (theme):

- Phase (prepare, respond, recover, rebuild);
- Theme (technical, financial, policy/legal, socio-economic, governance/ institutional).

Selected elements of the reports and case studies are included in Sections 4 & 5 of this report, to direct readers to the syntheses of most interest. Appendix A contains the full synthesis prepared for each of the twenty documents assessed in detail; Appendix B provides limited information on all remaining literature included in the original set of approximately one hundred documents.

We also used the literature review process to identify examples of System Functions found within the material. System Functions are expressed as simple, verb-noun pairs, as shown below.

The next phase of work will build on these initial findings by incorporating feedback to expand and further refine the system functions. The goal is to identify clear opportunities to implement scalable (multi-level) and flexible (multi-context) systems-based frameworks to improve the

resiliency of infrastructure in Canada; and which cover the entire event timeframe, from pre-event preparation through initial response, to post-event recovery and the eventual rebuild.

To deliver the next phase, we propose the following next steps:

STEP	DESCRIPTION
1	Issue draft report & present initial findings
2	Feedback provided on draft content
3	Expand functional analysis
4	Organize analysis in the context of the NAS development
5	Refine the analysis to provide a final set of recommendations

The final recommendations will build upon the results from the first phase, supplemented by any feedback from the British Columbia Ministry of Transportation and Infrastructure (BC MoTI), the Committee of Deputy Ministers on Rebuilding of Public Infrastructure, and Infrastructure Canada.

8 References

ID #	DOCUMENT TITLE AND BIBLIOGRAPHY	REGION
05	**Lifelines: Resilient Infrastructure Opportunity** *World Bank (Stéphane Hallegatte, Jun Rentschler, & Julie Rozenberg). 2019.* Available: https://openknowledge.worldbank.org/handle/10986/31805	Global
71	**A Catalogue of Nature-based Solutions for Urban Resilience** *World Bank and GFDRR. 2021*. Available: https://openknowledge.worldbank.org/handle/10986/36507	Global
93	**Global Compendium of good practices on post disaster recovery** *European Union, United Nations, and World Bank. 2020.* Available: https://www.latinamerica.undp.org	Global
69	**Climate-resilient Infrastructure - Policy Perspectives** *OECD. 2019.* Available: https://www.unisdr.org	Global
18	**Climate Change Adaptatio`n: A Priorities Plan for Canada** *B. Feltmate and J. Thistlethwaite, University of Waterloo, Canada. 2012.* Available: https://uwaterloo.ca/environment/sites/ca.environment/files/uploads/files/CCAP-Report-30May-Final.pdf	Canada
07	**Systems Approach to Management of Disasters – A Missed Opportunity?** *S. Simonovic, Journal of Integrated Disaster Risk Management. 2015.* Available: https://www.idrimjournal.com/article/11677-systems-approach-to-management-of-disasters-a-missed-opportunity	Canada
21	**A Managed-Participatory Approach to Community Resilience: NY Rising** *Simon McDonnell, et al; Governor's Office of Storm Recovery (New York) & Rockefeller Institute of Government. 2016.* Available: https://stormrecovery.ny.gov/sites/default/files/crp/community/documents/2016-06-Managed-Participatory_Approach.pdf	NY, USA
23	**California Climate Adaptation Strategy** *California Natural Resources Agency. 2021.* Available: https://climateresilience.ca.gov/	CA, USA
24	**Louisiana Climate Action Plan** **Our Land and Water: A Regional Approach to Adaptation** (part of Louisiana's Strategic Adaptations for Future Environments. *Louisiana Office of Community Development & the Foundation for Louisiana. 2009.* Available: https://lasafe.la.gov/.	LA, USA

40	**Anticipate, React, Recover: Resilient Infrastructure Systems** *National Infrastructure Commission. 2020*. Available: https://nic.org.uk/app/uploads/Anticipate-React-Recover-28-May-2020.pdf	UK
44	**National Climate Adaptation Strategy 2016: "Adapt with ambition"** *Ministry of Infrastructure and the Environment. 2016*. Available: https://klimaatadaptatienederland.nl	Netherlands
57	**Plan National D'Adaptation au Changement Climatique** (French National Adaptation Plan for Climate Change) *National C Ministère de la Transition Ecologique et Solidaire. 2018.* Available: https://www.ecologie.gouv.fr	France
54	**Copenhagen Cloudburst Management Plan** *Technical and Environmental Administration at the City of Copenhagen. 2012.* Available: https://en.klimatilpasning.dk	Denmark
102	**Australian Emergency Management Arrangements Handbook** *Australian Institute Disaster Resilience. 2019*. Available: https://www.aidr.org.au/media/1764/aidr_handbookcollection_australian-emergency-management-arrangement_web_2019-08-22_v11.pdf	Australia
74	**Preparing for a Climate Resilient Singapore** *E. K. Ludher, K. F. Hsu, N. Sim; Centre for Livable Cities Singapore. 2021.* Available: https://www.clc.gov.sg	Singapore

CASE STUDIES		
86	**Fort McMurray Wildfire: Learning from Canada's costliest disaster** Institute for Catastrophic Loss Reduction. 2019 Available: https://www.zurichcanada.com/-/media/project/zwp/canada/docs/english/weather/fort-mcmurray-report_canada.pdf	Canada
87	**Forewarned and Forearmed - The Calgary Emergency Management Agency and the 2013 Flood** *"Calgary's Flood Resilient Future" - Expert Management Panel on River Flood Mitigation. 2014* Available: https://www.calgary.ca/UEP/Water/Documents/Water-Documents/Flood-Info-Documents/Expert-Management-Panel-Report-to-Council.pdf	Canada
28	**Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada in June 2021** *Philip, S. Y. et al. 2021 (in review)* Available: https://doi.org/10.5194/esd-2021-90	Canada/ USA
30	**Adapting to Climate Change in the Upper Mississippi River Basin: Exploring Stakeholder Perspectives on River System Management and Flood Risk Reduction** *Tamsen Reed et al; Environmental Health Insights v14. 2020.* Available: https://journals.sagepub.com/doi/10.1177/1178630220984153	USA
65	**High Water 2021 - Facts & interpretation** *Expertise Netwerk Waterveiligheid. 2021.* Available: https://klimaatadaptatienederland.nl	Netherlands

Appendix A – Synthesised Reports

Synthesizer: Simon Kates Reference ID: 05

Title of document being synthesized and year it was published**: Lifelines: The Resilient Infrastructure Opportunity (2019)**
Author(s): **Stéphane Hallegatte, Jun Rentschler, Julie Rozenberg**
Category of document: **General Literature**
Geographic focus of the document: **Global**

Report Summary

"Resilient infrastructure is about people"
Examples of investments that make infrastructure more resilient
Assesses the costs and benefits of investing in resilient infrastructure

Four systems:
- Power
- Water and sanitation
- Transportation
- Telecommunications

Study shows that the extra cost of building resilient infrastructure is only 3% of overall investment. Net benefit of $4 for every dollar invested.
Business as usual would cost $1 trillion more than investing in resilient infrastructure

Organization of the document:
- Part 1: A Diagnosis: A Lack of Resilient Infrastructure is Harming People and Firms (establishes the scale of the problem, quantifies the costs of infrastructure disruptions, explore the role of natural hazards and climate change; demonstrates adverse impacts and contribution to poverty and poor health.)
    - Infrastructure Disruptions are a Barrier to Thriving Firms
    - Infrastructure Disruptions Affect the Health and Well-Being of Households
    - Natural Shocks are a leading Cause of Infrastructure Disruptions and Damages
    - From Micro to Macro: Local Disruptions Translate into Macroeconomic Impacts
- Part 2: A Matter of Design: Resilient Infrastructure in Cost-Effective (Identifies solutions to make infrastructure systems and users more resilient, estimates costs and benefits)
    - More Resilient Infrastructure Assets are Cost-Effective
    - From Resilient Assets to Resilient Infrastructure Services
    - From Resilient Infrastructure Services to Resilient Users
- Part 3: A Way Forward: Five Recommendations for More Resilient Infrastructure (concrete steps for development of more resilient infrastructure, including policy measures)
    - The Foundation for Resilient Infrastructure
    - Build Institutions for Resilience
    - Create Regulations and Incentives for Resilience
    - Improve Decision Making
    - Provide Financing

The report has three main conclusions:
1. The lack of resilient infrastructure harms people and businesses.
2. Investing in more resilient infrastructure is both urgent and profitable.
3. Good infrastructure management is the necessary basis for resilient infrastructure, but targeted actions are also needed.

Guiding principles in the report:

- Infrastructure disruptions are a drag on people and economies
  - Infrastructure disruptions cost businesses more than $300 billion per year.
  - Infrastructure disruptions' direct impact on people are worth at least $90 billion per year
  - Natural shocks are among the leading causes of infrastructure disruptions
- More resilient infrastructure assets pay for themselves
  - Building more resilient infrastructure assets in exposed areas is cost-effective.
  - Resilient infrastructure assets provide more resilient infrastructure services.
  - Resilient infrastructure assets lead to more resilient users and economies
- Making infrastructure more resilient requires a consistent strategy
  - The report concludes with a series of five Recommendations, each accompanied by several Actions. These Recommendations and Actions are summarized in the synthesis below.

1. Preparedness

1.1. Summary

Part II of the report explores how costs that would be incurred after infrastructure interruptions can be avoided through engineering and planning solutions that make infrastructure more resilient and better prepared for extreme events.

- Section 6 describes the benefits of providing more resilient infrastructure assets in reducing the life-cycle cost of assets.
- Section 7 describes the interconnectedness of infrastructure systems. Looking at assets alone is not enough to understand how resilient services operate as networks.
- Section 8 explores the benefits that resilient infrastructure has on users—including people and supply chains—reducing the impact of natural disasters on people, businesses, and the economy.

Part II of the report provides a series of five recommendations to enhance infrastructure resilience.

- Section 9 describes the challenge of infrastructure systems that are less resilient because they are poorly designed or mismanaged.
- Section 10 explores the political challenges and coordination failures that create barriers to more resilient infrastructure.
- Section 11 examines why public and private decision-makers do not have sufficient incentives to create more resilient infrastructure.
- Section 12 focuses on the lack of data, models, and tools that make it difficult for service providers to implement resilient solutions.
- Section 13 examines affordability and financing solutions to create more resilient infrastructure.

1.2. Technical

- The services that infrastructure assets provide are just as important as the assets themselves. This way of thinking is about how infrastructure assets, such as transportation, water, and power networks are integrated into how people experience everyday life.
- Diversifying assets creates greater resilience by building redundancies in the system. Decentralizing assets has a similar impact—an outage or disruption of one asset has a smaller impact on the overall network.
- Strategies to protect infrastructure systems, such as using dikes in densely populated areas and incorporating nature-based solutions can reduce infrastructure needs and costs.

1.3. Financial

- Building more resilient infrastructure can prevent damage from natural hazards, reduce repair costs, and reduce maintenance needs of the life cycle of the asset.

- More resilient infrastructure assets may come with higher up-front costs. The extent of these additional costs depend on the asset type and the hazards that the assets are designed to withstand.
- Higher up-front costs may be offset by lower maintenance and repair costs.
- Improving maintenance and operations can also increase resilience while reducing life cycle costs.

1.4. Policy & legal

1.5. Socio-economic

- The goal of making infrastructure assets more resilient is to increase the resilience of the end users. How catastrophic an infrastructure disruption depends a great deal on the ability of users to cope with the disruption.
- How critical an asset is depends in part on the end user—for example, a power distribution line that serves a hospital or shelter may be more important than a typical line. Investigation of users and supply chains can help communication criticality of each asset.

1.6. Governance & Institutional

- **Recommendation 1: Get the Basics Right**
  - Infrastructure systems often underperform because of poor management and governance. Performance increases along with increased spending, but only if quality of governance improves as well.
    - Introduce and enforce regulations, construction codes, and procurement rules
    - Create systems for appropriate infrastructure operation, maintenance, and postincident response.
    - Provide appropriate funding and financing for infrastructure planning, construction, and maintenance.
- **Recommendation 2: Build Institutions for Resilience**
  - Governments need to play a coordinating role to remove barriers to creating resilient infrastructure.
    - Implement a whole of government approach to infrastructure resilience, building on existing regulatory systems.
    - Identify critical infrastructure and define acceptable and intolerable risk levels.
    - Ensure equitable access to resilient infrastructure.
- **Recommendation 3: Include resilience in regulation and incentives**
  - Public and private decision-makers need incentives to avoid disruptions. If they incentive structure is only focused on lowering short term costs, rather than lifecycle costs and social costs, they won't focus on creating more resilient systems.
    - Consider resilience objectives in master plans, standards, and regulations and adjust them regularly to account for climate change.
    - Create financial incentives for service providers to promote resilient infrastructure services.
    - Ensure that infrastructure regulations are consistent with risk-informed land use plans and guide development toward safer areas.
- **Recommendation 4: Improve decision making**
  - Even if decision-makers have the right incentives, they also need access to the right data, tools, skills, and competencies to make good decisions.
    - Invest in freely accessible natural hazard and climate change data.
    - Make robust decisions and minimize the potential for regret and catastrophic failures.
    - Build the skills needed to use data and models and mobilize the know-how of the private sector.
- **Recommendation 5: Provide financing**

- Increasing resilience to infrastructure systems can often increase life-cycle costs to government or providers. When affordability is a challenge, government should seek solutions such as tax increases, trade-offs between quantity and quality of service provided, etc. More often, however, increased resilience brings higher up-front costs but reduces overall life-cycle costs. In this case, financing is the challenge (not affordability) so solutions have to factor in annual revenues to demonstrate ongoing cost benefits.
  - Provide adequate funding to include risk assessments in master plans and early project design.
  - Develop a government-wide financial protection strategy and contingency plans.
  - Promote transparency to better inform investors and decision makers.

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

Part I discusses infrastructure disruptions after disasters, largely impacting Recovery.

In Section 2, the report analysis the ways that infrastructure disruptions create barriers to business. This content is placed in the Recovery section because it relates to how businesses operate in the event of a disruption. The discussion here relates to the three types of impacts: direct impacts (visible, immediate consequences); coping costs (expenses associated with response and recovery efforts); and indirect impacts (less immediate impacts about investments and innovation). Section 2 is discussed under the Financial heading below.

Similarly, Section 3, which covers impacts of infrastructure disruptions on health and well-being of households, relates to recovery. This section covers the ability of families to react and recovery in the event of infrastructure disruptions. As above, the report discusses direct impacts, coping costs, and indirect costs on households. Section 3 is discussed under the Socio-economic heading below.

Section 4 describes the impacts of “natural shocks,” or natural disasters such as storms, floods, earthquakes, etc. on infrastructure systems. This section, which discusses the impacts of natural shocks on physical infrastructure, is summarized under the Technical heading below.

Section 5 covers the impact that local infrastructure disruptions can cause broader economic impacts. Further, simply measuring the asset losses caused by a natural disaster could be insufficient in that it does not reflect secondary impacts and impacts on vulnerable populations.

3.2. Technical

- The power sector can be highly vulnerable to natural hazards. Severe weather events are significant causes of power outages. In some cases, higher income countries have a higher share of power outages due to natural shocks (because lower income countries also suffer from less reliable electricity systems even without natural disasters). That said, Canada has a relatively low

share of power outages due to natural shocks, compared to other high-income countries (see Figure 4.2 on page 59).

- Water systems are especially vulnerable to climate change impacts, such as floods and droughts. Dams can be damaged by high river flows, putting downstream communities at risk. Water and wastewater treatment plants are at high flood risk because they are often sited at lower elevations.
- Transportation infrastructure can be damaged by extreme weather events, disrupting road, rail, water, and air transport. Natural hazards also contribute to large repair and maintenance costs.
- Telecommunications infrastructure has become central to modern life. Redundancies are built into dense systems, but widespread outages, or outages in more rural areas, can have severe consequences. Assets include submarine cables, terrestrial cables, internet exchange points, data centers, and wireless transmission infrastructure.

3.3. Financial

- The report argues here that resilient infrastructure systems is a baseline to having a thriving economy with growing businesses.
  - "Infrastructure development has positive effects on income growth and even distributive equity." (p. 34)
- Meanwhile, disruptions in infrastructure services impact the ability of businesses to grow.
  - The report provides examples from around the world demonstrating that infrastructure disruptions had a meaningful reduction in GDP among the countries surveyed.
- Businesses are forced to spend money to protect their own bottom line, when public infrastructure is unreliable
  - Coping costs include actions such as self-generating electricity, measures to conserve and reuse water, and adapting to transport disruptions.
- Unreliable infrastructure reduces productivity
  - The report describes studies that found that electricity outages and other disruptions cause a reduction in the outputs of impacted businesses.

- Indirect losses can exacerbate the macroeconomic impact of natural disasters. For example, drops in employment following an earthquake, interruptions to air travel after a volcano, or forced relocations due to disruption of the water supply following a hurricane are all indirect impacts that harm economic output.
- Supply chains can also be interrupted following natural disasters.

3.4. Policy & legal

3.5. Socio-economic

- This section discusses the costs that households shoulder when they expect long-term or frequent disruptions of service, for example purchasing a generator or relying on a car instead of spotty public transit service. Money spent on backup capacity is then not available for other investments.
- Infrastructure services help to support the basic needs of households and families. Interruptions in service of electricity, water, and sanitation have serious impacts on quality of life, wealth building, and public health. Reliable transportation reduces travel time and transport costs.

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

Interesting focus on marginal cost—we often think about climate adaptation as being about constructing infrastructure that isn't needed anyway. This framing is more about taking infrastructure that needs to be built anyway—and just making sure that it is resilient.

Focuses on why we need infrastructure—it's meant to serve people, so it has to be constructed with people in mind.

Helpful look at high-level, conceptual approaches that governments should take into account. This report does provide some examples and case studies along the way. However, the focus is at 30,000 feet—what concepts should decisions-makers keep in mind when developing a program to produce more resilient infrastructure? These concepts could provide useful guidance to Canada in determining how to develop an adaptation program.

Synthesizer: Gonzalo Fuentes Dellepiane (gfd@ramboll.dk) Reference ID: 71

Title of document being synthesized and year it was published**: A Catalogue of Nature-based Solutions for Urban Resilience (2021)**
Author(s): **The World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR)**
Category of document: **SBA-CRI**
Geographic focus of the document: **Global**

Report Summary

The catalogue of Nature-based solutions (NBS) 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 NBS. It provides good practice examples, design, benefits, and implementation considerations, and it provides insight to the suitability of NBS in the urban landscape and their effectiveness for climate resilience.

By presenting insights of the performance and benefits of 14 NBS typologies (NBS families), the catalog aims to support policymakers, 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.

The document is structured in three chapters as follow: Chapter 1 presents an introduction to the key elements in this catalogue by briefing on the urban resilience challenges and the increasing need for NBS, the NBS approach and its relevance to address different societal challenges, and the catalog of solutions and typologies that helps stakeholders to identify potential investments. Chapter 2 describes generic principles for integrating NBS into urban environments. Chapter 3 provides a reader's guide and holds the Catalogue of the fourteen NBS families. Each NBS family is addressed in seven sections:

1. Facts and figures
2. Visualizations
3. Functions
4. Benefits
5. Suitability considerations
6. Costs
7. NBS in practice

The Catalog focuses mainly on nature-based solutions for flood and heat risk management in urban areas, but it also provides insights for other social and environmental benefits of NBS.

1. Preparedness

1.1. Summary

This document mainly focuses on Preparedness since it was developed as a resource for practitioners aiming to shape cities and urban resilience with nature. The Catalogue provides an overall definition of nowadays challenges, the NBS approach to meet the rising challenges of reaching urban resilience, and catalog of good practices and solutions within depth descriptions that support the identification of urban NBS investments.

This is built upon two key questions that scope the NBS potential: (i) What are the desired benefits from the NBS? and (ii) Is the NBS suitable at the location? To help answer these two questions, the Catalogue provides: (i) technical descriptions, visualizations, and examples to better assess the potential of NBS in urban areas; (ii) unit costs and benefits' estimates to help assess the economic viability; and (iii) suitability considerations to provide guidance on possible locations for NBS.

1.2. Technical

When integrating Nature-based solutions in cities, this document describes five important principles that are applied for all 14 NBS families in the Catalogue. These principles are proposed as a guide for the identification and realization of potential investments in NBS:

1.2.1. Assess the functions, benefits, costs, and suitability considerations of NBS

- Assessments on functions, benefits, location suitability, and costs of NBS enable an initial identification of locations of potential investments.
- It increases understanding of the socioeconomic values of NBS and helps identify locations where environmental, technical, or urban conditions are suitable for NBS
- Each NBS is characterized by a set of processes that defines their **functions** and the **benefits** they provide.
- **Functions** are an important intermediate step for understanding the value, or benefits, of NBS for people.
- **'Benefits'** are provided if there are people who directly or indirectly benefit from NBS functions.
- In the Catalogue, each NBS family includes a visualization of their processes, a section describing its functions, and a section with its benefits described qualitatively

1.2.2. Apply an **integrated systems approach to NBS** for resilience in urban landscapes

NBS are often most effective when approached and planned in an integrated or holistic manner, especially in complex urban environments. This means first taking a system-based approach to address resilience and biodiversity challenges, and then, seeking practical ways to integrate NBS into policies plans, programs, and projects.

- A systems approach means that **NBS should not be designed independently**, but rather to complement and strengthen existing risk management interventions.
- **NBS can be integrated into broader programs**, such as risk management plans, plans for designs of structural measures, proactive urban and land use planning, evacuation management, and sustainable maintenance.
- With the alarming levels of biodiversity loss, **planning of ecological networks is therefore critical** in cities where NBS can be used to provide supplementary habitat.
- While resilience and biodiversity benefits are key in NBS design, it is often the variety of co-benefits contributing to human wellbeing that supports the value proposition over gray infrastructure alternatives.
- The longevity of **NBS also requires the support of local communities** and the integration of local community needs and aspirations into planning to ensure that interventions are supported and maintained in the long term.

1.2.3. Consider **the principles of ecosystem conservation** by adopting a hierarchy of ecosystem-based approaches

NBS are an umbrella concept covering a range of ecosystem-based approaches including **protection, sustainable management, restoration, and creation** of natural or green infrastructure.

- These approaches can be considered in a hierarchy, prioritizing the protection of existing ecosystems over enhanced management, rehabilitation and restoration, or the creation of new NBS:
    - **Protection** and sustainable management of existing nbs to sustain benefits and biodiversity

  - **Enhancement** restoration and rehabilitation of degraded nbs regenerating benefits
  - **Creation** of new NBS
- **protection, restoration, and creation of new NBS are complementary** and the development of an NBS strategy should assess all elements.
- Consideration of this hierarchy is particularly relevant when investigating and prioritizing NBS opportunities at a strategic level, such as when screening investment opportunities for a city.
- The Catalogue indicates which of the ecosystem-based approaches can be applied for each NBS family.

1.2.4. Consider the **integration of NBS across a range of spatial scales**

NBS should be considered at a range of spatial scales. The Catalogue considers NBS at three spatial scales: **the river basin scale, the city scale, and the neighborhood scale.** The different scales at which the NBS can be implemented are indicated for every NBS family.
It describes the difference between these spatial scales for flood resilience problems. Urban areas can be affected by **riverine flooding**, **coastal flooding**, and **either pluvial or ground water floods or combinations.**

- **The river basin scale:** Cities can be located at different positions in a river basin, their position determines the suitability of NBS types in the city at hand.
  - **Mountainous cities**
  - **River cities**
  - **Delta cities**
  - **Coastal cities**

  NBS at the river basin scale recognize **the interconnectedness of communities** and the **importance of integrated catchment management approaches** to address flooding and water resource challenges.

  These include NBS that address the problem near the source, outside of the city, and aim to tackle the problem before it reaches the city.

  - A schematic section of NBS at the river basin scale is provided including examples of NBS typically considered: Upland forests, River floodplains, Natural inland wetlands, Sandy shores, Mangrove forest, Artificial reefs.

- **The city scale:** NBS at the city scale include measures in a city or town that seek to complement and strengthen urban land use planning and to support disaster risk management.
  - A schematic section of NBS at the city scale is provided including examples of NBS typically considered: Urban Forest, Terraces and slopes, River and stream restauration, Green corridors, Constructed wetlands, Open green spaces, Natural inland wetlands, River floodplains.

- **The neighborhood scale:** At the neighborhood scale, resilience challenges are addressed at a local level including measures in buildings, streets, and open public spaces.
  At this scale, collaboration between the **public and the private** domain is key, and NBS implementation can help **build alliances between the different stakeholders**.

  - A schematic section of NBS at the neighborhood scale is provided including examples of NBS typically considered: Urban farming, Bioretention areas, River

and stream restoration, Pocket parks, Retention ponds, Green roofs, Green walls.

Spatial considerations for arid and semi-arid urban contexts: NBS planning for these contexts should integrate detailed analysis of the environmental factors critical for plant and tree survival.

1.2.5. Adopt a **multistakeholder and interdisciplinary approach**

Integrating NBS into urban resilience strategies **requires a collaborative, interdisciplinary, and cross-sectoral approach.** This means extensive coordination through project phases, and between a variety of actors.

Successful realization of NBS requires **interactive development of holistic long-term strategies.** It involves an **interdisciplinary approach** that integrates flood risk management, land use planning, and climate change adaptation strategies defined by **interdisciplinary teams** composed by urban planners, landscape architects, urbanists, civil engineers, and stakeholders.

Given their interdisciplinary and cross-sectoral character, NBS projects have the unique capacity and opportunity to catalyze **better cross-sectoral collaboration**.

The 14 NBS families in the Catalogue are presented through the following structure and information:

- Facts and figures
    - Short description
    - Type of city
    - Scale
    - Approach
    - Processes
- Visualizations
    - Visualization of the NBS in the urban context
    - Details of increased benefits for the urban living environment
    - Special techniques for the NBS
- Functions
- Benefits
- Sustainability considerations
    - Environmental considerations
    - Technical considerations
    - Urban considerations
    - Maintenance
- Costs
    - Costs considerations
        - Land
        - Construction and implementation
        - Maintenance
    - Unit Cost examples
- NBS in practice (Examples with global good practices)

The 14 NBS families are:

- Urban Forrest

- Terrace and Slopes
- River and Stream Renaturation
- Building Solutions
- Open Green Spaces
- Green Corridors
- Urban Farming
- Bioretention Areas
- Natural Inland Wetlands
- Constructed Inland Wetlands
- River Floodplains
- Mangrove Forest
- Salt Marshes
- Sandy Shores

1.3. Financial

1.3.1. Costs

For each NBS type, the Catalogue outlines key cost considerations for the investment and implementation stage, such as land-related costs, NBS construction costs, or longer-term maintenance costs. In addition, examples of unit costs are provided.

- **Upfront costs:** include costs associated with securing the land upon which the NBS will be installed and costs for planning, installing, and overseeing the effective implementation of NBS measures.
  - ***Land-related costs***
  - ***NBS installation or implementation***
- **Maintenance costs:** the actions required to maintain a functional NBS, providing the benefits it was designed for.

Some considerations regarding Costs:

Actual project-level NBS costs may differ from the example unit cost estimates provided in the Catalogue for the following reasons:

- NBS project costs vary significantly and are highly site- and project-specific.
- Many unit cost estimates in the literature are derived from developed countries, where unit costs may be much higher than in the developing country context.
- Unit cost estimates associated with implementing NBS in rural areas may be lower than in urban areas given the higher transaction costs that typically accompany urban projects
- Unit cost estimates in the literature vary depending on the components the project included—for example, land acquisition, construction technique, types of materials, maintenance needed.

Benefits assessment is important for identifying project financing

After the scoping phase and identification of NBS (and beyond the scope of this Catalogue), **a thorough assessment of the benefits and beneficiaries of NBS is critical for the identification of financing options**. The principal sources of funding are based on sustainable revenues derived from tariffs, taxes, or transfers that determine how investment costs are repaid over time, while also supporting project life cycle costs.

- Governments have traditionally provided economic and social infrastructure both as financier and by establishing the enabling policies and regulations.
- **public investments alone are often not sufficient**, given the size of investment required to meet future challenges relating to building urban resilience.
- **Valuation of a broad range of benefits can provide opportunities to leverage a wider array of financing options** that can help promote the application of nature-based solutions and continuous improvements in the quality of life and urban landscape.
- Based on the potential benefits and beneficiaries identified**, different financing mechanisms and sources can be adopted** and leveraged.

1.4. Policy & legal

1.5. Socio-economic

1.6. Governance & Institutional

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

This document, as presented, aims to guide practitioners and stakeholders on the process of evaluation and selection of NBS. It provides an overall understanding of the key concepts around NBS and it presents a general approach for the identification of urban NBS investments.

Its main section, the catalog of 14 NBS typologies, works as a toolbox for all practitioners and stakeholders that aim to implement urban resilience through NBS. It provides a systematic and comprehensive presentation of each typology, diving into design, benefits, and implementation considerations among others. The good practice examples for each NBS typology provides a general but assertive snapshoot of its applicability.

In terms of defining a scope of work or framework, this catalogue seems superficial by only providing general definitions and the “state of arts” around NBS. On the other hand, the Catalog of typologies and each description can provide a good help when defining the specific NBS toolbox for the Canadian context.

Synthesizer: Koen Broersma Reference ID: 93

Title of document being synthesized and year it was published**: Global Compendium of good practices on post disaster recovery**
Author(s): **UN (EU / WB)**
Category of document: **SBA-CRI / Framework**
Geographic focus of the document: **Global**

Report Summary

This systemization prepared by the United Nations Development Programme (UNDP) compiles Good Practices on Post Disaster Recovery, to disseminate and highlight the work and recovery processes that are being carried out in different countries of the following regions: Africa, Asia, East Europe (ECIS) and Latin America and the Caribbean (LAC).

This document brings together 25 initiatives developed in 23 countries at Global level (Kenya, Malawi, Mozambique, Niger, South Sudan, Zimbabwe, Bangladesh, Indonesia, India, Nepal, Bosnia and Herzegovina, Tajikistan, Serbia, Barbados, Bolivia, Haiti, Cuba, Colombia, Costa Rica, Ecuador, Guatemala, Mexico and Peru).

It compiles a selection of good practices on disaster recovery processes led by multiple actors including local, sub-regional and national governments, civil society organizations, communities, foundations, private sector organizations and academia, as well as in some cases with the support of the United Nations System and UNDP.

10 key criteria were analysed including universality, transferability, applicability, expandability, orientation, focus, assimilation, integrability, impact and effectiveness.

1. Preparedness

1.1. Summary

The framework for recovery and the tools for implementing recovery need to be planned or developed in normal times to avoid improvisation during times of disasters.

1.2. Technical

The development of drought mitigation's plans encompasses effective drought early warning and delivery systems, vulnerability assessments, mitigation and response actions.

Develop guidelines and a training kit on building safe and resilient community infrastructure.

The first step towards preparedness and increasing resilience is the adequate knowledge base leading to an increase in awareness among decision makers at the national as well as at the local level, followed by a stronger governmental commitment.

Disaster prevention and preparedness, enabled by communication and space technologies, can be far more effective and at a lower cost for disaster monitoring, early warning, and emergency response efforts.

1.3. Financial

A resilience 'cushion' to crisis impact and future shock impeding development progress, designed to be ring-fenced budget contingency lines, built into existing multi-year grants. These are set up to be released when agreed early warning triggers of emerging crises are met (removing some of the human bias in

decision making, through setting clear and automatic triggers for funding that can then be validated and targeted effectively using on-the-ground assessments.).
The aim is to no longer hold the risk of crisis in the project budget, but to convert it into an annual 'premium' and transferred out to a collectively owned facility that can pool this across different contexts and/or purchase re-insurance where needed.

1.4. Policy & legal

Key steps in planning the reconstruction process:

- The Legal and Governance Framework
- Participation, Communication and Outreach
- Financial Management, Transparency and Accountability

1.5. Socio-economic

1.6. Governance & Institutional

Improving recovery processes and institutionalizing the PDNA (Post Disaster Needs Assessment) in the country through:

- Risk management as a social process linked to development
- Making 'action plans for recovery' mandatory
- High-level oversight
- Decentralized coordination
- Planning instruments
    - A National strategy for disaster response
    - Plans for risk management at all levels of government to prioritize, program and implement actions
    - The mainstreaming of risk management in provincial, district and municipal development plans
    - Risk assessments for all large public works or other industrial activities that may create disaster risks
- The principle of participation
- The principle of environmental sustainability
- Financing risk management

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

The community approach is an important strategy to motivate people facing a traumatic event such as an earthquake or other crises. The opportunity to work collectively stimulates beneficiaries helping them overcome hardship and to work towards the common goal of recovering their livelihoods.

2.6. Governance & Institutional

Institutional and legislative capacity to assess, implement and monitor at national and county levels gender- and human rights-sensitive DRM and early warning systems, peace-building, conflict prevention and community security policies, strategies and plans; Coordination mechanisms, preparedness, and timely response and recovery systems operational at national, county and community levels.

Effective coordination effort among various organizations and stakeholders in this process stand as a key element to avoid the fragmentation of responsibilities for actions.

3. Recovery

3.1. Summary

While humanitarian assistance may constitute the most effective investment towards saving lives in the immediate term; from a longer-term perspective, effort have been made to establish linkages to early recovery and development processes by implementing a nationally owned strategy and addressing the poverty conditions in the affected regions.

Developing not only emergency interventions but also appropriate resilience building activities focused on the local population's needs to reduce loss and damages effects related to flood and to reduce vulnerability to future disasters.

New Way of Working (NWoW) centers on a three-pronged approach involving: (i) Joint analysis towards a mutual understanding of challenges; (ii) Promoting and advancing a resilience agenda; and (iii) Pursuing collective outcomes

An integrated and multi-sectoral approach was adopted in the design and implementation of the recovery plan, focusing on three main pillars: (i) infrastructure, (ii) economic reactivation and (iii) recovery of the social fabric. Environmental considerations are mainstreamed across all three pillars.
This includes the following principles:

- To avoid rebuilding risk
- Focus on the most vulnerable
- Support and empower the affected population
- Inter-institutional collaboration
- Restore capacities and strengthen institutions
- Support the role of local actors
- Monitor, evaluate and learn
- Financial transparency

Align recovery objectives with those of international frameworks and guidelines like the SDGs and the Sendai Framework.

3.2. Technical

A unique aspect of the [..] recovery process has been the dynamic digital databases. They take into account historical data and continuously build upon current data. Communities having as much control over the data and its use in the decision-making process as the government result in a more informed and enriched planning and decision-making process of recovery.

The Household and Building Damage Assessment Toolkit (HBDA) allowed government teams to use smartphones to gather the necessary data on damage to houses and critical public and commercial infrastructure such as schools, hospitals, and hotels, using a pre-designed online questionnaire. Such technologies enable a more rapid and effective collection, analysis and visualization of geo-referenced

disaster information. The ability to access real-time data empowers governments to make time-sensitive decisions.

The most unique factor was the application of drone captured imagery in the local level damage assessment. The use of drones helped to provide quick and accurate damage data. Compared to satellite imagery, drone imagery is higher resolution, less costly and less technical in application. Aerial photos captured by drones could be easily used by less technical experts, so it is more accessible to local communities. Being a relatively lower cost, widely available and easy to use technology it is more accessible to the communities who once trained can use this for future risk reduction purposes.

3.3. Financial

The recovery process relied on the livelihoods restoration among flood affected population, through cash for work programs to rehabilitate critical public infrastructure and which led to inject back cash in communities.

Temporary employment through different “cash-for-work” activities design to create community assets in the resettlement areas.

The financing of recovery needs to draw on different funding mechanisms such as government budget, specific recovery funds, government schemes, private sector, insurance.

3.4. Policy & legal

To be effective institutionalization requires more than programmes and initiatives, it needs a legal and policy framework as well as the functional organization of government to execute these.

3.5. Socio-economic

The recovery process has leveraged on different partnerships with authorities from government which had already conducted risk mapping and zoning for safer places for relocation and issuance of land certificates, International NGOs and communities engaging them in the implementation process.

By using local building materials, local manpower and locals’ institutions, the recovery solutions proved to be adaptable and sensitive to cultural considerations.

The willingness of the affected community to relocate and recover has been shown to be the most important driver for success.

3.6. Governance & Institutional

Rely on the National Disaster Recovery Framework (NDRF) & comprehensive Post Disaster Needs Assessment (PDNA)

Mechanisms by which local communities play a major role determining both short-term and long-term policies ensures collaboration among a diverse array of governmental and non-governmental actors.

Decentralization of recovery (national, provincial, local) makes it more inclusive by taking on board the needs and aspirations of different levels of government, civil society and most of all, the affected communities (especially the vulnerable like women). Furthermore, involvement of stakeholders across the board in recovery initiatives (housing reconstruction, livelihood diversification and managing of digital databases) gives it widespread acceptance and further importance in building resilience to future shocks and stresses.

4. Rebuild

4.1. Summary

Build Back Better (BBB) to promote community driven green recovery and disaster risk reduction measures (DRR) in housing reconstruction, diversification of livelihoods and develop digital databases to name a few and link these with cross-cutting issues like climate change adaptation (CCA) and disaster risk management (DRM) for longer term resilience and sustainability.

The reconstruction program at the outset provided: a major advantage to the new enterprises by forming the initial captive market; a critical visibility to the new technologies and improved systems of construction including (if systematically approached) building up the acceptance of these new “products” in the market. Followed by long term improvement in land and water management and economic opportunities, the recovery process has led to upgrade local economies and reduce community vulnerability in a sustainable manner.

4.2. Technical

It is necessary to collect “pre-flood” data and baseline indicators to measure disaster effect analysis at the community level in case it occurs and in order to fully contextualize recovery planning effort and “build back better”.

Building guidelines incorporating DRR for longer-term resilience to explore context specific alternative ecological practices and multi-hazard resilient design and construction practices.

A unique aspect of NHRP is the use of the Reconstruction Information Management System (RIMS) developed with support from UNDP, for real time tracking of the status of construction, tranche release, facilitation provided, and support required to accelerate the reconstruction process.
Data from mobile and web-based applications are uploaded in the database accessed by the project team remotely at all levels for monitoring and quality assurance of the activities. Data analytics help to generate dashboards to display data of reconstruction status and of each beneficiary. This easy to navigate technology makes it convenient to access up to date data for more efficiency and transparency of project execution and planning.

4.3. Financial

Lack of resources to rebuild stronger towards a resilient trajectory, as such every year they lost assets from floods and required support for shelter, food and other items. This context trapped vulnerable people in a cycle of desperation.

The reconstruction and rehabilitation need to be in a seamless continuum with livelihoods restoration efforts. The recovery and resilience building processes being a response strategy for creation of livelihood.

A Basket Fund as an agile tool to implement short-to-long term recovery activities with the aim to contribute to addressing the root causes of vulnerability and build resilience to future disaster. A recovery facility was drawn from a comprehensive Post Disaster Needs Assessment (PDNA) and the development of a Disaster Recovery Framework (DRF). The recovery facility is supported by an innovative partnership for resilient recovery which allows the mobilization of contributions from multiple donors to fund key programmatic interventions, with more speed and at scale.

Establish collaborative governance arrangement and provide strategic direction for the Facility allowing for prioritized funding needs, transparent fund allocation decisions for the overall fund implementation and impact.

The recovery facility addresses key constraint that limits the pathways to post-disaster resilience which is the time-bound nature of reconstruction funding. The recovery facility is an opportunity for long-term engagement and presence, very helpful for immediate response activities, as well as for the development of sustainable disaster risk management capacities.

4.4. Policy & legal

4.5. Socio-economic

Reconstruction becomes a process as it is about far more than a physical product, but a process that completely changes the recovery perception and trajectories it usually based on; the objective not limited to only getting people back up to the base line levels prior to the disaster, the intervention also improving quality of life and reduced levels of vulnerability.

Great care has been taken over issues such as beneficiary selection and the location of the reconstruction projects. During implementation, particular attention has been paid to the social and economic make-up of a settlement as community participation had been an integral and foundational component of the recovery design, not simply a politically correct, cosmetic add-on.

4.6. Governance & Institutional

Recovery and energy efficiency are activities with complementary policies, common stakeholders, and objectives. Energy-efficient recovery is not only contributing to community development, but also supporting the national adherence to the Sendai Disaster Risk Reduction and the Sustainable Development Goals.

Conclusions, Observations and Commentary

The UNDP developed National Disaster Recovery Framework (NDRF) & the Post Disaster Needs Assessment (PDNA) are gold standards in DRR based on:

- Disaster recovery is efficient if institutions, policies and financial mechanism for recovery are set up prior to the disaster.
- Disaster recovery is better planned if informed by strong data.
- Disaster recovery must balance social needs with demands for reconstruction of infrastructure.
- Disaster recovery must be participatory and inclusive.
- Recovery needs should be undertaken based on the analysis of the impacts and include DRR and BBB (Build back better).
- Disaster recovery an opportunity for DRR and BBB.
- Financing for recovery must be sustained.
- Monitoring and maintaining transparency and accountability are important elements for management of recovery.
- The private sector is important and can bring innovation.

One of the first critical recovery measures needed is to restore people's own income-generating capacity and enable them once again to support their families. Focusing on recovery of livelihoods as well as rehabilitation of the community infrastructure to ensure long-term resilience of the most affected communities.

The participation of civil society, academia, the public and private sectors ensures inter institutional collaboration throughout the process and benefits from broad support and expertise.

The role of new technology (digital tools through mobile and web-based applications, remote sensing, drones) in recovery should be proactively considered to enhance the recovery process. Exploring the use of disruptive technology (3D printing, drones, AI and geospatial and satellite imagery) for DRM and resilience brings together the private sector (technological industry) and government.

New funding mechanisms need to be explored to expand the scope of risk reduction measures, tapping into both public and private finance flows, to engage across sectors to unlock high impact and paradigm shifting climate investments in adaptation and mitigation initiatives, through loans, equity, guarantees and grants, to achieve climate risk related Sustainable Development Goals (SDGs); this can work in tandem with existing funding mechanisms to plan for effective recovery with sustainable outcomes.

Synthesizer: Koen Broersma Reference ID: 69

Title of document being synthesized and year it was published**: Climate-resilient Infrastructure - POLICY PERSPECTIVES (2018)**
Author(s): **OECD**
Category of document: **SBA-CRI / Framework**
Geographic focus of the document: **Global**

Report Summary

The first two chapters mainly discuss the need and benefits of including climate (change) resiliency in infrastructure planning and investments (the Why).

Chapter 3 and 4 elaborate on the how; regarding decision making and funding mechanisms respectively. Chapter 5 provided an overview of coverage in infrastructure in national climate risk assessments in OECD and G20 countries. Chapter 6 lists a number of useful tools and reports.

Ensuring that infrastructure is climate resilient will help to reduce direct losses and reduce the indirect costs of disruption.

Climate-resilient infrastructure has the potential to improve the reliability of service provision, increase asset life and protect asset returns.

Flexible, adaptive approaches to infrastructure can be used to reduce the costs of building climate resilience given uncertainty about the future. Decisions about infrastructure should consider relevant uncertainties to ensure resilience across a range of potential future scenarios.

Decision makers need to have access to high quality information, consistent data and capacity to use this information to inform planning.

Tools for mainstreaming adaptation in critical policy areas and encouraging investments in resilient infrastructure include:
- spatial planning frameworks to redirect development away from high-risk areas;
- infrastructure project and policy appraisals, including Strategic Environmental Assessment and Environmental Impact Assessment; and
- regulatory and economic standards (such as building codes).

Climate risk disclosure can help raise awareness of and encourage efforts to reduce climate-related risks to infrastructure.

The use of tools for decision-making under uncertainty can reduce the need for costly retrofitting while reducing upfront costs. Nature-based, flexible or innovative approaches to climate-resilient infrastructure may even be cheaper than traditional approaches. Global studies find that the benefits of investing in resilience outweigh the costs with high benefit-cost ratios, for example of investment in flood defences for coastal cities.

Developing and communicating infrastructure plans can help investors to identify investment opportunities.

Public policies that promote resilience include public procurement processes that consider climate resilience when comparing competing bids, by accounting for costs over the asset lifetime under alternative scenarios. Public finance can be used to mobilise private finance for climate-resilient infrastructure.

Support for project preparation can help to address capacity constraints relating to climate resilience. Blended finance can be used to improve the risk-return profile of investments where appropriate.

1. Preparedness

1.1. Summary

Climate risks to infrastructure can be reduced by locating assets in areas that are less exposed to climate hazards (e.g. avoiding new construction in flood plains), and by making the assets better able to cope with climate impacts when they materialise.
Resilience means that the risks have been considered and managed to achieve an acceptable level of performance given the available information, and that capacities to withstand and recover from shocks are in place.

This definition of climate resilience focuses on the process used and outcomes achieved to assess whether climate change impacts have been considered and, if necessary, managed. Given the context-specific nature of climate adaptation, the measures used to achieve this will vary widely, grouped into two categories:

- Structural adaptation measures: e.g., changing the composition of road surfaces so that they do not deform in high temperatures, building seawalls or using permeable paving surfaces to reduce run-off during heavy rainfalls. Ecosystem-based approaches using natural infrastructure to design adaptation measures are also key alternatives to be considered alongside structural adaptation measures.
- Management (or non-structural) adaptation measures: e.g., changing the timing of maintenance to account for changing patterns of energy demand and supply, investment in early warning systems or purchasing insurance to address financial consequences of climate variability.

Natural infrastructure and other flexible or innovative approaches to climate-resilient infrastructure may even be cheaper than traditional approaches. Global studies find that the benefits of investing in resilience outweigh the costs with high benefit-cost ratios.

1.2. Technical

Tools and capacity are needed to make raw climate data useful for decision makers, including national policymakers, regulators, private sector and local governments.

Tools such as Robust Decision Making and Real Options Analysis, portfolio analysis and iterative risk management are being used to support decision-making under uncertainty reducing the need for costly retrofitting while reducing upfront costs.

Stress testing can be used to identify how infrastructure will perform under a wide range of potential future climates.

Sustainability rating tools include:
- Infrastructure Sustainability Rating Tool (Australia)
- CEEQUAL (UK)
- ENVISION (USA)
- SURE Infrastructure Resilience Standard

1.3. Financial

Modifying economic regulations can lead to more resilient infrastructure, by removing barriers to investment in adaptation measures.

The TCFD guidelines suggest indicative metrics to consider using to inform investment decisions, but identifies the development of methodologies, datasets and tools as an area where further work is required.

Improving the quality and availability of relevant infrastructure projects is a first step in making those projects resilient to climate change. Infrastructure pipelines can help to do this by signalling the availability of bankable projects. For infrastructure in general, the lack of transparent infrastructure pipelines was rated by investors as the second most significant barrier to infrastructure investment, after uncertain and unfavourable policies and regulations.

A promising area for this is the development of "pathways" of climate-resilient investments in section 3). These go beyond lists of potential projects in infrastructure sectors to create sequenced packages of investment that consider interconnections. The use of pathways makes it possible to identify a wider range of options for addressing uncertainty than would be possible when focussing at the level of individual projects (e.g. Delta Programme. Netherlands Reference ID: 46).

Decision-support tools, such as cost-benefit analysis, should consider the range of potential benefits of enhanced resilience. In the UK, this was achieved by producing supplementary guidance for the normal appraisal framework (HM Treasury and Defra, 2009). The use of lifecycle costing and "green" procurement can also ensure a level playing-field for resilient approaches.

Procurement policies can facilitate innovation in the provision of climate-resilient infrastructure by specifying objectives rather than mandating the use of specific technologies

Some of the main initiatives that address climate risks in asset risk management include:

- CDP - this global reporting framework covers a range of sustainability issues, including climate resilience.
- Global Reporting Initiative (GRI) - this modular reporting framework is widely used, with 93% of the world's 250 largest corporations having adopted it.
- Sustainability Accounting Standards Board (SASB) - this initiative, based in the United States, provides guidance for corporations on how to disclose material sustainability information through their financial reporting.

Public procurement processes can support climate resilience by comparing bids' costs over the asset lifetime. This includes considering both operating expenses (OPEX) as well as capital expenses (CAPEX). For Public Private Partnership (PPP) contracts, it is important to clarify the allocation of responsibilities regarding climate-related risks planning, management and response.

Lenders and public funders are increasingly using risk screening to identify infrastructure that may be vulnerable to climate change. One of the emerging lessons is that screening should be combined with support to generate solutions to the risks that have been identified in the screening process.

Blended finance can be used to support investment in climate-resilient infrastructure. Public finance and policies can be used to mobilise private finance for climate-resilient infrastructure. PPPs work best when the contracts are as complete as possible: in other words, when risks are clearly identified and allocated to the different parties. The underlying issue for climate resilience is to ensure that risks relevant to climate change are identified and allocated correctly.

Public finance providers can use a range of tools to allocate risks effectively during project preparation and bridge the bankability gap for climate-resilient infrastructure, in the form of technical and financial assistance to project owners or concessionaires.

There are growing examples of instruments and mechanisms being implemented to translate the potential benefits of climate-resilient infrastructure into adequate revenue streams.

A particular area of interest relates to the potential of insurance or guarantee products that could be developed for climate-resilient infrastructure; however, this is dependent upon the availability and commercial viability of such products.

1.4. Policy & legal

Industrialised countries predominantly face the challenge of replacing and upgrading existing infrastructure and networks, particularly as technological advances and policy decisions provide opportunities.

Efforts to ensure resilience at the project level should be embedded within a strategic approach to infrastructure network planning that accounts for the direct and indirect effects of climate change and climate variability.

There is a need to map interdependencies across critical infrastructure and to adopt a multi-sector, multi-hazard approach to climate risk assessments.

Climate change risk assessments and adaptation measures need to be integrated across existing policy processes and decision cycles. This process of mainstreaming requires the identification of suitable entry points at multiple levels of decision making: national, sectoral, project level and local level. It is therefore important to adopt a whole-of-government approach to adaptation planning.

Spatial planning can help reduce infrastructure exposure to climate hazards, integrating climate risk into decision-making at an early stage minimising downstream costs associated with adaptation measures and maintenance costs, and avoid locking in maladaptation. Spatial planning frameworks tend to be established nationally, but local authorities are involved in their implementation and may issue their own regulatory requirements.

Regulatory standards, such as technical codes, are being reviewed and strengthened to promote climate resilience. Government policies can be used to encourage or require risk disclosure by the private sector. Procurement policies can be used to ensure that publicly financed infrastructure is resilient to the effects of a changing climate.

Technical guidance is being developed to help decisionmakers to incorporate climate risk into infrastructure. National standard organisations in Australia, Britain and the US have released risk management guidelines that focus on resilience for buildings and infrastructure.

1.5. Socio-economic

Well-designed participatory approaches can improve decision-making and build support for implementing climate-resilient approaches. Experience to date highlights the important role of local and indigenous knowledge in identifying vulnerabilities and impacts that may not be well known because of the highly localised and contextual nature of climate risk.

1.6. Governance & Institutional

A range of barriers can prevent new and existing infrastructure from being built and operated in a climate-resilient manner:

- Time horizons
- Uncertainty about the future
- Information and capacity
- Policy misalignments
- Externalities

Decision makers need to have access to high quality information, consistent data and capacity to adapt planning to account for climate change. This can be achieved through the development of platforms and online tools to provide accessible, credible and transparent information on past and future climate behaviour. Access to information should be complemented with the development of technical and institutional capacity to manage climate-related risks.

Tools for mainstreaming adaptation and encouraging investments in resilient infrastructure include:

- spatial planning frameworks
- infrastructure projects and policy appraisals,
- regulatory and economic standards (such as building codes).

Climate risk disclosure can help raise awareness of and encourage efforts to reduce climate-related risks to infrastructure.

Creating a supportive enabling environment will be critical to driving more climate-resilient infrastructure investment. Given the potential complexity of the topic, and capacity constraints, it recommended the sharing of good practices between subnational governments. More transparency is needed about the extent to which climate risks are included in public procurement frameworks. The use of mandatory screening for projects complements the voluntary disclosure of climate risks by organisations.

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

The document is very much focussed on getting climate resiliency mainstreamed in infrastructure planning and development, and including climate risks in the financial decision making. It provides in table and text boxes a number of examples from various countries regarding:

- Illustrative impacts of climate changes in different sectors
- Examples of adaptation measures for energy infrastructure
    - Selected infrastructure projects integrating climate-resilience in OECD and G20 countries
    - Modelling the macro-economic impacts of a major flood in Paris
    - Stakeholder engagement for climate-resilient infrastructure
    - Initiatives for communicating climate risks and supporting decision-making
    - Promoting ecosystem-based adaptation in South Africa
    - Copenhagen: working with ecosystems to cost-effectively build resilience (Cloudburst Management Plan 2012, City of Copenhagen Reference ID: 54)
- EXAMPLES OF INFRASTRUCTURE PATHWAYS
    - Integrating climate risks into public infrastructure planning
    - Risk screening by IDB invest
    - Colombia's 4th generation road concession PPP
    - Recommendations for incorporating climate resilience into the PPP process
    - Instruments and approaches to mobilise private investment
    - Mobilising finance for climate-resilient infrastructure

Synthesizer: Ernesto Diaz Lozano Reference ID: 18

Title of document being synthesized and year it was published**: Climate Change Adaptation A Priorities Plan for Canada (2012)**
Author(s): **Blair Feltmate, Jason Thistlethwaite**
Category of document: **General Literature**
Geographic focus of the document: **Canada**

Report Summary

This report was issued in 2012 as part of the Climate Change Adaptation Project (CCAP), which was a collaboration between the University of Waterloo and Intact Financial Corporation. This partnership eventually evolved into the Intact Centre on Climate Adaptation.

The CCAP "was designed to identify and operationalize practical, meaningful and cost-effective adaptation solutions to the most challenging impacts of climate change facing Canada." The purpose of the CCAP was to identify:

1. Five key areas and courses of action that Canada must engage to limit **current and future impacts to industries and public sectors** that will otherwise result due to climate change.
2. Three key areas and courses of action that Canada must engage to limit **current and future property & casualty insurance** impacts that will otherwise result due to climate change.

The CCAP was executed in five stages:

1. **Develop & Establish Climate Change Projections for Canada.** Environment Canada and the Canadian Climate Change Scenarios Network ran ensemble climate change projections for Canada for the years 2020 and 2050. These projections establish the parameters within which adaptation must occur.
2. **Engage Primary Subject Matter Expert.** The experts were presented the projections that were developed in step one, and they were tasked with identifying key climate change challenges within their core areas of expertise for various industry and public sectors. Their results were presented to the Adaptation Advisory Committee (AAC).
3. **Prioritize key sectors.** The AAC, which consists of approximately 80 leaders from sectors such as industry, finance, law, academia, aboriginal communities, government, youth, and NGOs, was tasked with reviewing the presentations from the primary subject matter experts. The AAC ultimately selected the five sectors and three areas of property and casualty insurance identified as the key climate challenges to be addressed in Canada.
4. **Engage secondary subject matter experts.** Nationally recognized subject matter experts (for each of the top five sectors and three insurance areas) were asked to identify specific climate change challenges, and propose three practical, meaningful, and cost-effective actions to address those challenges for their area of expertise.
5. **Operationalize recommendations. The final report was released in 2012.** The next three years of the project remain dedicated to operationalizing climate adaptation recommendations presented in the CCAP. This process involves holding meetings with key decision-makers, across industry and public sectors throughout Canada. **Note: the work under the CCAP seems to have been folded into the Intact Centre on Climate Adaptation.**

The five key sectors for climate adaptation for Canada identified by the AAC are:

1. City Infrastructure
2. Biodiversity
3. Freshwater
4. Aboriginal Communities
5. Agriculture

Additionally, the three key areas for property and casualty insurance identified by the AAC are:

1. Better align insurance coverage/pricing with climate change risk
2. Champion building codes to reflect climate change risk
3. Develop tools for insurers to promote climate change adaptation

Figure 1 below (from the report) summarizes at a high level the adaptation recommendations within all these areas. Further detail of each adaptation recommendation is provided within the following sections, in the corresponding area of preparedness, response, recovery and rebuild.

Figure 1 – Recommendations for Key Areas identified by the AAC

Industry and Public Sector Climate Change (CC) Challenges		
	Adaptation Recommendation	**Next Steps**
City Infrastructure	**Incorporate Adaptation into City Planning Policy**	Meet with environmental officers within major Canadian cities to embed CC adaptation into city policy. Job descriptions of managers, engineers and utility personnel should define responsibilities and reporting requirements to adhere to the updated city policy.
	Prioritize Areas of High CC Risk and Implement Adaptation Measures	Meet with environmental officers within Canada's major cities to estimate CC risks to critical infrastructure (using such tools as the Public Infrastructure Engineering Vulnerability Committee – PIEVC – protocol). For critical vulnerabilities, implement adaptation immediately.
Biodiversity	**Identify Bioclimatic Zones with Greatest Need of Adaptation Measures**	Determine the extent of change in bioclimatic zones caused by CC in comparison to Canada's National Ecological Framework in collaboration with Environment Canada and provincial conservation authorities. Next, undertake vulnerability assessments of key species and community types to climatic changes to establish geographical priorities for adaptation on a national and provincial basis.
	Increase Habitat Connectivity in Human-Dominated Settled Landscapes	Develop and support programs such as Ontario's 50 Million Tree Program to increase habitat connectivity in four key localities in Canada in collaboration with Environment Canada and provincial conservation authorities.
Freshwater Resources	**Preserve/Restore Critical Wetlands**	Establish a national priority to identify, preserve and/or restore wetlands that are "key capacitors" within watersheds across Canada in cooperation with Environment Canada and Natural Resources Canada.
	Move Population and Water-Intensive Industry to Water (not vice-versa)	Develop and promote policies to encourage new development on the Peace River (where there is ample water supply), rather than the small South Saskatchewan River, in collaboration with multiple government agencies (federal, provincial, municipal) and aboriginal representatives.
Aboriginal Communities	**Redesign and Relocation of Climate- Stressed Communities**	Design climate vulnerability assessments with aboriginal communities and Aboriginal Affairs and Northern Development Canada (AANDC). These assessments should determine whether communities affected by ongoing spring floods such as Kashechewan, Attawapiskat (Ontario), Tuktoyatuk (Northwest Territories) and Peguis First Nation (Manitoba) require the redesign or potential relocation of key facilities.
	Factor Traditional Knowledge into Adaptation	Work with aboriginal communities and AANDC to ensure that adaptation policy integrates local and culturally specific knowledge about CC. Develop adaptation policies to protect threatened local sources of food.
	Integrate Resiliency into Community Access/ Transportation	Develop a transportation infrastructure assessment program with AANDC to identify aboriginal communities vulnerable to CC induced isolation, and contingency protocols that address vulnerable locales.
Agriculture	**Develop CC Information and Dissemination Programs to Engage Agricultural Stakeholders**	Engage representatives from agricultural producers, businesses, government agencies and the research community to develop agriculture-relevant CC dialogue, with a focus on factoring CC into decision-making in cooperation with the Canadian Federation of Agriculture (CFA).
	Incorporate CC into Planning Decisions	Work with the CFA to identify cases where decision-making processes within the agricultural industry can include material considerations of CC risks and opportunities.
Property and Casualty Insurance Challenges		
New Homes and Adaptation	**Integrate Adaptation into New Home Builds through the National Building Code**	(1) promote building durability and resiliency as a core theme for the National Building Code, (2) develop information on future weather extremes relevant to the building code, and (3) pursue building code reforms that support adaptation (i.e. mandatory backwater valves).
Existing Homes and Adaptation	**Incorporate Pre- and Post-Disaster Improvements in Infrastructure Design to Mitigate Future Losses**	In cooperation with the Insurance Bureau of Canada (IBC): (1) incorporate adaptation into federal and provincial Disaster Financial Assistance Arrangements, and (2) develop and promote insurance programs with incentives for home owners to implement adaptation practices.
Insurance Pricing and Adaptation	**Perform Attribution Analysis to Identify Key Variables that Explain Weather-Related Losses**	Initiate an extreme-weather attribution study to identify key variables contributing to weather-related losses by working with the Insurance Bureau of Canada, the insurance industry, and Environment Canada.

1. Preparedness

1.1. Summary

The report is structured around the 5 sectors and 3 key areas discussed earlier. Within each, the context for climate adaptation is presented as well as a discussion of suggested adaptation measures. Most of this fall under the preparedness category as they relate to preparing for climate events. The following are the main challenges for climate adaptation for each of the five areas.

- Cities
  - Uncertainty about the nature and rate of local climate change
  - Unknown risks of climate change impacts to individual infrastructure components
  - Lack of knowledge and capacity among municipal staff to maintain infrastructure at a level of service that is resilient to climate change
- Biodiversity
  - Changing bioclimatic envelopes, which affects species survival
  - Altered disturbance regimes (e.g. insect, disease, pathogens, drought, fire, extreme storm events and floods)
  - Exotic invasive species, and eruptive native species caused by removal of thermal barriers that limited species movement
- Freshwater resources
  - Reduced water availability and quality in Alberta and the Prairies
  - Reduced water availability and quality in Great Lakes and River Systems
  - Overland flooding
- Aboriginal Communities
  - Dramatic or continuous degradation of community infrastructure
  - Diminution of traditional livelihoods
  - Catastrophic disruption to community access and energy capacity
- Agriculture
  - Denial of climate change by substantial proportion of the agriculture community
  - Influence of other conditions in the industry
  - Multiple decision makers increase variance of needs

Furthermore, the following are the main challenges for climate adaptation for each of the three areas of insurance.

- Adapting Building Codes for Climate Change
  - Adapt the Code for Climate Risks and Extreme Weather
  - Cost-effective Adaptation Through the Building Code – balance trade-off between code reform that incorporates future weather conditions and cost effectiveness
- Tools to promote adaptation by existing homeowners
  - Cost of retrofits
  - Lack of public knowledge of risk-reduction options
- Align price of insurance with the risk of damage
  - Understanding of how climate change influence extreme weather and affect insurance practices

The adaptation recommendations for each of the above noted sectors and areas are further described in the following sections.

1.2. Technical

1.2.1. Cities

- **Estimate the Probability of Matching or Exceeding Climate Thresholds for the Remaining Service Life of the Infrastructure.** Establish a profile of relevant climate

parameters, using historical / recorded data from the past 30 years (which is the normal period of record used by Environment Canada to establish climate norms and climate criteria from existing codes and standards.) This will provide a baseline to compare with the original design values, and a means to then determine future criteria. With the assistance of climate models, an analysis can then be conducted to estimate the probability of matching or exceeding climate thresholds for the remaining service life of the asset.

- **Conduct Climate Change Related Vulnerability/Risk Assessments to Define Risks.** Conduct vulnerability assessments for infrastructure using a methodology such as the PIEVC (Public Infrastructure Vulnerability Committee). This will help identify high-risk areas that require immediate action as well as longer term adaptation solutions.

1.2.2. Biodiversity

- **Modelling to Prioritize Change and Vulnerability in Bioclimatic Envelopes.** Develop models to measure change in bioclimatic envelopes with respect to historical baselines. The output of these models will help inform adaptation priorities from the perspective of level of climate change threats, species, community vulnerabilities, and risk assessment/management strategies.
- **Increased Habitat Connectivity in Human Dominated Settled Landscapes.** The isolation of ecosystems is a threat to species needing to migrate to more favourable areas due to changes of their local environment as a consequence of climate change. The recommendation is to invest in natural infrastructure to reconnect the fragmented landscape. Strategies include developing habitat corridors, increasing habitat density, and developing natural heritage systems. A successful program in this area is Ontario's 50 Million tree program which is recommended to be scaled to other areas of the country.
- **Management of Disturbance Regimes.** Conduct additional regional scale modelling to better understand how climate change will affect the regional disturbance regimes necessary for maintaining ecosystem's lifecycles.

1.2.3. Freshwater resources.

- **Protect and Restore Wetlands and Natural Drainage Systems.** Wetlands have a key role to play in climate change adaptation as nature-based solutions, as they act as "capacitors" for watersheds, reducing the risk of flooding by reducing peak flows into rivers during precipitation events. Wetlands can also help remove pollutants from runoff. A national initiative to identify, preserve and restore wetlands is recommended.

1.2.4. Aboriginal Communities.

- **Integrate Resiliency into Community Access & Energy Capacity.** This can be achieved by:
  - Developing a "climate adaptation emergency measures protocol" to be used when communities need help responding to a climate event. This would help fulfill the federal government's responsibility to meet the human needs of the communities during a climate event.
  - Assess and renew critical transportation infrastructure to reduce the risk of aboriginal communities becoming isolated from the rest of Canada as a result of a climate event.
  - Promote the implementation of renewable energy sources for off and on grid communities.

1.3. Financial

1.3.1. Aboriginal Communities.

- **Comprehensive capital planning for climate adaptation.** Existing infrastructure in aboriginal communities has not been designed to meet climate change threats. Through capital planning, infrastructure can be upgraded to increase resiliency, which in some cases may involve relocation of communities. Further, the federal government must integrate climate change adaptation design features into a community infrastructure program.

1.3.2. Agriculture

- **Develop agriculture-relevant climate change information.** This will help promote better understanding of climate change and its impacts around the agriculture community. To do this, it is necessary to identify the attributes of climate change that are relevant to the sector and develop material that expresses these attributes in terms that are understood by the community, as well as discuss the expected changes in the attributes.
- **Incorporate climate change in planning decisions.** Agriculture planning requires balancing multiple other forces and factors (e.g. seed costs, prices, markets, technologies, policies, and personal circumstances). It is recommended that climate change considerations also be included as an additional factor in planning decisions.
- **Adaptation Specific to Roles and Situations.** Develop guidelines for adaptation that are tailored to the specific roles of the different members of the agriculture community.

1.3.3. Align price of insurance with the risk of damage

- **Educate on the Role of Insurance**. Establish a joint strategy to champion actions by homeowners and businesses to adapt to severe weather. This includes the development of a public education program.
- **Develop better data to estimate the risk of severe weather damage.** This data will support insurance companies in adjusting their pricing to better reflect risk posed by climate events.

1.4. Policy & legal

1.4.1. Cities

- **Incorporate Adaptation in City Planning Policy.** Adaptation requires multidisciplinary collaboration from engineers, planners, managers, operators, climate specialist, and other scientific professionals. The recommendation is to embed a “no regrets” approach to climate change into city policy with specific reference to adaptation. This approach consists of identifying actions that increase infrastructure resilience and generates community benefits, regardless of whether the anticipated climate changes materialize or not. As part of this approach, the job descriptions of all managers, engineers, and utility personnel need to integrate adaptation into defined responsibilities and reporting requirements. The recommendation also includes increasing knowledge and teamwork in the area by completing case studies of infrastructure risk and adaptation planning, as well as conducting awareness campaigns to involve the broader public.

1.4.2. Biodiversity

- **Exotic Invasive Species Management.** Incorporate findings from climate modelling and vulnerability and risk assessments to update existing international, national, and provincial plans for limiting exotic invasive species migration.

1.4.3. Freshwater resources

- **Move population and water intensive industry to water, not vice versa.** Undertake policy and planning changes to encourage large population centres and water intensive industries to be located in areas with plentiful water. This can be done through tax incentives, water pricing, or other measures.

1.4.4. Adapting Building Codes for Climate Change

- **Incorporate Expectations Regarding Future Climate into the Building Code Process.** Federal and provincial governments should support work to incorporate historic and projected climate conditions into the codes, by supporting research on buildings resiliency and formally endorse buildings durability and resiliency as objectives for the national building code.
- **Insurance Industry Must Identify High-Priority Risks Linked with Future Extreme Weather.** To make the adoption of more stringent codes more cost-effective, building codes should prioritize risks related to future extreme weather events. This will require specific data on severe events which can be fulfilled through collaboration between Environment and Climate Change Canada and Infrastructure Canada.

1.5. Socio-economic

1.5.1. Freshwater resources.

- **Change the design and use of human infrastructure to conserve water quality and quantity.** Adapt human infrastructure and behaviours to help conserve water. Incorporate strategies such as porous roofs and paving to recharge groundwater and foster on site rainwater harvesting. Maintain flooding maps up to date to mitigate risk of damage due to flash flooding

1.5.2. Aboriginal Communities.

- **Adaptation Guided by Traditional Knowledge.** Aboriginal communities must document climate change in their territories and use this to find adaptation solutions. Adaptive management can be implemented as a viable framework through the integration of traditional knowledge and western science, with the approval and consent of the aboriginal groups. Additionally, measures must be taken by governments to protect species and foodstuffs used by aboriginal communities which are threatened by climate change, and develop plans to address other sources of food insecurity in aboriginal communities.

1.6. Governance & Institutional

1.6.1. Freshwater resources.

- **Integrate Human Water Uses at Watershed scales.** Typically, human water consumption needs are managed in a piecemeal fashion by licensing projects individually. A more holistic approach for water management is recommended, by integrating human water uses and demands into watershed management, to improve the efficiency of water use. A successful demonstration of this approach has been done by the Bow River Project Consortium in southern Alberta, who showed that this approach can result in significant savings. A specific example within this project showed that summer releases from upstream hydroelectric reservoirs demonstrated improved flows and water quality downstream.

1.6.2. Tools to Promote Adaptation by Homeowners.

- **Insurance and Government Incentives for Risk Reduction.** Provide financial incentives to foster the uptake of risk mitigation measures by homeowners and reduce the financial burden of retrofits.
- **Adapt FireSmart Model for Urban Flood and Wind.** This program provides a framework for addressing the challenging tasks of communicating relevant knowledge about climate risk to homeowners.
- **Disaster Mitigation Assistance.** This consists of the implementation of disaster mitigation options, including land use planning, building relocation, building retrofits and education – in advance of disaster events Three ways mitigation planning can be improved include:
  - development of a program for pre-disaster mitigation;
  - better incorporation of post-disaster mitigation in government disaster-relief programs; and,
  - post-disaster mitigation programs that do not rely on the existence of government disaster-relief payouts.

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

- The Intact Centre of Climate Adaptation has a very robust list of reports relating to diverse topics on climate adaptation and risk mitigation, including: wildfire protection, flood protection, extreme heat, rising seas and coastal communities, assessment of climate change preparedness of 16 Canadian cities as well as provinces. They also have an extensive list of experts that can be engaged further in the development of the National Adaptation Strategy.
- The report has an extensive summary of the climate change models developed as part of step 1 of the CCAP. These have not been covered in detail in this synthesis as they are not truly relevant to the objective of the current report.
- The report has useful information about the cost effectiveness of climate adaptation measures. As an example, in the executive summary, it is discussed that a backwater valve costs $200 to install in a new home, $6,000 in retrofitting an existing home, and can prevent damage worth $20,000 or more by preventing flooding from water backing up from drains.

Synthesizer: Ernesto Diaz Lozano Reference ID: 07

Title of document being synthesized and year it was published**: Systems Approach to Management of Disasters – A Missed Opportunity? (2015)**
Author(s): **Slobodan P. Simonovic**
Category of document: **General Literature**
Geographic focus of the document: **Canada**

Report Summary

This paper discusses how systems approaches can be leveraged for improving disaster management. Disasters typically involve complex interactions between the components of three mayor systems:

1. Physical Natural Environment,
2. Socio-Demographic Environment, and
3. Constructed Environment.

Traditional siloed approaches for disaster management are ineffective at accounting for the interrelationships between the components of these systems. In the Canadian context, the current institutional approach for disaster management is "decentralized, fragmented and subject to incremental lawmaking. This makes it difficult to address serious disaster management decisions in a comprehensive, holistic (systematic) fashion" (Simonovic, 2015).

Emerging trends of looking at disasters through a regional lens, taking into account the consideration of all costs and benefits, elaborating broad ranges of risk mitigation measures, and increasing stakeholder engagement, can be leveraged to implement scalable system based approaches to address the above noted gaps. The paper presents case studies of systems approaches used in disaster preparedness and modelling and concludes with recommendations on how these can serve a national disaster management strategy.

1. Preparedness

1.1. Summary

Multiple case studies are discussed in the context of existing implementations of various components of systems approaches for modelling and planning for disaster management. While some of these models involve variables that span the various categories noted below, and also intend to model the response stage of a disaster, they are inherently technical tools to evaluate potentially fictitious scenarios and as such they have been summarized under the technical section.

1.2. Technical

The paper presents detailed discussions about applications of modelling and computational analysis for improving preparedness for disaster response. Sample studies referenced include:

- Atlay and Green (2006). Review of progress of systems approach in management of disasters. Showed that at the time of their review, simulation was just making an entry into the field of disaster management – less than 2% of their reviewed research included system dynamics simulations.
- Lane et al. (2000). Model of an accident and emergency department, which takes int account demand modeling, resource deployment, bed numbers, and other resources
- Lane et al. (2003). Extended model of emergency department to understand patient wait times in the emergency department. This included active involvement of the clients – which is known as shared vision modelling.

- Fawett and Oliveria (2000). Novel approach for modelling casualty treatment following a large-scale disaster. Model simulates movement of casualties to hospitals and accounts for fatalities and other statistics of the healthcare system response. The model can be used as a tool for planning disaster response strategies.
- Simonovic and Ahmad (2005). Flood evacuation simulation for the Red River basin in Manitoba, which uses system dynamics to model human behaviour during an emergency flood evacuation. Main purpose is to evaluate the effectiveness of different flood emergency management procedures.
- Chen et al. (2009) Dynamic programming for emergency recovery. Developed optimization model to minimize the recovery time and optimize resource allocation.
- Atlay and Green (2006). Showed that mathematical programming is the most commonly mathematical method in disaster management. Also showed only about 10% of existing research at the time deals with multiobjective details.

1.3. Financial

1.4. Policy & legal

1.5. Socio-economic

1.6. Governance & Institutional

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

The paper concludes by noting that the current Canadian institutional disaster management context is decentralized, and identifies the following opportunities for leveraging a systems approach to address disaster in a comprehensive, holistic (systematic) manner:

1. **Data availability.**
   a. Provide a platform to organize disaster related information and foster information sharing across departments and government institutions seamlessly.
   b. Conduct analytics to understand resource flows and the larger disaster context, which can be utilized as an educational tool do educate the public on the relationship between their behaviour and the environmental and economic consequences of disasters
   c. Support data-driven decision making through data analytics, planning and forecasting, which can lead to policy and planning decisions.
2. **Modelling and simulation.**
   a. Develop standardized tools and simulation models to improve disaster related decision-making at the various levels of government.
   b. Educate officials on the dynamics that govern the interactions between the natural, socio-demographic, and constructed environment.
3. **Organizational change.**
   a. Use systems thinking to build organizational community around shared visions. This will enable all individuals in the system to see themselves as important actors in the decision making and disaster management process.
   b. Embed the unpredictability of complex systems in the general culture, which leads to disaster management policies that are more realistic and precautionary.

Synthesizer: Simon Kates Reference ID: 21

Title of document being synthesized and year it was published**: A Managed-Participatory Approach to Community Resiliency (2016)**
Author(s): **Simon McDonnell, Swati Desai, Daniel Berkovits, Pooya Ghorbani, Maria Jessa Cruz, Renata Silberblatt, Alexander Breinin, and Xavier Williams**
Category of document: **SBA-CRI**
Geographic focus of the document: **New York State**
Other: Additional information sourced from the New York website for the NY Rising Program: https://stormrecovery.ny.gov/

Report Summary

The Governor's Office of Storm Recovery (GOSR) was established by New York State in 2013 to centralize the state's recovery and rebuilding efforts following three major storm events in 2011 and 2012: Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy. The objective of GOSR was to address the most urgent needs of impacted communities while also identifying innovative solutions to make New York's infrastructure and critical systems more resilient. GOSR managed the NY Rising program with funding from the U.S. Department of Housing and Urban Development (HUD) Community Development Block Grant Disaster Recovery (CDBG-DR) program. Funding through the NY Rising program was focused on Housing Recovery, Small Business, Community Reconstruction, and Infrastructure. GOSR also coordinated with HUD's Rebuild by Design competition to develop innovative green infrastructure solutions to mitigate the impacts of climate change on coastal communities. One of the key innovations of the NY Rising Program was to involve local communities in a participatory planning process to identify how funding should be distributed among implementation actions within each community.

The synthesized report, *A Managed-Participatory Approach to Community Resiliency*, was authored by members of GOSR, as well as the Rockefeller Institute of Government. The report provides an overview of the unique approach developed by New York State to help communities recover from Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee, and to reduce vulnerability to future disasters. These efforts were conducted through the NY Rising Community Reconstruction Program (NYRCR) through a combination of community participation and facilitation, technical expertise, and financial support provided by the state. The report discusses the two types of mechanisms deployed to identify disaster recovery and climate change adaptation strategies.

The two mechanisms are:
- Horizontal: among community stakeholders
- Vertical: between political institutions and local communities.

The report argues for the integration of these two mechanisms as a way to best respond to disaster recovery and climate change adaptation at the level of the local community. In order to best contextualize the NYRCR program and the work of GOSR, the following synthesis includes both conclusions of the report summarized above, as well as components of the NY Rising program. The report is synthesized in section ***Rebuild***, subsection ***Governance & Institutional*****.** The remaining content in the synthesis is focused on the overall characteristics of the NY Rising Program.

The NYRCR program provided funding for localities to produce and implement NY Rising Community Reconstruction Plans. There were a total of 66 NY Rising Plans created, covering communities throughout NY State. The Plans were developed by Planning Committees consisting of local residents, business owners, and civic leaders, with the assistance of NYRCR program staff and consultant teams. Planning Committees met regularly and hosted public events to solicit community input. The Plans included an assessment of community needs, identified assets and risks, and concluded with projects recommended for funding using CDBG-DR monies allocated to NY State.

This participatory planning model is intended to provide a balance between limited government resources (both in responding to local needs and evaluating priorities) and the local population's own on the ground knowledge and resources to develop the best solutions and to build consensus: "by keeping local community members informed and involved through the process, plans gain legitimacy and government agencies earn the public's trust" (p. 4).

The NYRCR program was designed to work within pre-existing models within NY State to recommend projects for funding. These include the state's Regional Economic Development Councils (REDCs), which review and recommend projects for funding through the state's Consolidated Funding Application (CFA); and the Waterfront Revitalization of Coastal Areas and Inland Waterways Act which allows communities to develop locally specific Local Waterfront Revitalization Programs (LWRPs). These two mechanisms—the REDCs and LWRPs—may not need to be replicated in other areas for a participatory planning program to succeed. Rather, the lesson is that basing the NYRCR program on frameworks that existed and were known throughout NY state made the NYRCR program easier to implement, modify as needed, and communicate to local elected officials and staff members.

1. Preparedness

1.1. Summary

The NY Rising Program included limited—but notable—examples of large-scale projects focused on preparedness and mitigation of impacts of future extreme weather events. These examples are outlined below. In addition, individual NY Rising Community Reconstruction Plans also included local projects that may address the Preparedness category.

1.2. Technical

1.2.1. Program: Housing Recovery

NDR Public Housing Programs

- *Public Housing Resiliency Pilot Program* provides funding for resilient interventions and reduced exposure for public housing residents in coastal and riverine communities.
  - Program focuses on needs of highly vulnerable low-moderate income public housing residents and on resiliency improvements
  - Program funding came from HUD through GOSR, but provided via a National Disaster Resilience Competition framework.
  - GOSR partnered with four local public housing authorities to identify project sites and several small/local developers to implement the design/construction projects
- *Public Housing Assistance Relief Program:* The Program provides funding for the repair or replacement of damaged public housing stock as well as the construction of new resiliency improvements. Focuses more on repair and damage.
- Both programs eligibility criteria reference 'Covered Storms' so programs are specific to three identified storms that caused damage to public housing properties.
- GOSR reviewed the Unmet Recovery Need (URN) of Public Housing Authorities (PHAs) in disaster-declared counties outside of New York City which were damaged by one or more of the Covered Storms. Assistance is provided directly to the PHA or to a development partner acting in concert with the PHA.

1.2.2. Program: Infrastructure

The NY Rising Infrastructure Program provided funding for implementation of projects to improve New York infrastructure, including transportation networks, energy supply, coastal protection, weather detection and warning systems, and emergency management systems.

- FEMA Public Assistance Program (immediate post-storm response needs and funding for damaged public infrastructure to repair to pre-storm condition) . GOSR also earmarked Federal CDBG-DR HUD funds as match funds for PA program costs.
- Suffolk Water Quality Initiative Program: expanded sewerage of unsewered areas in Suffolk County. Not sure of the current status of this program.
  - Collaboration of multiple State/environmental regulatory entities
- Bridge Scour Program: rehabilitation of 105 bridges (foundations) due to effects of scour and erosion.
  - Collaboration of multiple State/environmental regulatory entities with local governments
  - Not sure of the status of this program
- Roberto Clemente State Park: replacement of failing seawall and bulkhead to shore up a waterfront community park in a minority neighborhood
- Robert Moses State Park
- Energy Infrastructure: LIPA restoration and rehabilitation program.
  - Created the NY Prize Microgrid Competition, in partnership with NYSERDA, to incentivize design and implementation of community-based microgrids.
- Hazard Mitigation Grant Program: State OEM, announced availability of FEMA HMGP funds to develop/update HMGPs

1.2.3. Program: Rebuild by Design

Although Rebuild by Design was a separate initiative from NY Rising, the two programs were implemented in coordination and both ultimately received funding from HUD. Rebuild by Design was a competition for interdisciplinary design firms to propose resiliency projects. GOSR is working with two recipients of the award:

- Living with the Bay: $125 million project in Nassau County, Long Island to increase resiliency by mitigating damage from storm surge, manage stormwater, improve habitat and water quality, and increase access to the Mill River.
- Living Breakwater: Coastal green infrastructure project to reduce erosion from storm waves and improve the ecosystem of the Raritan Bay off the shoreline of southern Staten Island.

1.3. Financial

1.4. Policy & legal

1.5. Socio-economic

1.6. Governance & Institutional

2. Response

2.1. Summary

The NY Rising Program did not include examples of large-scale projects focused on disaster response. Individual NY Rising Community Reconstruction Plans included local projects that may address the Response category.

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

The NY Rising Program did not include examples of large-scale projects focused on Recovery. Individual NY Rising Community Reconstruction Plans included local projects that may address the Recovery category.

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

A substantial focus of the various components of the NY Rising Program was to rebuild in the aftermath of Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. Some of the components outlined below also include funding for mitigation (or, preparedness) efforts, but the precipitating event for creation of these programs was to rebuild after these disasters.

4.2. Technical

4.2.1. Program: Housing Recovery

- Single Family Homeowner Program
  - To facilitate home repairs, rehabilitation, mitigation, and elevation.
  - With 300,000 housing units damaged, it was important to expedite funding to get families back in their homes, while also complying with HUD requirements.
- Co-op & Condo Program
  - Provides funding for repairs of units that are being used as a primary residence (by the unit owner or a renter).
- Rental Properties Program
  - NY Rising Housing Recovery Program facilitated home repairs, rehabilitation, mitigation, and elevation for owners of rental properties. Program also provided assistance to tenants who were temporarily or permanently displaced.
- Buyout & Acquisition Programs
  - Established to purchase the properties of interested homeowners whose homes were substantially destroyed.
  - In select neighborhoods, homes would be purchased, demolished, and the parcels transformed into wetlands, open space, or stormwater management systems. Selected areas were chosen based on cooperation of the homeowners.

4.2.2. Program: Small Business

- Small Business Recovery Program

- Provides grants of $50,000 or more to independently-owned and operated small businesses that were damaged by Superstorm Sandy, Hurricane Irene, or Tropical Storm Lee.
- Grants my cover rehabilitation, repair, replacement, and mitigation.

4.2.3. Program: Community Reconstruction Program

- NY Rising Community Reconstruction Program (NYRCR)
  - This is the most well-known component of the overarching NY Rising program.
  - NYRCR is the participatory recovery and resiliency initiative that established local Planning Committees to develop Community Reconstruction Plans.
  - A total of 66 Plans were developed, covering a total of 124 New York communities.
  - Each of the 66 final plans can be viewed here: https://stormrecovery.ny.gov/nyrcr/final-plans

4.3. Financial

- New York State received $4.5 billion in CDBG-DR funding from HUD. $700 million of this was allocated to the Community Reconstruction Program.
  - State officials identified communities for participation in the program based on storm damage assessments using FEMA data.
  - NYRCR communities were allocated between $3 million and $25 million in funding to implement eligible projects in their plan.

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Managed-Participatory Approach to Community Reconstruction

- Model of horizontal and vertical integration.
  - Horizontal integration.
    - "Mechanisms through which local people integrate with one another and also with community-based organizations, self-help groups and local associations" p. 16
  - Vertical integration.
    - "quality of relationships between citizens and policymaking entities and institutions" (p. 16)
    - "…both horizontal and vertical engagement are necessary for effective community planning because communities with a low degree of horizontal integration have difficulty organizing for collective action, and those with a low degree of vertical integration may have weak ties with central authorities and thus face problems in taking ownership of eternal programs in their communities" (p 16)
- NYRCR is vertically managed as a result of state leadership. The is necessary in order to allocate federal resources to address community needs within the policymaking bureaucracy.
- NYCRC is also horizontally participatory because the Community Reconstruction Plans were developed by local Planning Committees within the framework established by the state.
- Horizontal characteristics of the NYRCR Program
  - HUD requires that recipients of CDBG-DR funding create citizen participations plans. Therefore, the federal funding source mandated a degree of horizontal characteristics.

    - Planning Committees were composed of diverse and representative members of each community.
    - The role of professional planning firms to develop and implement a community engagement strategy.
    - Commitment to local participation and capacity-building.
    - Assigning professional planning firms to communities based on areas of expertise and the communities' local needs.
- Vertical characteristics of the NYRCR Program
    - State leadership in connecting local communities with federal funding.
    - Program design connected local communities with state agency staff and dictated the specific format of the planning process and the outline of the final plans.
    - Strengthened ties between local communities and state policymakers by focusing on community assets such as public goods, local services, and critical infrastructure.
    - Encouraging citizen participation to help identify assets, risks, and vulnerabilities, suggest solutions for projects, and commenting on final community reconstruction plans.

Conclusions, Observations and Commentary

NY Rising is a wide-ranging state-wide program that impacts diverse communities from New York City to upstate Villages and rural Towns. The greatest applicability to the Canadian context is the program design. Although Canadian communities may also experience the weather events that preceded development of the NY Rising program, the program is not comprehensive in terms of the events that it addresses (Superstorm Sandy was a storm surge event, while Hurricane Irene and Tropical Storm Lee were heavy rain events that caused riverine flooding). That said, the model of program design, especially the horizontal-vertical model of managed-participatory approach is an innovative strategy for creating a bureaucratic policy framework and then empowering local communities to direct funding within that framework.

The NY Rising was largely a reactive program. Most of the initiatives developed as a result were intended to rebuild from extreme weather events in the past. However, within individual NY Rising Community Reconstruction Plans, one could certainly find many examples of projects funded through the program that address preparedness, response, and recovery. This more comprehensive view of the program was dictated by the priorities of local Planning Committees and guidance provided by state agency staff and consultant teams who helped to facilitate the planning process and develop each individual community reconstruction plan.

Synthesizer: Simon Kates Reference ID: 23

Title of document being synthesized and year it was published**: 2021 California Climate Adaptation Strategy**
Author(s): **Government**
Category of document: **SBA-CRI**
Geographic focus of the document: **California**
Other: Additional information sourced from the California Climate Adaptation Strategy Website: https://climateresilience.ca.gov/

Report Summary

The report synthesized here is an excerpt of the California Climate Adaptation Strategy. The excerpt includes the Strategy Priorities, Goals, and Actions. The synthesis is supplement by additional information sourced from the website for the California Climate Adaptation Strategy.

The California Climate Adaptation Strategy is a platform to link the state's existing and planning adaptation efforts into a common framework. The Strategy is based around six climate resilience priorities, with a focus on outcomes and an integrated approach to climate resilience.

The six climate resilience priorities are:

- Strengthen protections for climate vulnerable communities.
- Bolster public heath and safety to protect against increasing climate risks.
- Build a climate resilient economy.
- Accelerate nature-based climate solutions and strengthen climate resilience of natural systems.
- Make decisions based on the best available climate science.
- Partner and collaborate to leverage resources.

The first Climate Change Assessment in California was produced in 2005 and the first Climate Change Adaptation Strategy was produced in 2009. Therefore, this current Climate Adaptation Strategy reflects nearly two decades of evolution and revisions. California is required by state law to issue a statewide climate adaptation strategy every three years. The prior version was published in 2018.

The current 2021 Climate Adaptation Strategy builds upon efforts in prior climate plans, but attempts to take a more integrated approach that draws connections between sectors, and provides flexibility for updates and adjustments as climate change impacts change conditions on the ground. The Climate Adaptation Strategy gathers together initiatives from other state plans and strategies in the following categories:

- Statewide climate action plans
- Sector-based strategies
- Regionally-focused strategies
- State stewardship plans

From these prior planning documents, the Climate Adaptation Strategy includes nearly 150 actions, based on recommendations from state agencies and members of the public. These actions have been chosen based on their ability to achieve the six climate resilience priorities outlined above. The organization around the six climate resilience priorities is a new framework for the 2021 Climate Adaptation Strategy. This organization was chosen to break down silos and create a more unified way of considering the impacts and benefits of climate adaptation initiatives. Rather than focusing on sector-specific actions, the document is organized based on intended outcomes.

Although the objective of the 2021 Climate Adaptation Strategy is to focus on outcome-based organization, the website for the strategy allows users to explore the actions By Priority (the outcome-based intent of the plan) or By Region. The website also includes a Summary of Projected Climate Change Impacts on California, a section on Climate Adaptation in Partnership with California Native American Tribes, and a Timeline of California's Climate Adaptation Policy.

Within each of the six priorities is a list of goals. Actions are organized within each of the goals. The website also provides a Success Metric, Timeframe, Agency, and more details about each of the Actions (see outline below). In many cases, Actions included in the Climate Adaptation Strategy have been derived from other climate-related plans or programs. In these cases, the More Details section includes links for additional information about those prior plans or programs.

- Priority
  - Goal
    - Action
      - Success Metric
      - Timeframe
      - Agency
      - More Details

As noted above, the 150 actions included in the Climate Adaptation Strategy are derived from other reports, plans, policies, and recommendations. In many cases, the "More Details" subheading links to other planning/program documents that provide more information about the source materials that went into the development of each action. As a result, the Climate Adaptation Strategy is not a primary source document, but rather serves as a way to gather the highest priority recommendations from other sources.

1. Preparedness

1.1. Summary

The concepts of adaptation and resilience appear throughout the document. These themes are more focused on Preparedness than the other categories below. At the forefront of this plan is an attempt to focus on Adaptation ("an action of set of actions that reduce physical climate risk") and Resilience ("a state of readiness to face climate risks").

1.2. Technical

1.2.1. Priority: Strengthen Protections for Climate Vulnerable Communities

- Goal B: Improve understanding of climate impacts on California's communities, including what drives vulnerability
  - The Actions in this goal are largely focused on conducting research and otherwise gathering information to inform decisions about climate adaptation strategies.
  - Objectives include identifying vulnerable communities and increasing the collection, analysis, and reporting of data on climate-related impacts.
  - Balance between conducting risk assessments and using climate science along with gathering input from communities to guide decision-making.

1.2.2. Priority: Bolster Public Health and Safety to Protect Against Increasing Climate Risks

- Goal C: Improve infrastructure's climate resilience to protect public health and safety
  - This goal is focused on capital improvements that impact public health.
  - Actions are focused in energy infrastructure and their contribution to wildfires, resilience of energy infrastructure, vulnerability of water and wastewater infrastructure, and water supply for tribal nations.

1.2.3. Priority: Accelerate Nature-Based Climate Solutions and Strengthen Climate Resilience of Natural Systems

- Goal A: Increase the pace and scale of nature-based climate solutions
  - The objective of this goal is to encourage investment in projects focused on land management, wildfire resilience, wetland restoration, agriculture, and ecosystems and habitat protection.
  - The focus is on nature-based solutions to make natural resources more resilient to climate impacts/
- Goal B: Increase landscape connectivity and establish climate refugia
  - The focus of this goal is on utilizing natural systems that are naturally protective against climate impacts and protecting natural systems that are vulnerable to climate impacts.
  - Actions describe efforts to increase areas of high resilience to climate change and building climate resilience of coastal and marine resources, including efforts to help fish and wildlife endure drought conditions.
  - Actions also discuss efforts to enhance wildlife areas and ecological reserves and restore habitat such as rivers, mountain meadows, and deltaic wetlands to increase biodiversity and natural resources that sequester carbon and buffer against flood waters.
- Goal C: Integrate nature-based climate solutions into relevant infrastructure and investments
  - This goal considers the interactions between nature-based systems and infrastructure investments such as transportation and water supply.
  - Actions describe strategies to integrate resource management, ecosystem protections, and public health into planning for resiliency of infrastructure projects to minimize the adverse impacts of infrastructure projects on natural resources and public health.

1.3. Financial

1.4. Policy & legal

1.4.1. Priority: Strengthen Protections for Climate Vulnerable Communities

- Goal C: Build resilience in climate vulnerable communities through state programs
  - This goal generally identifies government actions that involve changes to policy, program development, allocation of resources, funding, and awareness campaigns.
  - Actions identify wildfire risks and the need to prioritize vulnerable communities while also expanding the Regional Forest and Fire Capacity Program.
  - Identifies policies and programs related to transportation infrastructure (including high speed rail), housing, homelessness, and land use planning.
  - Emphasis on developing policies that guide decision-making in a way that centers vulnerable populations, cultural heritage, equity, and community input.

1.4.2. Priority: Bolster Public Health and Safety to Protect Against Increasing Climate Risks

- Goal A: Reduce urgent public health and safety risks posed by climate change
  - This goal is generally focused on identifying topic areas where public health improvements needs to be prioritized. Examples include: wildfire smoke, water conservation, drought, groundwater, flood risk, drinking water, etc.
  - Although many of these components would require technical solutions (i.e., capital improvements), the actions as described in this goal are more focused on the policy that would guide those investments.
  - Another recurring theme in this section is health equity, including integrating health equity data, tools, and metrics into climate change-related plans to improve outcomes.

- Goal B: Consider future climate impacts in governmental planning and investment decisions
  - Again, the outcome of this goal is technical solutions (capital projects), however the objective of this goal is to guide policy and decision-making to guide the types of projects that agencies and local governments pursue.
  - The goal recommends developing guidance and providing technical assistance for local communities so that decision-making at the local level (land use, transportation, resource preservation, etc.) contributes to the state's climate goals.
  - The goal also recommends incorporating climate change considerations into emergency planning efforts, creating coastal adaptation plans, and critical infrastructure.

1.4.3. Priority: Accelerate Nature-Based Climate Solutions and Strengthen Climate Resilience of Natural Systems

- Goal D: Accelerate state processes to support implementation of nature-based climate solutions
  - The goal outlines a series of Actions designed to streamline the regulatory approvals/permitting process for climate adaptation and resilience projects.
  - Actions in this goal recommend reducing barriers to planning to reduce wildfires.
  - Several actions address reducing permitting processes, including for wildfire resilience projects, groundwater recharge projects, water resilience projects, restoration and nature-based solutions in coastal settings, and large habitat restoration projects.

1.5. Socio-economic

1.5.1. Priority: Strengthen Protections for Climate Vulnerable Communities

- Goal A: Engage with and build capacity in climate vulnerable communities
  - This goal is focused on actions that build capacity at the community level. Even when actions relate to technical solutions, the overarching goal is to expand equity and empower communities.
  - Highlight efforts to provide support and expand the capacity of Native American tribes.
  - Emphasis on partnerships with underserved communities and increasing public input, including on infrastructure and resilience projects.
  - Emphasis on community partnerships, volunteerism, providing technical support, and community engagement so that communities affected by climate adaptation have a role in planning decisions.

1.5.2. Priority: Build a Climate Resilient Economy

- Goal A: Expand economic opportunities for California by building climate resilience
  - This goal is focused on policy priorities to support regions and communities that will experience changing economies due to climate change impacts. The objective is to emphasize high quality jobs, with opportunities for a diversity of businesses and workers.
  - Help communities attract businesses and investment from adaptation actions—and effort to capitalize on spending that will occur in order to improve adaptation and resilience efforts.
  - Protect existing industry sectors, such as agriculture, tourism, fisheries, and forestry from climate impacts and adverse development.
- Goal B: Deepen understanding of climate change effects on California's economy
  - This goal is focused on communicating climate risks to the business community and funding research on economic impacts.
  - This section looks to quantify economic loss and opportunity associated with climate change and assess financial cost of sea level rise and other impacts.

1.6. Governance & Institutional

1.6.1. Priority: Make Decisions Based on the Best Available Climate Science

- Goal A: Support Actionable Climate Science
  - This goal is focused on building the knowledge-base to support decision-making by government entities to improve adaptation and resilience.
  - Actions include implementation of California Climate Change Assessments to fund applied science and tools that provide information on climate change impacts.
  - Actions also support investment in science-based approaches to forest management, weather forecasting, and decarbonization.
  - This goal also emphasizes coordination across agencies and jurisdictions, within California (tribal nations, businesses, universities) and also with the federal government to support climate adaptation science.
- Goal B: Operationalize climate science into decision making
  - This goal is generally focused on incorporating and integrating climate risk, resilience, and adaptation into decision-making by state agencies.
  - Examples include providing wildfire smoke guidance for schools and other vulnerable populations, using information on climate impacts on agricultural land to inform agency decisions, integrating climate change projections into decisions about conservation investment, and incorporating sea-level rise data into polices, plans, and permits.

1.6.2. Priority: Partner and Collaborate to Leverage Resources

- Goal A: Collaborate to build climate resilience across sectors and regions
  - This goal is focused on sharing best practices for climate adaptation through coordination and collaboration with communities, tribal stewardship, local governments, federal agencies, and private partners.
  - Topics highlighted for coordination and collaboration include investment in climate resilience, water sector, public lands, sea-level rise adaptation, agriculture, forest health and wildfire resilience, transportation (including high speed rail), energy resilience, and public health.
- Goal B: Increase Awareness of climate adaptation and resilience issues
  - This goal is focused on information sharing between government agencies, universities and researchers, and community stakeholders.
  - The focus of this collaboration is to share information among recipients of state funding for climate resilience, share research and training opportunities between academic institutions and increase consultation between state government with tribal nations.

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

- More proactive than reactive. To be sure, components of this plan have been developed in response to prior climate-influenced events. However, the actions are forward looking, more focused on adaptation to prepare for future events, rather than response, recovery, and rebuilding after past events.
- Little information on process, but appears to be a relatively top-down approach. Public comment was solicited on drafts of the Climate Adaptation Strategy, but it's not clear how participatory the process was. That said, since the Climate Adaptation Strategy draws from so many other plans and programs, it may reflect the community priorities and input that were included in those prior plans.
- How actionable is this Climate Adaptation Strategy? The Actions are relatively high level. They refer to prior plans and programs that may be more specific, but this document itself is more aspirational, rather than providing concrete direction on the next steps to implement specific projects.

Synthesizer: Simon Kates Reference ID: 24

Title of document being synthesized and year it was published**: Our Land and Water: A Regional Approach to Adaptation (2022)**
Author(s): **Louisiana's Strategic Adaptations for Future Environments (LA SAFE), Louisiana Office of Community Development, the Foundation for Louisiana (FFL)**
Category of document: **SBA-CRI**
Geographic focus of the document: **Louisiana**

Report Summary

LA SAFE was a community planning effort led by the Louisiana Office of Community Development-Disaster Recovery unit. The program with put into place as a way to allocate $40 million in funding from the U.S. Department of Housing and Urban Development (HUD). Funding will be used to support the design and implementation of projects to support coastal resilience and managed retreat. LA SAFE is envisioned as a regional adaptation strategy—projects identified in the plan are based in local parishes, but the approach is regional in nature to ensure coordination.

LA SAFE is organized around five goals:

- Goal 1: Manage Flooding and Subsidence
- Goal 2: Plan for Safe and Affordable Development
- Goal 3: Improve Mobility throughout the Region
- Goal 4: Diversify Educational and Employment Opportunities to Strengthen the Regional Economy
- Goal 5: Support Healthy Communities, Regional Culture, and Recreational Access to Nature

Each Goal includes several Strategies to increase resilience. Each Strategy includes several Actions that the state or other project sponsors can implement. These Strategies and Actions are summarized in the synthesis below. The plan identified catalytic projects, ranging in cost from $475,000 to $7,000,000.

LA SAFE was developed using a community-based model for identifying regional and parish-specific projects to improve resilience and adapt to climate change. The plan includes a discussion of managed retreat, which is always an extremely sensitive topic to discuss among communities. Community-based processes are critical when evaluating managed retreat as an option. Any top-down approach to recommend moving communities away from the coastline are bound to raise controversy. However, if the discussion is brought forward by community members, it can be more feasible to build consensus around controversial ideas.

LA SAFE was a community-driven process, which was developed over the course of eight months and five rounds of public meetings. The community engagement process for developing LA SAFE began in the Spring of 2017, with a series of public meetings to identify challenges and priorities. Later that summer, there were a series of additional meetings to locate areas of opportunity and to evaluate the community vision and strategies. In the fall of 2017, public meetings were held to define strategies and identify project partners. Finally, in December 2017, meetings were held to evaluate the demonstration projects.

Public input was also supplemented by planning and design best practices, data about climate change and sea level rise, and scientific research about land loss, storm surge, geology, ecology, and climate. The plan also takes into account regional plans developed by other state and regional agencies throughout Louisiana.

The culmination of the process is a series of seven document. One is a Regional Strategy. The other six are Parish Strategy. The regional plan describes the regional challenges and high-level program and policy recommendations. The Parish Strategies provide more detailed recommendations and six project

proposals to achieve the strategy. One to two specific projects were chosen to be funded for implementation through the LA SAFE program.

1. Preparedness

1.1. Summary

1.2. Technical

1.2.1. Goal 3: Improve Mobility throughout the Region

- Strategy 1: Promote well-connected, multimodal transportation options within parishes and across the region—including water transportation—to better connect existing communities to emerging and growing sectors, industries, and job opportunities.
  - This strategy discusses potential details and criteria to create resilient transportation infrastructure
    - Require the use of Base Flood Elevation and 50-year flood risk projections when planning future transportation routes.
    - Model the impacts of new transportation projects on hydrological processes.
    - Improve connectivity between transportation routes and natural destinations
    - Prevent future loss of purchasing power to help pay for maintenance
    - Prioritize multimodal transportation
    - Update the state's Complete Streets Policy
- Strategy 2: Protect and elevate key supply chain and evacuation routes.
  - This strategy outlines potential capital improvements to make critical existing transportation infrastructure more resilient
    - Identify and improve key transportation and evacuation routes that are vulnerable to flooding and other extreme weather.
  - Incorporate existing transportation assets into evacuation plans.

1.3. Financial

1.4. Policy & legal

1.4.1. Goal 1: Manage Flooding and Subsidence

- Strategy 1: Institutionalize considerations of future flood risk in daily operations and programs within state agencies.
  - This strategy is focused on actions that state agencies can take to plan for and anticipate the impacts of changing coastal flood risks. Examples include:
    - Developing oversight and coordination of regional adaptation initiatives
    - Requiring state agencies to assess flood risk to their own assets based on the state's Coastal Master plan
    - Requiring state agencies to include current and future land loss and population movement with evaluating/updating programs.
- Strategy 2: Align public funding and project prioritization to promote green infrastructure and stormwater management
  - This strategy recognizes that need to encourage green infrastructure as a stormwater management solution by providing public funding. Actions are focused on:
    - Developing stormwater policies that are based on watersheds, not jurisdictional boundaries.
    - Requiring publicly funded projects to capture and store a minimum amount of rainwater.
    - Adopting guidelines for graywater use.
    - Incorporating stormwater management into recreation areas.
- Strategy 3: Incentivize the incorporation of stormwater management features and green infrastructure in private development
  - This strategy addresses the need to encourage stormwater management facilities in private projects.

- Encouraging local governments to develop GI programs.
- Providing incentives to private developers for investment in stormwater management best practices.
- Promoting shared detention areas for adjacent property owners
- Providing outreach, education, and technical assistance on stormwater management and GI.

1.4.2. Goal 2: Plan for Safe and Affordable Development

- Strategy 1: Encourage Elevation of homes based on current and future flood risk
  - The strategy provides policy guidance for development of new residential buildings so that new construction is resilient to future flood risk.
    - Requiring all new development or substantial rehabilitation to be built two feet above base flood elevation for a 100-year flood or to the 500-year floodplain.
    - Develop financial incentives and education to assist with home elevations.
    - Create weatherization programs to assist with wind fortification, extreme heat, and seismic upgrades.
    - Develop an education campaign to encourage pier-and-beam construction.
- Strategy 2: Plan future development based on risk typologies with mixed-use residential growth in low-risk areas
  - This strategy provides options to for local municipalities to encourage new development in low-risk areas.
    - Create small area plans to shift future development in low-risk areas.
    - Develop zoning incentives to attract mixed-use development in low-risk areas.
    - Create optional buy-out programs.
    - Ensure demolition at the end of life of commercial developments in high risk areas.
- Strategy 3: Identify ways to address insurance affordability
  - This strategy provides options to reform the flood insurance program.
    - Evaluate the feasibility for Louisiana to leave the National Flood Insurance Program and develop its own flood insurance program.
    - Provide incentives to communities in the floodplain to participate in FEMA's Community Rating System.

1.5. Socio-economic

1.5.1. Goal 4: Diversify Educational and Employment Opportunities to Strengthen the Regional Economy

- Strategy 1: Increase coastal education for students of all ages.
  - This strategy is focused on providing education about coastal and climate related issues to students in Louisiana.
    - Create a statewide curriculum about coastal landscapes, including regional land and water ecosystems.
    - Expand weekend and summer camp opportunities about coastal education.
- Strategy 2: Expand skills training in coastal careers.
  - Diversify local economies so they are less reliant on declining industries (seafood, oil and gas) and more reliant on industries related to adaptation.
    - Develop a coastal specialization pathway for high school students
    - Match education with skill needs
    - Support apprenticeship programs
    - Expand the state's expertise in coastal and stormwater management
    - Offer retraining programs in emerging industries such as adaptation, mitigation, and recovery.
- Strategy 3: Grow and diversify the economy.
  - Diversify local economies
    - Promote expertise in coastal restoration and adaptation

        - Support and foster emerging economies.
    - Strategy 4: Support Louisiana seafood and fisheries.
        - Support the seafood industry as an economic driver and as a cultural and historic asset.
            - Study how environmental changes will affect Louisiana fisheries.
            - Assist the fishing industry in adapting to the changing economy and environmental conditions
            - Provide technical assistance and loans to commercial fishers to diversify their businesses.
            - Increase fisheries certification.
            - Develop and promote the Louisiana seafood label.
            - Create a marketing and branding training program.
            - Provide research and assistance for adopting sustainable fisheries.

1.5.2. Goal 5: Support Healthy Communities, Regional Culture, and Recreational Access to Nature

- Strategy 1: Increase access to nature for recreational use and ecotourism
    - This strategy encourages expanded access to natural areas to promote local economies.
        - Support businesses that provide recreational services.
        - Promote ecotourism opportunities
        - Expand access to outdoor recreation for youth.
- Strategy 2: Preserve and support Louisiana's culture and heritage
    - This strategy recognizes that importance that coastal landscapes play in Louisiana's culture and history. The objective is to seek ways to preserve that history even as human occupation of coastal areas has to change.
        - Host cultural events and programs
        - Expand the Percent for Art Program
        - Preserve the culture and history of high flood risk areas.
        - Promote local tourism
- Strategy 3: Encourage development that is informed by an understanding of the relationship between public health and the built environment
    - This strategy acknowledges the intersection between public health and other environmental factors.
        - Use municipal ordinances and incentives to incorporate public health objectives into new developments
        - Create best practices guidelines for minimizing negative health impacts
        - Address mental health issues associated with living in high risk areas.

1.6. Governance & Institutional

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

What is most notable about this SBA-CRI is the process for developing it. The community-driven process was critical to creating a strategy that is both regional in effect as well as locally specific enough to build consensus and identify priority projects for implementation. The creation of a series of strategy documents is a unique approach to address both high-level regional objectives as well as locally specific solutions. As a best practice, one can imagine a process in Canada where the federal or provincial governments create a high-level document, then provide funding for creating local plans. Local plans that follow the strategies and actions of the regional plan could then be eligible for implementation funding for select projects. This is a strategy to allow local communities to plan with their own priorities in mind, which also creating a framework to ensure that the local plans support regional and/or national goals.

Synthesizer: Adam Simpson (adam.simpson@ibigroup.com) Reference ID: 40

Title of document being synthesized and year it was published**: Anticipate, React, Recover: Resilient Infrastructure Systems (2020)**
Author(s): **National Infrastructure Commission**
Category of document: **SBA-SRI**
Geographic focus of the document: **UK**

Report Summary

The UK's National Infrastructure Commission (NIC) exists to provide the UK Government with independent, impartial advice on coping with long term infrastructure challenges, supporting sustainable economic growth that helps to improve the quality of life.

The NIC's remit covers *'economic infrastructure'*, meaning energy, transport, water and wastewater (drainage and sewerage), waste, flood risk management and digital communications. Private housing is not included in the remit, although they do consider the potential interactions between their infrastructure recommendations and general housing supply. Also not in scope is social infrastructure, such as schools, hospitals or prisons, or agriculture / other land use.

Once in each parliament (every ~5 years) the NIC produces a national assessment, with a series of recommendations for government to act on. The assessment is supported by an annual monitoring report to track progress against objectives; with targeted studies performed on any pressing infrastructure challenges identified, as & when required.

Once the NIC's recommendations have been endorsed by government, a separate body called the Infrastructure & Projects Authority (IPA) is responsible for delivering the projects needed to ensure the long term plans are met.

All investment recommendations from the NIC must:

- show how they can be accommodated within pre-set annual spending levels (as a % of GDP),
- include a cost-impact assessment on businesses, consumers, public bodies and other end users,
- take into account the role of the UK's economic regulators in regulating infrastructure providers,
- align with the government's legal obligations, e.g. meeting carbon emissions reduction targets;
- comply with any statutory obligations, e.g. to perform environmental impact assessments.

The Commission must ensure its recommendations do not reopen decision making processes where programmes and work have been decided by the government or will be decided in the immediate future; including via any devolution settlements; which means there may be separate recommendations in relation to government infrastructure responsibilities in England, Scotland, Wales and Northern Ireland.

To help stakeholders meet their objectives, the NIC has developed a six-part framework for considering resilience in terms of how a shock would impact infrastructure systems over time; with recommendations in each stage – summarised in the table below, and expanded on in subsequent sections.

	Stage	Description	Recommendation
Prepare d-ness	**Anticipate**	Before any disruption, operators can anticipate shocks and be prepared	Government sets resilience standards
Respon se	**Resist**	Systems can resist shocks and stresses to prevent an impact on infrastructure services	Regulators oversee regular stress testing

Recovery	**Absorb**	Systems can absorb shocks and stresses to minimise the impact on services	Infrastructure operators address vulnerabilities
	Recover	After the shock, actions help quickly restore expected levels of service	
Rebuild	**Adapt**	Longer-term, to be better prepared next time, systems may need to either: (i) adapt, or (ii) transform.	Infrastructure operators produce long term resilience strategies.
	Transform		Regulators value resilience in decisions to support investment

1. Preparedness (aka Setting the Standards)

1.1. Summary

The 'Anticipate' phase of the NIC resiliency framework addresses Preparedness. One major element of preparedness identified in the framework is the need for a common set of standards that define the understanding between each Infrastructure Operator, their Regulator, and the Government. This understanding should identify the types of disruption or failure that could happen, and the response needed by each party to protect the public, should that disruption occur.

1.2. Technical: Not covered directly

1.3. Financial: Not covered directly

1.4. Policy & legal:

Complex systems are reliant on many infrastructure services continuing to function, and so it is important to define common standards that clarify the resilience outcomes that government wants to see achieved; while giving operators the necessary incentives to invest in resiliency.
While the report acknowledges that setting these standards can be an uncomfortable process, with difficult choices to make; implementing transparent standards help to ensure operators understand what level of resilience they are expected to deliver as they anticipate potential events. Other benefits identified include:

- increased transparency: assumptions can be scrutinised & tested, mitigating groupthink
- reduced coordination costs: contingency planning based on a common set of expectations
- incentive to upgrade: to encourage operators to invest in improved resilience
- clear accountability: with responsibility for delivering & funding standards assigned
- test planning: defining what constitutes a failure / near miss, to determine when action is needed

The intention is to reach an agreed upon set of standards that are supported by the relevant industry Regulators (road, rail, energy, water, etc). The Regulator's role is to provide Operators with advice on the costs and benefits of different resilience standards, warn about dependencies with standards in other sectors, and monitor the range of shocks and stresses that infrastructure services should be resilient to.

The report recommends that resilience standards should be set by Government, using the following principles. Each standard must be:

- informed by a solid understanding of the resilience of the public and of businesses
- mindful of the capacity for response of different locations or systems
- informed by the real cost of response,
- transparent,

- aligned with broader policy priorities

Standards should reflect the level of service that customers or the public can expect. The NIC recommends the following principles are adopted when setting service levels, to ensure a balance between costs, impacts, and expectations:

- minimise costs & risks for potentially catastrophic events\
- use a wide range of methods to understand consumer views on disruption
- consider the widest possible range of impacts of any potential disruptions or failures
- the right discount rate should be used for assessing costs and benefits of resilience, which might be lower for extreme cases where lives or irreversible socio-economic changes are at risk.
- consider wider social impacts and any impacts on other dependent sectors qualitatively or quantitatively.

A technical annex to the main report provides more detail on these principles, including where specific approaches are not applicable when setting out clear resilience expectations and when making the case for specific resilience investments. See National Infrastructure Commission (2020), Principles for setting levels of service https://nic.org.uk/app/uploads/Technical-Annex-Service-levels.pdf

1.5. Socio-economic

1.6. Governance & Institutional

2. Response (aka Testing the Standards)

2.1. Summary

In lieu of responding to actual events; the framework proposes how systems can be 'Stress Tested' to mimic the response to an event; this is covered in more detail in the Policy section below

2.2. Technical

The NIC has published a separate guidance document focused solely on best practice related to the collection & use of data pertaining to national infrastructure.
A copy can be found at: https://nic.org.uk/app/uploads/Data-for-the-Public-Good-NIC-Report.pdf

2.3. Financial

2.4. Policy & legal

Once a common set of resilience standards have been agreed, Infrastructure Operators must be able demonstrate their effectiveness and providing resilience to a major event. The NIC report recommends Stress Testing as a key means of demonstrating resilience without actually waiting for an event to occur.

Stress testing gives Infrastructure Operators a better understanding of the resilience of their infrastructure systems; helping them to identify and address vulnerabilities. It also gives assurance to the Regulators and to Government that the resilience standards can be met. To be effective, it does require accurate, up to date data about infrastructure systems, including asset condition and location, which may not always be collected, shared and used effectively.

Stress testing provides a mechanism to help infrastructure Operators:

- identify and address vulnerabilities in advance of an event.
- test decision making processes, and

- prepare for a range of potential disruptions, not just the scenarios set out in the stress tests.

To address resilience vulnerabilities, the NIC report suggests that Regulators:

- set out scenarios and scope for stress tests
- provide guidance for developing bespoke tests (frequency, common scenarios, etc)
- oversee the stress tests, scrutinising outcomes

Operators would be responsible for developing and implementing the plans needed to remedy any vulnerabilities identified as part of the stress tests.

It also recommends that best practice in stress testing should be promoted across all relevant Regulators, including learning lessons from the financial sector and others who may have more advanced techniques.

Over the longer term, Infrastructure Operators may need to adapt, or potentially transform, their systems or services to enhance resilience, and must develop appropriate strategies to do so. Implementing these strategies effectively require strong governance and clearly identified decision points; a role that Regulators are well placed to support via oversight and guidance. Regulators can use these strategies to develop a sector wide view of resilience, and address any issues raised. See the Recovery section, below.

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery [aka Setting the Longer Term Strategy]

3.1. Summary

Infrastructure Operators are ultimately responsible for the resilience of their own networks or systems in both the short and longer term; meaning they are best placed to develop long term strategies that manage interdependencies with other sectors, and taking advantage of opportunities to adapt and transform to improve resilience – which may include lessons learned from others.

Setting clear resilience standards, and requiring infrastructure operators to carry out stress tests will enable infrastructure operators to understand the level of resilience they should be aiming for, the level they already have, and potential risks and challenges. This should help them to develop realistic, comprehensive and affordable long term resilience strategies.

Tools proposed by the NIC that can be used to develop longer term strategies include the following:

Tool	Description	Rationale

Keep existing options open	• Build or retain flexibility within systems.
	• Examples include:
	  ○ reserving land in case future growth is needed;
	  ○ not shutting down legacy systems which could be used in future;
	  ○ trial new options before scaling them up
		• Provides flexibility to enhance overall resilience
		• Infrastructure operators to consider whether it is more cost effective to build resilience into new systems

Managed adaptive approaches	• Incrementally adapt. • Identify a range of options or potential pathways, and system 'tipping points.'	• Pathways can be tailored over time to suit unfolding conditions. • Operators can take 'least regret' decisions, respond to future risks and

	• When reached, trigger implementation of the best option for the circumstances.	demands as they emerge, and spread resilience costs over time. • Need to balance investment in adaptive capacity with affordability and time pressures
Systems Mapping	• Explore how different decisions can impact the level of service delivered to consumers, and • Consider the impact of decisions within and across sectors	• Increasing reliance on electricity and digital communications, as well as increasing interaction between technological developments and decarbonisation in energy and transport will not be manageable if they are only thought about within individual sectors.

3.2. Technical

3.3. Financial

In regulated markets, Regulators will need to take the costs of resilience into account in their future price determinations, acting on consumers' behalf.

Regulators must ensure investment can be made to enable government's resilience standards to be met, while also scrutinising companies' resilience bids to ensure they are proportionate, and consumers will not be paying for excess resilience (i.e. avoid 'gold plating').

3.4. Policy & legal

Although the Infrastructure Operators are likely to best placed to develop long term resilience strategies for their infrastructure systems and services, long term resilience planning cannot be left entirely to the operators; as they do not always have the right incentives for resilience; and may have internalised assumptions that are unrealistic or optimistic.

Regulators have a role to:

- require infrastructure operators to produce long term resilience strategies;
- produce guidance on developing those strategies to ensure a proportionate approach;
- scrutinise those strategies, to develop a sector wide view of resilience
- share best practice from within the sector, and facilitate expert review of the long term strategies
- ensure a proportionate approach, and provide guidance on the appropriate time horizon

Where government, not the regulator, has resilience responsibilities, or multiple regulators are involved, all relevant parties should be involved in scrutinising the long term strategies.

Expert review of the long term strategies, including minority views can help ensure that the strategies address a range of future challenges, while ensuring they are affordable and deliverable; and help operators avoid uncomfortable truths

3.5. Socio-economic

If the standards have been set correctly, the benefits to consumers and wider society will outweigh the costs.

Government will need to pay particular attention to the ability of consumers in vulnerable circumstances to pay the costs, but also be aware that the benefits may be greatest for people who are vulnerable.

3.6. Governance & Institutional

4. Rebuild – not directly addressed in this report as it does not deal with any one specific event

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

Core recommendations:

- Government to publish clear, proportionate and realistic standards for the resiliency of infrastructure services; and review/update these standards regularly
- Regulators should require infrastructure operators to put in place a system of regular stress testing to ensure that infrastructure operators' systems and decision-making can credibly meet resilience standards for infrastructure services.
- Regulators should introduce obligations on infrastructure operators to require them to participate in stress tests, and to require remedial action in case of failure of stress tests.
- Operators should develop and maintain longer term strategies to ensure infrastructure services can continue to meet the agreed resilience standards
    - Where there is no current requirement, Regulators should mandate that infrastructure operators must develop and maintain long term resilience strategies.
- Regulators should set out, in future price reviews, how their determinations are consistent with meeting the agreed upon standards of resilience, in both the short and long term.

Additional suggestions

- Government to commission further work to better understand how the public would likely respond to different types of crisis, to assist in response planning.
- Regulators and Government to assess how existing control mechanisms drive Operator behavior.
    - E.g. are infrastructure operators incentivised to behave in certain ways,
    - Is that behaviour appropriate/desirable?
    - How could changes be introduced to enable operators to better deliver against the 'new' standards;
    - How could those changes be regulated?
- Operators that undertake stress tests to share their experiences across different industry sectors.
    - This is to support regulators and government gain a better overall understanding of the resilience of infrastructure.
- Regulators to use the stress tests to develop an overview of resilience in their sector and assess whether any additional actions are needed.
- Government to use the reports to develop an overview of systemic and cross-cutting resilience issues that arise across multiple sectors.

The main report also includes several technical annexes with suggested further reading:

1. Setting Service Levels: https://nic.org.uk/app/uploads/Technical-Annex-Service-levels.pdf
2. Expected costs and their impacts: https://nic.org.uk/app/uploads/Technical-Annex-Impact-and-costing-note.pdf
3. Case Studies & Examples of Good Practice: https://nic.org.uk/app/uploads/Technical-Annex-Good-practice-case-studies.pdf)

Synthesizer: Koen Broersma Reference ID: 44 (45, 46, 47)

Title of document being synthesized and year it was published**: National Climate Adaptation Strategy 2016: "Adapt with ambition"**
Author(s): **Ministry of Infrastructure and the Environment**
Category of document: **SBA-CRI / Framework**
Geographic focus of the document: **Europe / Netherlands**

Report Summary

The National Climate Adaptation Strategy (NAS)—Netherlands (2016) initiates new initiatives and accelerates and broadens existing initiatives. The NAS builds on a decade of climate adaptation policy in the Netherlands and, together with the Delta Programme, covers the Dutch tasking for climate adaptation. An important component of the strategy is connecting all parties and promoting a joint approach. The NAS is the Dutch response to the European Commission's call to adopt a climate adaptation strategy by 2017 at the latest.

The NAS 2016 provides insight into the main effects of climate change (chapter 2) and mainly focuses on the most important effects that require action in the short term (chapter 3). Chapter 4 sets out the steps needed to ensure that the Netherlands is structurally less vulnerable to climate change by 2050. Chapter 5 kicks off the Climate Adaptation Implementation Program that will be elaborated in 2017.

The NAS is the prelude to a Climate Adaptation Implementation Programme (separate document), which builds on all implementation that has already been initiated, such as by the Delta Programme. Where supplementation and acceleration is necessary, the Implementation Program provides for this, with sufficient capacity and resources from the parties involved. The Delta Program also contributes to implementation, for example by drawing up the Delta Plan on Spatial Adaptation. Together with the knowledge institutions, the Ministry of Infrastructure and the Environment will explore how a basic facility can be set up, within which central government, provinces, municipalities, water boards and the other parties involved can monitor their progress in the implementation programme. Coordination with the monitoring program for the Delta Program is the starting point.

The NAS has a strong connection with the Delta Program (separate document) in the sense that the Delta Program fulfills a large part of the adaptation implementation regarding the tasks arising from pluvial flooding, heat, drought and fluvial/coastal flooding.

1. Preparedness

1.1. Summary

The NAS charts the effects of climate change for nine sectors in four diagrams – warmer, wetter, drier and sea level rise –: water and space; nature; agriculture, horticulture and fishing; health; recreation and tourism; infrastructure (road, rail, water and also aviation); energy; IT and telecom; safety.

1.2. Technical

Six urgent effects require action now:

1. More heat stress for people due to extreme weather: more sick people, hospitalizations, deaths and reduced work performance/increase in absenteeism.
2. More frequent failure of parts of vital and vulnerable functions due to extreme weather: energy, telecom, IT facilities and main infrastructure.
3. More frequent crop damage and other damage in agriculture and horticulture due to extreme weather: reduced crop yields, damage to means of production.

4. Shifting of climatic zones as a result of which part of the flora and fauna – partly due to a lack of international spatial cohesion in nature – cannot move sufficiently with the shifting climate.
5. Loss of health, loss of work and costs due to a possible increase in infections and allergies such as hay fever or other respiratory complaints.
6. Cumulative effects where failure in one sector or at one location has consequences for other sectors and/or other locations.

In addition, there are effects that will take place later this century, but because of their impact also require attention now. This concerns the failure of parts of the electricity network due to extreme weather, limitation of shipping due to extreme high or low water, loss of species and habitats due to extremely low water in river arms, large-scale IT outages due to the failure of crucial IT service providers elsewhere in the world, large-scale failure of IT services due to overheating and changing migration patterns of migratory species. This also concerns additional subsidence with the following consequences: damage to buildings and infrastructure, safety risks such as the rupture of pipes and extra CO_2 emissions due to peat oxidation.

1.3. Financial

The coordination of the implementation of the Implementation Program NAS lies in the hands of the NAS program team. Ministry of Infrastructure and Water Management provides the capacity for this team. A budget is available from Ministry of Infrastructure and Water Management for process support. The parties directly involved in the Implementation Program NAS provide sufficient capacity and resources for the necessary coordination; and for the implementation of specific spearheads or other actions.

The Water Act stipulates that the Delta Program Commissioner will submit a proposal for the Delta Program every year. The Delta Commissioner arrives at this proposal in consultation with ministries and local authorities. On Budget Day, the Minister of Infrastructure and Water Management presents the Delta Program to the House of Representatives. This makes it part of the budget process. The Delta Program contains three Delta Plans with studies, measures and facilities for flood risk management, spatial adaptation and freshwater supplies in the Netherlands. The programming of the measures is detailed for the first six years and indicative for the subsequent twelve years, with a look ahead to 2050 (in accordance with Article 4.9, fifth paragraph of the Water Act).

1.4. Policy & legal

The Implementation Program identified six spearheads for the 2018-2019 period:

1/ Heat stress

The climate adaptation dialogue 'Heat and health', which started in 2017, was continued. Participants from the three pillars under this topic are involved: healthcare (for vulnerable people); adaptation, management and maintenance of buildings (built environment); and spatial planning. In 2018, a guideline is drawn up for local heat plans and their implementation. Research is also being conducted into the risks of the combination of heat and smog during sporting events in particular. The first Heat Stress Congress took place on 25 June 2018, with the subtitle: 'how the Netherlands is dealing with a warmer climate'. This also fulfils the commitment to the House of Representatives to provide an overview of developments in this area.

2/ Infrastructure

Many measures in the 'infrastructure' sector are based on the current weather. In the coming years, further research is conducted into additional measures that are necessary to be able to cope with extreme weather situations. The results will help determine policy development.

3/ Agriculture

The climate adaptation dialogue 'Agriculture, water management and insurance', which started in 2017, is continued; with attention to damage that is not currently insurable.

4/ Nature

The climate adaptation dialogue 'Nature and climate change', which started in 2017, is followed up; with a focus on measures for the benefit of nature as well as for solutions that nature can offer for climate effects in other sectors. In addition, in 2018 it was investigated whether a fifth climate trend should be distinguished – from a nature point of view: higher CO_2 levels, with the possible effect of acidification of the sea.

5/ Built Environment

In 2018, a climate adaptation dialogue 'Built environment' started. The aim of this dialogue is to increase awareness of the consequences of climate change for the built environment. An inventory is also made of possible measures, opportunities and obstacles or ambiguities in legislation and regulations, guidelines and/or frameworks and any other necessary instruments. Linking together plays a role in this: connecting climate adaptation with the energy transition and circular construction. By paying attention to this linking, implementation projects can reinforce each other. The 'built environment' chain is added to the NAS bulb schemes in 2018. The Central Government Real Estate Agency will take new steps in research into the climate resilience of central government buildings.

6/ Working together on provincial and regional strategies and visions

The connection between the ideas of the NAS and the formulation of provincial and regional strategies and visions is deepened in 2018. During consultations and meetings, the parties involved in these strategies exchange knowledge and experience about embedding climate adaptation in policy (strategies, environmental visions, plans) and implementation (practical examples).

The Ministry of Infrastructure and Water Management coordinates the implementation of the Implementation Program NAS (knowledge base research, knowledge exchange, progress and monitoring, support for the six spearheads and action-oriented climate adaptation dialogues and a communication strategy).

1.5. Socio-economic

Some matters to be tackled by the government are:
- research into the climate resilience of government buildings and government land;
- organizing an adaptation dialogue on the insurability of climate risks with the parties involved;
- inventory of chain dependencies of weak links in the rail network in extreme weather situations;
- drawing up a guideline for climate adaptation for the Multi-Year Program Infrastructure, Spatial Planning and Transport (MIRT).

1.6. Governance & Institutional

A climate-proof Netherlands is a joint task, for which every Dutch person is jointly responsible. The National Climate Adaptation Strategy sets the course and the central government ensures implementation by initiating a number of actions:
1. raising awareness of the need for climate adaptation;
2. stimulating the implementation of climate adaptation;
3. utilizing and expanding the knowledge base;
4. addressing urgent climate risks;

5. embedding climate adaptation in policy, legislation and regulations;
6. monitoring progress and effectiveness of the adaptation policy.

The Ministry of Infrastructure and Water Management (IenW) acts as a coordinating ministry and, as a coordinator, monitors the overall progress and efficiency of implementation, without assuming the separate responsibilities of the other departments involved. IenW also ensures proper coordination between the NAS and other programs, including the Delta Programme. The progress of the Implementation Program NAS is coordinated in the NAS directors' meeting (DO-NAS). This meeting takes place at least three times a year. The DO-NAS is chaired by the Ministry of Infrastructure and Water Management. Participating parties are the Ministries of Foreign Affairs (BuZa), Justice and Security (JenV), the Interior and Kingdom Relations (BZK), Economic Affairs and Climate (EZK), Agriculture, Nature and Food Safety (LNV), Public Health, Welfare and Sport (VWS), Delta Commissioner Staff, Interprovincial Consultation (IPO), Association of Dutch Municipalities (VNG), Union of Water Boards (UvW) and the knowledge institutes KNMI, PBL and RIVM. The Ministry of Education, Culture and Science (OCW) is a member of the agenda.

The Ministry of Infrastructure and Water Management coordinates the implementation and the program team. Coordination at shop floor level takes place in the Sounding Board Group NAS, which includes all parties that are also represented in DO-NAS, supplemented by the Ministry of Education, Culture and Science, RWS, the provinces of Overijssel and South Holland, WUR, TNO, ProRail and NEN. In addition, the NAS program team and the DPRA team coordinate their activities.

2. Response

2.1. Summary

Response to a climate event is left to the executive organisations (e.g. Rijkswaterstaat) and lower governments (Water boards and municipalities) and private sector (business and private citizens)

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

Recovery from a climate event is left to the executive organisations (e.g. Rijkswaterstaat) and lower governments (Water boards and municipalities) and private sector (business and private citizens)

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

Rebuilding after a climate event is left to the executive organisations (e.g. Rijkswaterstaat) and lower governments (Water boards and municipalities) and private sector (business and private citizens)

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

In 2020 the Implementation Program NAS was evaluated.

Climate adaptation dialogues were initiated for the spearheads of insurability, the built environment, agriculture and nature, and heat and health. The dialogue on insurability resulted in climate adaptation becoming part of De Nederlandsche Bank's supervision of insurers. For agriculture, the dialogue process resulted in an Action Program for Climate Adaptation Agriculture. An action program was expected to be completed in 2020 for the built environment and nature. An approach has been developed for government buildings to make the buildings climate-proof. Representatives of policy and implementation are in intensive discussions with each other about making the national infrastructure climate-proof.

The heat stress spearhead is a cross-sector theme. The NAS Program Team focused on a broad awareness of heat stress, health aspects and more socially oriented measures. The Heat and Health dialogue led to, among other things, the Heat Stress Congress in June 2018, the guideline for local heat plans, the Sunpower Action Plan and the heat and loneliness maps for the G40 (2019).

The NAS program team has also taken other targeted actions. For example, the Consultation on Climate Adaptation Standards (OSKA) was established together with the team of the Delta Program on Spatial Adaptation (DPRA).

The urgent risks included in the NAS 2016 remain crucial to work on, as do the resulting spearheads, as included in the Implementation Program NAS. Steps have been taken since 2016 towards anticipating and reducing the identified climate risks and activating relevant actors for some risks. In these years of growing attention to the climate, the Ministries of Health, Welfare and Sport (VWS) and Agriculture, Nature and Food Quality (LNV) needed little encouragement to get started with their policy files. This has resulted in a good collaboration in NAS context. The follow-up in many cases requires additional investments in cooperation and further agreements between governments, companies, social organizations and educational and knowledge institutes. A regular assessment of the urgent risks is necessary in order to continue to focus on the most urgent risks that have not yet received sufficient attention.

Entering the next phase in the implementation of the NAS, three points of attention are important:
- Full commitment to urgent risks and spearheads; in particular on heat, built environment and infrastructure.
- Connecting with other transitions and social challenges.
- Invest in a long-term knowledge and monitoring system.

Achieving climate adaptation in a rapidly changing environment is an enormous challenge. In the past years, the NAS Program Team has gained good experience with an informal, fast, creative, goal-seeking approach. The program team looked for answers on a national scale - based on the government-wide system responsibility for climate adaptation - via flexible and open network management. With a small wins approach, small but meaningful steps have been taken that lead to results relatively quickly, so that more parties are moving and the goal - climate adaptation - comes closer.

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Author(s): **Ministère de la Transition Ecologique et Solidaire**
Category of document: **SBA-SRI**
Geographic focus of the document: **France**

Report Summary

This report presents the French National Adaptation Plan for Climate Change for the period 2018-2022. The general objective of this Plan is "to implement the actions necessary to adapt, by 2050, French metropolitan and overseas territories to expected climate change impacts at the regional level.". The plan is in line with the objectives of the Paris Agreement as well other international conventions, to reduce greenhouse gas emissions in view of limiting the rise in average global temperatures to no more than 2°C. The national adaptation policy is therefore the essential complement to France's climate change mitigation policy, which aims to achieve carbon neutrality. It also aims to avoid contradictions between the various adaptation and environmental protection actions. It recognizes the value of biodiversity and ecosystem services for adaptation and seeks, wherever possible, synergies by favouring nature-based solutions. It is also part of the principle of ecological and inclusive transition.

The National plan focuses on six key thematic areas: (1) Governance, (2) Prevention and Resilience, (3) Nature and Environment (4) Economic sector, (5) Knowledge and Information, (6) International. Within these six focus areas, fifty-six key actions are identified.

The Governance actions are linked with a good articulation of roles and responsibility between the territorial and national levels and a good implication of the society as a whole for the implementation of the PNACC2, as well as a coherent approach between climate adaptation and mitigation and reinforcement of the juridical and legislative frames around climate adaptation.

The Prevention and Resilience present actions to protect people and assets/goods against climate risks and prepare the economic sector to respond to expected climate impacts. The focus is put on preventing fires, health, and sanitary risks, as well as other natural disaster risks thanks to better urban planning approach regulated by labels and regulations. Another key action is the improvement of observation and prevision of climate risks, better information dissemination, awareness raising and early-warning systems for the population at risks. Another important action is the development of medium and long-term land-use strategies taking socioeconomic, environmental and cultural challenges in account (i.e. through restricted areas, ecological restoration, allowing infiltration of precipitation…). Another action is the climate proofing of cultural heritage assets. Lastly, as part of the prevention and resilience component, development of resilient eco-district type of project will be supported mobilising European funds/investments.

The Nature and Environment thematic present the need to focus on actions that are whenever possible nature-based and in all cases respecting ecosystems and biodiversity. Focus is on better water resource management preservation of aquatic ecosystem, limiting soil consumption and surface unsealing, restoration of industrial wastelands, depollution. Other actions include coastline adaptation, forest preservation, biodiversity protection.

The Economic Sector section focuses on prospective studies to identify vulnerabilities of economic actors, climate proofing of investments, sustainable overseas-tourism, resilience planning within fishing and aquaculture sectors, transition towards agro-ecology, bio-economy and sustainable forestry. Finally, there should be a focus on creating favourable conditions for key investors to invest in climate adaptation in France.

The Knowledge and Information actions focus on a building a strong scientific knowledge and raising awareness of the population on the need to fight against climate change and adapt to it.

The International section presents the frame to collaborating at the international level to learn from other countries as well as disseminate best practices from France worldwide.

The conditions for the success of the PNACC-2 require the establishment of a rigorous mechanism for monitoring the actions included in this ambitious plan and the resources mobilized. This mechanism will have to involve the different levels of actors in a virtuous approach to ensure, in complete transparency, the good start and then the good progress, throughout the five-year term, of the multiple actions included in this plan. This will make it possible to measure the progress made in terms of adaptation at the end of the five-year period which will close this 2nd cycle of public policy in an area which is still in an emerging phase. The monitoring mechanism will be based on a specialized commission which will act as a partnership monitoring body, according to terms that it will define from the start of the implementation of the plan. The specialized commission will regularly report to the Minister for Ecological and Inclusive Transition, on the progress of the actions listed in the PNACC-2, with the ambition of maintaining the highest level of mobilization of all levels responsible for these actions or involved in carrying them out. This is how the consolidation of the national adaptation to climate change approach will materialize as one of the two pillars, along with mitigation, of France's climate policies in the logic of the Paris Agreement.

1. Preparedness

1.1. Summary

The French National Climate Adaptation Strategy is focused on preparing for climate risks through:

- a detailed technical approach including coherence between climate adaptation and mitigation actions, future looking data, climate risks assessment, nature-based solutions, research and innovation
- a comprehensive financial approach: enhancing favourable financial conditions for climate adaptation investment, mobilising European funds, collaboration with the Insurance sector
- an evolving political and legislative framework for climate adaptation
- ensuring socioeconomic factors are well-considered and that climate justice is in place
- a multi-level governance where actions at local, municipal, national, European and international levels are well-coordinated and reinforcing each other

1.2. Technical

- Coherence between climate adaptation and climate mitigation, identifying co-benefits
- Fire prevention:
    - Forest management
    - Modelisation of fire-climate relationship
    - Evaluation of intensity of fire and vulnerability analysis of buildings surrounding forests
    - Landscape planning to reduce fire risks when restoring forests
    - Improvement regarding surveillance and rescue protocols (at national and EU level)
    - Sensibilization of population
- Public Health
    - Consolidation of surveillance and warning systems for epidemiology and sanitary risks through research and better knowledge
- Tools for natural disaster prevention
    - Climate resilient urban planning accompanied by labels and regulatory tools to ensure construction take climate risks into account
    - Improvement of observation and prevision of climate events and early warning systems and sensibilization of populations

    - Solutions to improve indemnity schemes for losses resulting from a climate disaster event (CatNat PPP scheme)
- Land use planning
    - Zoning and restricted areas,
    - Ecological restoration,
    - Allowing infiltration of precipitation
    - climate proofing of cultural heritage assets
    - key prevention projects will be supported including:
        - primary infrastructure planning and upgrading
        - reducing heart islands effects through innovative urban, ecological, and architectural solutions
        - Nature-based solutions, BGI
        - Natural hazards as well as biodiversity in mountain areas research and development
        - Transition towards Agroforestry, agroecology and bioeconomy
        - Land use planning tools in both urban and rural contexts
    - Reinforce resilience of ecosystems adapting to climate change and use ecosystem to support climate adaptation
        - Improve water resource management and preserve aquatic ecosystems
        - Limit soil consumption and work towards surface unsealing to allow for infiltration
        - Restoration of industrial wasteland
        - Depollution
        - Coastline adaptation
        - Forest preservation
        - Biodiversity protection and climate proofing
    - Research and Development
    - Education and training
    - Climate services

1.3. Financial

- Applying a climate lens to inform and prioritize investments: the Ministry of Finance and Economy will define in collaboration with key stakeholders, a framework to evaluate the economical, socioeconomic and environmental aspects of investments and specific criteria based on climate projects will be developed to avoid investments that could be affected by climate change and reorientate these taking risks into account. (Action ECO-2)
- Create favorable conditions for financial actors to invest and finance climate adaptation in France through:
    - The production and knowledge sharing of climate expertise between financial actors, experts' poles, academic sector and other knowledgeable actors (Action ECO-10)
    - Increase intervention capacity of financial enterprises with regard to climate adaptation defining modalities for their intervention (Action ECO-11)
    - Collaboration between public authorities, climatologists, (re)insurance sector, banks, institutional investors, asset managers for a better coordination to reinforce resilience and financing of adaptation (Action ECO-12)
- Mobilise European structural and investment Funds to finance key prevention projects such as resilient eco-district projects (Action P&R-8)

1.4. Policy & legal

- Biodiversity laws
- Integrating present and future resilience stakes of ecosystems and water resource in any relevant public policies and sectorial plans for economical activities.
- Regional committees and observatories will be responsible for monitoring and reporting of adaptation at the local level and provide inputs to the national reporting on climate adaptation within

the United Nations Framework Convention on Climate Change and at community level. (Action GOUV-3)

- Medium- and long-term regional climate projects will be considered for the development and updating of laws, codes, standards, and technical regulations that have for the most part been based on past climate data rather than projections. Once new benchmarks have been established, such as the cross-functional standard relating to adaptation currently being developed at the international level, they will be incorporated into existing labels and considered in technical or legal standards and regulations by applying the logic of simplification and of predictability initiated by the Government with a view to establishing a favorable framework for adaptation. (Action Gouv-5)
- Develop new policies to accompany the transition towards agroecology and bioeconomy (Action ECO-7)

1.5. Socio-economic

- The plan considers the social and economical vulnerability of populations, territories and economic sectors in terms of climate risks exposition and adaptation capacities respecting the principle of climate justice
    - The qualitative elements of monitoring, analysis and evaluation of adaptation approaches will focus on the impacts on the most vulnerable people. (Action GOUV-2)
    - Develop a framework to evaluate economical relevant and socioeconomic impacts of investment projects (Action ECO-2)
    - Eco/resilient tourism in overseas territories (Action ECO-3) and mountain areas (i.e. ski industry) (Action ECO-4)
    - Build a climate resilient fishing and aquaculture industry which respect the environment and ecosystems (Action ECO-5) as well as prevents climate induced sanitary risks (Action ECO-6)
    - Transition towards agroecology and bioeconomy (Action ECO-7)
    - Wood Forest sector: improve knowledge of climate adaptation and mitigation strategies (Action ECO-8) and develop local strategies for forest development (Action ECO-9)
- Information, sensibilization and participation of the population regarding key climate adaptation issues and potential solutions to offset these challenges:
    - Resource center on climate adaptation dealing with to following topics: public health, water, agriculture, forest, soils, biodiversity, natural disaster, urbanism, mobility, fishing and aquaculture, tourism, financial sector (Action C&I-9).
    - Communication events to sensibilize actors at all level as well as general public regarding the need to adapt to climate change (Action C&I-10)
    - Publications of scientific reports on latest findings that can be read easily by all stakeholders (Action C&I-11).

1.6. Governance & Institutional

- The Governance actions are linked with a good articulation of roles and responsibility between the territorial and national levels and a good implication of the society as a whole for the implementation of the PNACC2, as well as a coherent approach between climate adaptation and mitigation and reinforcement of the juridical and legislative frames around climate adaptation.
- Strengthen the strategic management of the adaptation process in a logic of co-construction with the levels of territorial governance, including local actors and civil society. The PNACC-2 will be progressively more prescriptive, in addition to actions that until now were still largely incentive-based. Close monitoring of the plan will ensure the consistency of climate change adaptation policies and policies for mitigating greenhouse gas emissions at the national level.
- Develop co-benefit approach between climate adaptation and climate mitigation (Action GOUV-1)
- Management and monitoring of the PNACC-2 will be based on a specific system adapted to the multitude of areas and actors involved in the policy of adaptation to climate change.

- This system will be entrusted to the specialized commission of the National Council for Ecological Transition (CNTE) in charge of guiding ONERC. This commission will thus act as a national adaptation monitoring committee to ensure annual monitoring of the detailed implementation plan, to choose relevant indicators in terms of adaptation and to propose, if necessary, changes in the national adaptation policy, through additions to this PNACC. This body aims to make the PNACC an evolving public policy instrument while preparing its overall evaluation which will be carried out in 2022 (GOUV-2 Action).
- Mechanisms will be put in place jointly by the State, the local authorities (in the first place the Regions, and the inter-municipalities) and the actors concerned to ensure the best possible articulation of adaptation policies from the national scale to the local scale, taking into account the skills exercised. This will be an important factor of consistency that will promote sharing and feedback.
- setting up a coordination mechanism between the territorial levels and the national level, by developing and leading a network of regional adaptation committees in mainland France and overseas as part of the development or revision of regional guidelines dealing with adaptation to climate change
- entities responsible under each thematic are clearly list

- The plan aims to be a flexible and evolutive plan based on iterative approach looking at local, national and international level.
- International level: strengthening France's leading role in international, community and regional cooperation bodies as well as the place of French communities, businesses and researchers, and confirming France's solidarity with the most vulnerable countries, particularly in terms of financing the fight against climate change, in line with axis 21 of the Climate Plan.
  - International Presence and influence
    - Following international best practices and frameworks for climate adaptation such as climate justice, SDGs, NBS (Action INT-1)
    - Financial support to the development of climate adaptation services that can be exported abroad (Action INT-2)
  - International Scientific contribution
    - Promotion of climate adaptation in European and International programme such as H2020, FP9, Belmont Forum, Future Earth, WCRP (Action INT-3)
    - Contribution of scientific governmental bodies and universities to key climate services and observatories at European (COPERNICUS) and Global (GFCS, GCOS) levels.
  - Development aid
  - International action of local French actors
  - Cross-border collaboration
    - Develop knowledge of impacts and vulnerability of border territories and strengthening of capacity for data collection and analysis (Action INT-10)
    - Harmonization between neighboring States in terms of strategies, climate plans, legislation and national and regional legal and technical regulations will be encouraged (Action INT-11)
  - EU Level
    - Strengthening of access and mobilisation of European Funds (Action INT-12)
    - Reinforcing climate adaption process at the EU level within communal policies (i.e. flood directives, common agriculture policy, biodiversity strategy, development aid) and coordination and harmonization of risk management approaches of European countries when relevant (i.e. sea level rise approach) – (Action INT-13)

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

- indemnity schemes for losses resulting from a climate disaster event (CatNat PPP scheme)

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

- Comprehensive plan taking an SBA to CRI as it looks at the various key sectors and how climate adaption actions are needed in these to ensure resilient infrastructures, economy, communities, and environment
- Focus in on prevention and preparedness
- Aspects relevant to response, recovery and rebuild are mostly regarding financing aspects (i.e. PPP for indemnity schemes)
- Technical approach: high emphasis on climate projections, nature-based solutions, research, innovation and cutting across different key sectors and areas
- Financial approach: applying a climate lens to inform and prioritize investment, seeking European Funds, investing in Research and Development and Education
- Policy and legal: adapting the current policies, regulations, standards to the current and projected climate risks, focus on land use planning
- Socioeconomic: climate justice, reducing vulnerability of key sectors, informing and involving communities and key actors
- Governance & institutional: clear roles and responsibilities of the relevant actors under the different themes, clear articulation of the different level to ensure a good multi-level governance of the

proposed plan, from high level to local level, flexibility and evolutive nature of the document. Importance of the potential collaboration at the European and International level to lift National climate adaptation efforts but also to export French know-how and best practices in the field of climate adaptation.

Synthesizer: Oana-Daniela Cristea (odc@ramboll.dk) Reference ID: 54

Title of document being synthesized and year it was published**: The City of Copenhagen Cloudburst Management Plan (2012)**
Author(s): **The city of Copenhagen - Technical and Environmental Administration**
Category of document: **SBA-CRI**
Geographic focus of the document: **Denmark**

Report Summary

Based on future weather projections and in accordance with the city's vison for safety and wellbeing, the Cloudburst Masterplan proposes an outline of solutions that can realistically be applied in a minimum timespan of 20 years and prevent extreme rainfall from causing damage to public and private assets.

Extreme rainfall events in August 2010 and July, August 2011 challenged the existing Adaptation Plan and brought forward the acknowledgement that the proposed Blue Green Infrastructure (BGI) needs to be complemented by grey infrastructure. The extreme rainfall in July 2011 had a statistical return period of over 1000 years, and more than 100 mm rainfall in an hour. The Cloudburst Masterplan proposes a series of combined measures where water can be retained by BGI and drained into the sea by large pipes when necessary.

The Cloudburst Management plan presents an analysis of flood-proofing needs in Copenhagen. Hydraulic calculations are used to divide the city into catchments that offer an overview of affected areas. This data is used to assess risk and determinate most vulnerable areas within the city which feeds into a **prioritization methodology** that allows decision-makers to establish the order of actions.

Roles and responsibilities are set by first amending existing legislation to allow utility companies to invest in climate adaptation solutions. Second, governance is structured between utility companies, public and private entities based on asset jurisdiction and functionality. The proposed outline aims at facilitating coordination between the different stakeholders involved in the city's maintenance and development.

Considering the magnitude of the Cloudburst Management Plan, **funding schemas** are proposed based on roles and responsibilities. As such, three methods of funding are proposed: private financing, funding by charge revenue and funding by taxes.

Finally, the document calls for a response plan to safe proof the city while the solutions are being applied. Furthermore, a permanent response strategy is encouraged as a safeguard against unforeseen events.

1. Preparedness

1.1 Summary

Copenhagen has a combined sewer systems for wastewater and rainwater, with the capacity to handle 10-year events. To address large rain events, the plan proposes a series of technical solutions focused primarily on **BGI** but completed with the acknowledgment that grey infrastructure is needed especially for discharge. In addition, governance structures and funding schemes are proposed to assure action is taken towards implementing the Cloudburst Management Master Plan.

1.2 Technical

1.2.1 Risk assessment

- Setting priority areas by analysing the hydrology, assessing risk, and establishing catchment areas used to identify highly vulnerable zones

1.2.2 Grey infrastructure

- Drain Stormwater to sea, lakes and suitable recipients via roads, canals, waterways and specifically dedicated stormwater tunnels
- Stormwater storage within areas with least possible damage or underground
- Establishment of storage buffer areas where water can be retained during extreme rain events
- Retaining water on road with high kerbstones
- Change the requirement to the existing combined sewage system from 1 combined sewer overflow per 10 years to:
  - One combined sewer overflow per 10 years,
  - Maximum level of stormwater on terrain on 10 cm of water stored on roads during extreme rain events with a statistical return period of 100 years (researched to be one of the least damaging solutions while maintain functionality)

1.2.3 Blue Green Infrastructure

- Implementing a BGI systems that outlines the correlation between green areas, canals, lakes, streams
- Establishing lakes
- Daylighting streams and canals

1.2.4 Combined measures

- In terms of the best socio-economic solution, it has been deemed, that a combined solution where the existing sewer is supplemented with surface based retention works best. For areas of the city where this is not enough during extreme stormwater events, it will be supplemented with high discharge solutions such as underground storm water tunnels.
- Supplement BGI with underground drainage systems
- Integrating stormwater solutions in green areas and thus complimenting rainwater storage solutions with recreational and socio-economical use
- A goal is to avoid increasing the size of the existing combined sewer network by removing rainwater into local solutions, thereby using the money for adding green solutions to the cityscape.

1.3 Policy & legal

1.3.1 Decision-making mechanisms

- **Use of data and hydraulic calculations**
  - To obtain an overview of benefits, a first level assessment is established by using the formula: **Flood damage x probability of recurrence = damage costs**
- **Ranking initiatives according to the following criteria:**
  - High risk areas
  - Areas where measures are easy to implement
  - Areas with ongoing urban development projects
  - Areas where synergetic effect can be gained
- **Catchment assessment feeding into the establishment of priority areas**
  - Risk
  - Implementation
  - Coherence with urban development

1.4 Socio-economic

1.5 Governance & Institutional

1.5.1 Amendments to existing legislation

- Establishing a more fluid finance scheme that addresses jurisdiction for funding and implementing cross-organization collaboration
- Allowing for utility companies to get involved in funding climate adaptation measures
- Establishing a clearly defined public- private partnership between the city of Copenhagen, utility companies and private owners
- Adding stormwater management concerns to the local planning around the city, as well as to newer urban development areas

1.5.2 Division of responsibility

- Property owners are responsible for flood proofing their property above ground level.
- Utility companies are responsible for assuring the drainage system capacity meets service level and implementing adaptive measures in accordance with the risk dimensioning.
- City Administration is responsible to coordinate with urban planning on climate adaptation and redirection of water courses.

1.5.3 Financing

- The proposed funding outline divides responsibility by area jurisdiction and private-public entities. As such, the following structure is proposed:
  - **Private financing** - private properties are responsible for flood proofing above ground level
  - **Financing by charge revenue** – Utility companies finance the majority of adaptive measures
  - **Financing by taxes** – Municipal tax cover the recreational parts of the surface-based stormwater management solutions

1.5.4 Warning systems

- Flood maps containing city-wide information on flood-prone areas are publicly available

2. Response

2.1. Summary

Based on technical research and vulnerability study, priority zones have been established, and since the implementation time of the total solution will be at least 20 years the plan advice the establishment of a permanent response plan to mitigate unforeseen events and extreme rain events throughout the implementation period.

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

NOTES:

- The City of Copenhagen Masterplan has been used to develop detailed master planning projects across Copenhagen and has been the main inspiration in developing the New York Cloudburst Adaptation Plan.
- Furthermore, the Cloudburst Management Plan is used as a tool of promoting climate adaptation solutions and therefore is bringing revenue to the city.
- Within the last 3-4 years The City of Copenhagen has updated their approach to cloudburst masterplanning, to a method that includes screening of existing recreational and architectonic value, as well as traffic and parking requirements. They are currently in the process of redoing existing masterplans for the entire city.

Synthesizer: Audrey Benoist (atob@ramboll.dk) Reference ID: 102

Title of document being synthesized and year it was published**: Australian Emergency Management Arrangement Handbook (2019)**
Author(s): **Australian Government, Department of Home Affairs**
Category of document: **SBA-SRI**
Geographic focus of the document: **Australia**

Report Summary

The Australian Emergency Management Arrangements Handbook (AIDR 2019) has been prepared to articulate the national arrangements for emergency management within Australia and its states and territories. The handbook establishes a set of principles that are intended to guide emergency management activities. It also describes the emergency management roles and responsibilities of all levels of government, non-government organisations (NGOs), businesses, communities and individuals. Arrangements and responsibilities for the comprehensive approach to emergency management - prevention, preparedness, response and recovery (PPRR) are discussed. These arrangements support emergency management in Australia through the concepts of an 'all hazards' approach and 'shared responsibility'. The purpose of the Arrangements is to provide a high-level, scalable overview of how Australia addresses the risks and impacts of hazards through a collaborative approach to the prevention of, preparedness for, response to and recovery from emergencies. The principles and structures herein also support Australians affected by emergencies overseas and allow the Australian government to assist foreign governments affected by emergencies. The Arrangements outline the collaboration necessary to address the nature and scale of different emergencies.

This handbook is intended to: (1) be the authoritative and trusted source of knowledge of the emergency management arrangements in Australia; (2) provide nationally agreed principles that underpin emergency management arrangements in Australia; (3) identify and promote the adoption of good practice in emergency management arrangements; (4) build interoperability between jurisdictions, agencies, (5) businesses, communities and individuals by the application of the principles and common language, and (6) align national disaster resilience strategies, frameworks and policy with emergency management arrangements by informing and assisting jurisdictions, agencies, businesses, communities and individuals in the implementation and adoption of these arrangements. The purpose of the handbook is not to specify the management of an emergency in response to a specific event or disaster. However, the underpinning principles provide a context for guiding the approach to these situations.

The Handbook is aimed at all types of emergencies, but it has a specific section on catastrophic disasters. These catastrophic events potentially leading to cascading events are to be handled applying the current emergency plans and arrangements. However, it is mentioned that these types of events will require more enhanced measures (higher strategic leadership and high-level coordination) to ensure the maximum good for the maximum number of people. It is therefore recommended to identify gaps in capabilities and capacities at every level to address these types of emergencies.

The document has the following chapters:
- Chapter 1: Legal and Administrative Framework
- Chapter 2: Prevention and Mitigation
- Chapter 3: Preparedness
- Chapter 4: Response
- Chapter 5: Recovery
- Chapter 6: Catastrophic Disaster

Other relevant climate change adaptation National Frameworks, Strategies, Guidelines dealing include:
- National Climate Resilience and Adaptation Strategy 2021 – 2025
- National Disaster Risk Reduction Framework, 2018

- Australian Disaster Preparedness Framework, A guideline to develop the capabilities required to manage severe to catastrophic disasters, October 2018
- Australian Government Crisis Management Framework, July 2021
- National research priorities for natural hazards emergency management, 2019
- Monitoring and Evaluation Framework for Disaster Recovery Program, May 2018

1. Preparedness

1.1. Summary

- A key principle of Australia's emergency management arrangements is the collaborative and effective emergency planning for all hazards. The existence of such plans allows all emergency managers and responders to understand the roles, responsibilities, capability and capacity of other organisations.
- Preparedness activities include developing, auditing and testing emergency management legislation, policy, plans and procedures.
- Preparedness plans should be amended as future risk changes.
- Planning, exercising and lessons management are key to continually improving preparedness and development of capability systems.
- Testing of procedures and systems is an indicator of a resilient community.

1.2. Technical

1.2.1. Examples of prevention and mitigation strategies

- hazard-specific control programs, such as building flood levees, bushfire mitigation programs, and installation of automatic sprinkler systems
- land use planning and building controls in legislation and regulations
- quarantine and border control measures
- public health strategies, such as vaccinations
- community education and awareness, for example flood and cyclone safety messaging
- hazardous material safety/security initiatives
- critical infrastructure protection
- crowded places health and safety/protection measures
- ensuring access to publicly available geologic and topographic mapping and earthquake and tsunami
- monitoring services
- implementing specific hazard and disaster risk research studies.

1.2.2. Example of preparedness activities

- developing household emergency plans and preparing emergency kits to last 72 hours
- developing tailored response and recovery plans
- critical infrastructure resilience planning and cooperation, across all levels of government and in partnership with the business sector
- public communication arrangements
- interoperability of systems across the country
- warning systems for the public, including the national telephone-based warning system, Emergency Alert
- stockpiling and distribution of essential items, such as generators and medicines
- education and training programs
- testing of procedures through exercise programs
- lessons management and continually improving preparedness systems.

1.3. Financial

- Australian government has a continuing role in providing financial assistance to state, territories and local government to assist in meeting their disaster mitigation responsibilities

- Families and individuals should have as much physical and financial self-reliance as possible preparing for potential disaster
- Insurance, which is essentially risk transfer, allows the economy to manage risk more effectively, reducing financial uncertainty in the event of an emergency and allowing for more efficient use of capital by individuals, business and government. Insurance can also play a role in encouraging mitigation to reduce losses from future emergencies. The price, or premium for, and availability of, insurance provide signals about the level of risk from a range of hazards and provide some encouragement for risk mitigation and therefore taking preventative action to reduce vulnerability to loss.
- Essential service providers and critical infrastructure owners and operators are ultimately responsible for determining and discharging their own legal obligations and managing risks to their operations that might have a financial impact on themselves and others

1.4. Policy & legal

1.4.1. National Strategy for Disaster Resilience, 2011

- Emphasis on prevention, mitigation, preparedness and capacity building
- Based on the principle of shared responsibility between key actors (see 2.6. governance)

1.4.2. Sendai Framework for Disaster Risk Reduction

- Management of disaster risks through prevention and risk reduction strategies
- Four Global Priorities: understanding disaster risk; strengthening disaster risk governance to manage disaster risk; investing in disaster risk reduction for resilience and enhancing disaster preparedness for effective response, and to 'Build Back Better' in recovery, rehabilitation and reconstruction.

1.4.3. National Disaster Risk Reduction Framework, 2018

- Endorsed by the Ministerial Council for Police and Emergency Management (MCPEM) on 28 June 2019
- Informed by the Sendai Framework
- Guide national, whole society effort to proactively reduce disaster risk to minimise loss and suffering caused by disasters

1.4.4. Standards and legislations

- In some hazard types, risk management planning may be determined by relevant standards and legislation. Examples include standards for crowded places, bushfire risk minimisation, flood mitigation and built environment standards.
- The building and construction industry has a role in promoting hazard awareness and hazard minimisation in the industry and a culture of compliance with building codes and standards.

1.5. Socio-economic

- The state and territory governments will work on strengthening partnerships with local governments, communities including remote and Aboriginal and Torres Strait Islander (Indigenous) communities, and encouraging and supporting them to undertake emergency risk assessments and carry out mitigation measures
- Communities are put as an important actor in preparedness to emergencies through promoting awareness of hazards risks and mitigation actions, volunteering activities, identifying community strengths and capacities to be used to support preparedness

1.6. Governance & Institutional

1.6.1. Governance structure for National Strategy for Disaster Resilience

Figure 1: Governance structure for the *National Strategy for Disaster Resilience* (COAG 2011)

The Ministerial Council for Police and Emergency Management focusses on the broad themes of law enforcement reform and emergency management and collaboration across these themes. It provides national leadership and governance on emergency management and disaster resilience policy. MCPEM comprises ministers for police and emergency management from the Australian Government, states and territories and New Zealand, and the President of the Australian Local Government Association. It is supported by a Senior Officials Group (SOG). The Australia-New Zealand Emergency Management Committee (ANZEMC) supports MCPEM and MCPEM SOG and works to influence and advocate for national policies and capabilities that reduce disaster risk, minimise the potential for harm and uphold public trust and confidence in emergency management matters. ANZEMC comprises senior representatives from the Australian, state and territory governments, the Australian Local Government Association and the New Zealand government. ANZEMC is co-chaired by the Department of Home Affairs and a rotating state/ territory representative. The Mitigation and Risk Subcommittee (MaRS) and the Community Outcomes and Recovery Sub-committee (CORS) are sub-committees of ANZEMC.

1.6.2. Clear roles and responsibilities of governments

- Local governments: building and promoting resilience to emergencies, undertake cost-effective measures, risk assessment in land use planning, represent community interests in emergency management, drills for emergencies, provide emergency risk information and warnings, ensuring appropriate local resources for emergency planning, provide services during emergencies, etc..
- State and territory governments: primary responsibility for protecting life, property and environment within their borders, other responsibility include:
  - risk assessment and assurance monitoring activities,
  - land use planning, infrastructure provision, building standards compliance,
  - aligning jurisdictional emergency arrangement to national frameworks,
  - strengthening partnerships with local government, communities (incl. indigenous communities) for emergency risk management
  - arrangement and plans for emergency preparedness
  - emergency awareness
- Australian Government
  - Build and promote resilience to emergency
  - Be a party to international and foreign country agreements and guideline on emergency preparedness
  - Build national capability with states and territories
  - National research for emergency management
  - Identify national priorities for emergency mitigation with relevant stakeholders
  - Support emergency risk assessment and mitigation measures with states, territories and local governments
  - Support public safety broadcasts
  - Public warning systems
  - Allocate resource from the Government
  - Provide key information (meteorological, hydrological, etc.)

1.6.3. Shared approach with clear responsibility for various actors as below

- Families and Individuals
- Communities
- Schools and school communities
- Emergency management volunteers
- Critical infrastructure owners and operators
- Business, industry, and primary producers
- Residential and small businesses
- Land use planners
- Design, building and construction industries
- Insurance industry
- Non-government Organisations (NGOs)
- Not-for-profit sector
- Natural resource management bodies
- Broadcasters and information dissemination mechanisms
- Scientists and researchers

2. Response

2.1. Summary

- Response is primarily about the protection of life, property and the environment.
- First response to an emergency is often the local community and emergency responders.
- States and territory governments are responsible for establishing response arrangements.
- A key feature of response is the provision of warnings and information to enable the community to act to protect themselves.
- Arrangements should include systems for incident management, unity of command and coordination.
- Response planning should adopt an 'all hazards' approach and be applied at incident, region, state or territory levels as needed
- Response may extend beyond borders and into foreign country borders.
- Planning for relief and recovery commences in parallel with the response phase.

2.2. Technical

2.2.1. Response actions

- risk assessment
- providing warning messages and public information in relation to changing risks or vulnerabilities
- evacuating people or communities
- providing medical support
- searching for, rescuing and re-uniting displaced or lost people and animals
- disaster victim retrieval and identification
- containing or neutralising the threat from a hazard (e.g. firefighting; hazardous materials containment; eradication campaign for pests/diseases)
- providing for animal/stock welfare
- situation reporting
- procuring and prioritising the application of key and specialist resources
- assessing damage
- incident cause investigation, and
- observations and insights to inform lessons management.

2.2.2. Relief services

- community information
- emergency shelter
- provision of food, water and sanitation
- household drinking water

- continuity of food supply
- psychosocial support
- disbursement of material aid (non-food material items)
- reconnecting family and friends
- primary first aid and health care
- emergency financial assistance and
- animal welfare.

2.3. Financial

- The Government support the states and territories through cost sharing arrangements to alleviate the financial burden associated with the provision of emergency relief services and activities
- Families and individuals should attain the highest degree of physical and financial self-reliance – before, during and after an emergency
- Essential service providers and critical infrastructure owners and operators are ultimately responsible for determining and discharging their own legal obligations and managing risks to their operations that might have a financial impact on themselves and others

2.4. Policy & legal

- All jurisdictions have their own emergency management legislation, structures, plans and procedures that can be used to respond to an impending or actual emergency. All jurisdictions have established groups of representatives from emergency services that coordinate all available resources at local, regional and jurisdictional levels.

2.5. Socio-economic

2.6. Governance & Institutional

2.6.1. Roles and responsibilities of governments

- Local governments: ensure an adequate local emergency response capability is in place (incl. resources for local volunteers), continue to provide services to municipality during emergencies
- State and territory government: ensure that arrangement for response is in place, maintain capability including equipped and trained career and volunteer emergency response personnel
- Australian government: support state or territories response when needed, manage cross-jurisdiction coordination of events when needed, financial support for response and recovery

2.6.2. Response arrangements

- Most often it is the community who are first at the scene and who are able to provide the first response. Notwithstanding this initial community response, personnel in the emergency services and other agencies at the local level are usually the first organised response to an emergency.
- Coordination and support at a regional level may be required to ensure the response is effective and tailored to the situation. The response may be progressively escalated, in a graduated and planned manner, from the local level to the region, state and national level as circumstances require. As the scale of impact and complexity of an emergency increases, intra-state/territory arrangements may be activated. Further escalation may activate inter-state/ territory arrangements for additional assistance.
- Arrangements are also in place for provision of assistance from the Australian government. Examples include the arrangements for assistance from the Australian Government Crisis Coordination Centre, Bureau of Meteorology, Geoscience Australia and the Australian Defence Force.

- National coordination will occur when assistance is requested by the state or territory, or if the crisis has the potential to affect, or has affected, multiple jurisdictions, the broader community or an Australian government area of responsibility, regardless of the level of emergency.

Table 2 summarises the features of emergencies of different intensity and impact. National coordination may occur in times of catastrophic disaster and when international assistance has been offered or received.

INTENSITY	IMPACT	RESPONSE
CATASTROPHIC	• A whole of government response is required • Normal decision-making may be degraded • Resource coordination may be overwhelmed • Crisis plans may be activated. Significant relief and recovery arrangements may be required. International assistance may be requested	• Impact may be greater than previous experience and modelling • More than one state/territory may be impacted • Severe disruption to community, economic wellbeing, social networks, infrastructure and environment • Impact may be across an extensive area and may continue for a very long time • The consequences of the impact may be felt across numerous sectors
MAJOR	• Multi-state/territory and multi-agency command, control and coordination arrangements are in place • Strategic resource coordination may be required • Specific hazard plans may need activation • Specialised assistance from other states and territories, from the Australian government, or internationally may be required	• Impact across a significant area • Significant population or population centres may be impacted • Impact over an extended period of time • The impact may have consequences beyond the area of the impact
MINOR	• Response by individual state/territory • Jurisdictional plans and arrangements sufficient • Jurisdictional recovery plans sufficient	• Local and minor impact • Short duration

INCREASING SIZE, INTENSITY AND COMPLEXITY

Table 2: Features of emergencies of increasing impact

Relief efforts may be coordinated at a regional or state level by the principal community or health services department within a state or the Australian Government.

3. Recovery

3.1. Summary

- Planning for recovery commences well before an emergency.
- Recovery includes working with responders to establish relief functions within and for the affected community.
- Recovery extends across built, social, environmental, and economic environments.
- Recovery should recognise the key leadership role of landowners, local community organisations and their leaders.
- Recovery is often protracted.
- Recovery agencies must be an integral part of emergency management arrangements.

3.2. Technical

- As an emergency is brought under control, the emphasis shifts from response to relief and recovery. This transition should be done in an integrated and concurrent manner.
- Recovery plans provide technical information such as: ongoing impact and needs assessments, reporting that monitors recovery progress and improves its effectiveness, public health aspects of recovery, approaches for providing continuing information to the affected population
- Recovery plans include the need to identify lessons then implement them, to improve systems and recovery operations in the future.

3.3. Financial

- The Government support the states and territories through cost sharing arrangements to alleviate the financial burden associated with the provision of emergency relief and recovery services and activities
- The insurance industry assists individuals, business and the community more broadly to recover financially from emergencies. Insurance provides financial protection in the event of loss through a process of aggregating premiums and spreading risk. All property owners – including home owners, occupiers and small businesses – are able to minimise the financial impact from emergencies by purchasing insurance.

3.4. Policy & legal

- The Australian government has a range of recovery coordination arrangements to support states and territories, communities and individuals during and after an emergency. These arrangements are documented in Community Recovery (AIDR 2018).

3.5. Socio-economic

- Recovery principles include using community led approach, communication in effective manner between the affected communities and other partners, recognising and building individual, community and organisational capacity
- Recovery plans include detailed arrangements for psychosocial support and counselling of affected communities

3.6. Governance & Institutional

3.6.1. Roles and responsibilities of governments

- Local governments: ensure an adequate local emergency recovery capability is in place (incl. resources for local volunteers), ensure appropriate local resources and arrangements are in place to provide emergency recovery services to communities
- State and territory government: ensure that arrangement for relief are in place, maintain capability including equipped and trained career and volunteer emergency recovery personnel, post-emergency assessment
- Australian government: where necessary provide direct assistance to affected communities

3.6.2. Response arrangements

- As with other emergency management arrangements, Australia has in place coordinated recovery arrangements across all levels of government. Recovery agencies are part of each state's and territory's emergency management committees to ensure continuity, consistency and coordination between response and recovery. This includes input from the community and NGOs.
- The arrangements in jurisdictions are documented in recovery plans, or as sub-plans of broader emergency management plans. Generally, these plans include governance and institutional elements such as:
  - arrangements for managing recovery activities at local, and state or territory levels, including the involvement of community leadership in recovery activities
  - detail arrangements for establishing and managing public appeals, donated goods, and emergent volunteers and agencies

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic
- Recovery plans usually identify the types of activities that rebuild communities, including economic activity and social cohesion, and clean and healthy environments

4.6. Governance & Institutional

Conclusions, Observations and Commentary

The Australian Emergency Management Arrangements Handbook provides a comprehensive approach to emergency management (including Prevention, Preparedness, Response and Recovery) with a strong focus on shared responsibilities and on getting clarity on the roles of the different actors impacted or having an impact prior, during and after a disaster event hits. It provides a good overview of the legal and administrative framework for disaster resilience planning. The multi-level governance approach to disaster management is clearly outlined and the key stakeholders' responsibilities are well defined.

Prevention and Preparedness have been presented combinedly in the Preparedness section of this synthesis. Technical actions under this component are listed, the policy and legal framework presented, and the governance and institutional arrangements are well defined. There is an important focus on developing strong partnerships at different levels and ensuring communities (including indigenous population) are part of the preparedness process.

The Response approach is also presented including response actions and relief services to be provided during emergencies, the financial aspects to be in place for a good response to emergencies, roles and responsibilities of the governmental actors, and arrangements in place at different levels.

The Recovery approach presents actions during early recovery and medium to long-term recovery as well as recovery arrangements across all levels of government including inputs from communities and NGOs.

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Title of document being synthesized and year it was published**: PREPARING FOR A CLIMATE RESILIENT SINGAPORE (2021)**
Author(s): **Elyssa Kaur Ludher, Kevin Fan Hsu, Norio Sim and team (Center for Livable Cities Singapore)**
Category of document: **SBA-CRI / Study Case**
Geographic focus of the document: **Singapore**

Report Summary

This report presents how the city of Singapore has evolved in terms of climate resilience building looking at its vulnerability and gradually developing new strategies. It is structured as follows:

- Chapter 1: Singapore and its vulnerability to Climate Change
- Chapter 2: Before 1990s: Establishing the foundation for environmentally conscious development
- Chapter 3: 1990s-2000s: Understanding Climate Change and its impact
- Chapter 4: 2007-19: Institutionalising efforts to respond to climate change
- Chapter 5: Building a climate resilience future

Singapore is following the Garden City vision established in 1967 shortly after gaining independence. What at first was an effort to sanitize and green Singapore has now evolved into a leading example of applied sustainability and resilience principles and actions.

Building upon decades of experience, Singapore developed an advanced governance structure that works across disciplines, monitors progress, enables innovation and research on sustainability and resilience and enables communities to act. Some of Singapore's commitments include clean environment, water safety and sanitation, climate change resiliency and resource independency all of which, and more, are addressed through different committees, acts, incentive schemes and international cooperation arrangements. All these commitments were addressed gradually throughout the last decades and have undergone several revisions to assure relevance.

The overarching framework has at heart three principles: High quality of life, competitive economy, and sustainable development; all of which are sustained by implementing Integrated Master Planning and development and Dynamic Urban Governance.

Integrated Master Planning is focused on maximizing efficiency within services by addressing the energy, water and building sectors. The main drivers behind the actions taken within these realms are carbon emission reduction, climate change safe proofing, flood protection, food security and ecology.

Dynamic governance in Singapore is built upon decades of experience in addressing climate related issues. Governance structures are constantly monitoring progress, revising relevance, and setting new and more ambitious goals at every turn. Actions are based on data gathering and analysis feeding into research and innovation.

An outstanding quality of Singapore's approach is the value attribute to research and scientific programs. Several international institutions have joined the climate research making Singapore a leading expert in Climate research.

The emerging pattern when looking at Singapore's evolution over time is identifying issues, researching data and best approaches, setting goals and continuously updating solutions and actions to adapt current climate challenges.

1. Preparedness

1.1. Summary

Singapore presents a complex system of governance and polices that break down into committees and further into system/industry specific actions and frameworks.

1.2. Technical

Active in developing sustainable solution for energy, building, water supply, climate resilience, carbon reduction, heat food security, public health. There is a series of technical documents approaching most of the up mentioned themes. For example, ABC Water Program which provides detailed technical solutions for Blue Green Infrastructure.

1.2.1. Climate adaptation

- Coastal Protection (against sea level rise), Water Resources (ensuring water resilience) and Drainage (holistic stormwater management and flood protection)
- Biodiversity and Greenery (i.e. nature-based solutions, restoration projects)
- Keeping buildings and infrastructures safe
- Building resilient network infrastructure
- Climate proofing the city against heat
- Public Health and Food Security

1.2.2. Scaling clime models to fit Singapore

- International cooperation between Singapore based scientists and international climate experts to assess climate impacts
- The initial study has improved local capacities and local teams have further reduced the resolution to 20km by 20 km and delivered climate change projections up to 2100 .
- Creation of a national climate model (SINGV) by the national Supercomputing Center.

1.2.3. Buildings

- Implementation of District cooling to effectively reduce carbon emissions
- Research on Green buildings
- Achieved first net 0 building

1.2.4. Transport

- Planning a high density, transit-oriented city

1.2.5. Water

- Creating water infrastructure to address potable demand, sanitation, and flooding
- Enhancing water resource management

1.2.6. Energy & Electricity

- Fuel-switch to Natural Gaz and improve electricity efficiency
- Energy efficiency within transport, building, industry, households, waste and water
- Adoption of advance low-carbon technologies

1.2.7. Waste management

- Pneumatic Waste Conveyance Systems (PWCSs)
- Mass burn incineration technology generating electricity

1.3. Financial

- Energy efficiency funds, financing and training grants incentivise the industry to increase efficiency and transition to better equipment.

- Prime Minister Lee stated that S$100 billion or more may be needed over 100 years to protect Singapore against rising sea levels caused by climate change. A new Coastal and Flood Protection Fund was announced in 2020 by the Deputy Prime Minister and Minister for Finance Heng Swee Keat. The fund will be topped up whenever the fiscal situation allows.

1.4. Policy & legal

Following an emission and climate change impact assessment, Singapore has taken several sector focused initiatives.

1.4.1. Policy framework

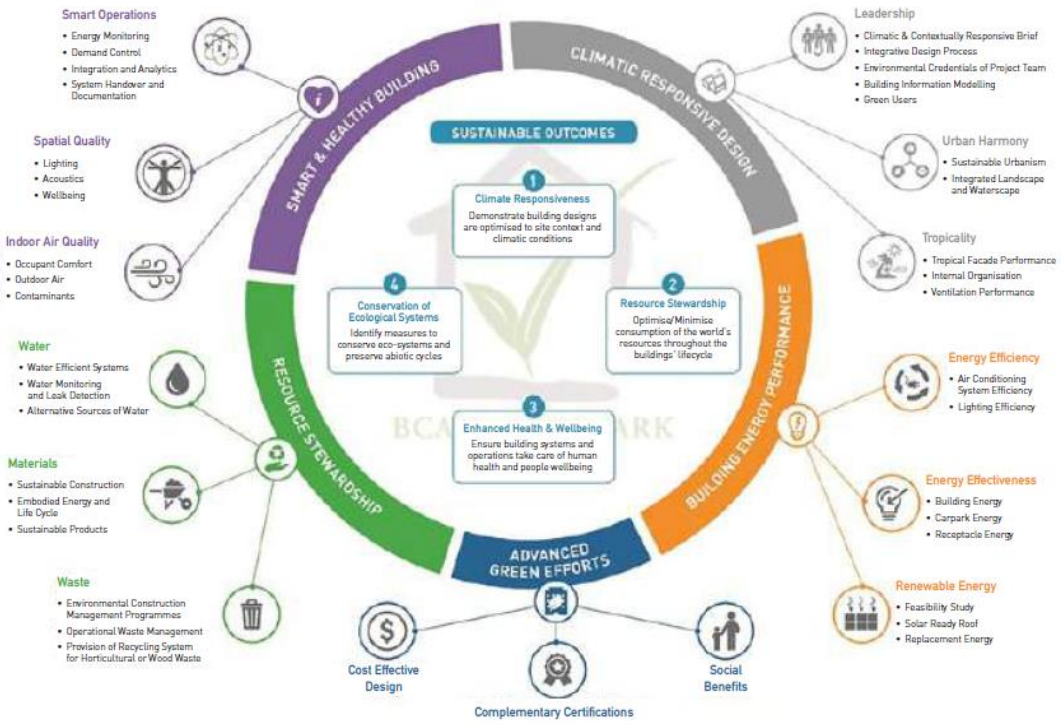
- Earth Summit and the United National Framework Convention on Climate Change
- Kyoto protocol
- Singapore Green Plan
- National Commitment to a sustainable environment
- Parliament declared greening a national policy
- Set up of the Center for Climate Research Singapore (CCRS) that focuses on tropical climate and with drives the efforts to produce the national Climate Science Research Masterplan.

1.4.2. Energy efficiency

- Development of 4 switches framework that will enable the city to mange carbon emissions and energy consumption by alternately using Natural Gas, Solar Power, Regional Power Grids and Low-Carbon Alternatives.
- Establishment of different multi-agency programs leading int innovation programs aiming at facilitating implementation of green energy by awarding grands, enabling materials and experience sharing
- Encourage solar energy
- Improve operations within power plants and gas supply
- Incentive schemes made available to support facilities to identify their energy gaps and adopt energy efficient solutions
- Industry focused Energy Efficiency national partnership – voluntary collaboration for companies through networking and knowledge sharing
- Energy conservation act - regulation on energy consumption in transport, households and industry
- Carbon tax
- Carbon pricing

1.4.3. Building Energy efficiency

- The Building and Construction Authority (BCA) created their own Green Mark Scheme. Buildings are assessed by the following criteria:
  - Climatic responsive design
  - Energy performance
  - Resource stewardship
  - Smart and healthy features
  - Advanced green efforts
- Green Building Masterplan: goal is to green 80% of Singapore's buildings.
- Green Mark Gross Floor Area (GM GFA) - incentive scheme to incentive private sector developer
- Green Mark Gross Floor Area for existing buildings - including retrofitting and undergo energy efficiency audits



The above picture presents the Green Mark Scheme which covers energy and resource efficiency, smart and healthy buildings, climatic responsible design and other green efforts.

1.5. Socio-economic

- Community involvement in resiliency planning
  - 2018 Year of Climate Action to invite communities and private sector as partner for climate action – collaboration of residents on localised solutions
  - Raising awareness and People's action
  - Community stewardship in nature conservation and integration of greenery into urban landscapes
  - Participatory planning and design process to address climate risk in neighbourhood
- Raising internal capacity for climate action
- whole-of-society effort—one that combines strategic government-led public policies and infrastructure investments as well as citizen-initiated community-owned programmes and initiatives.

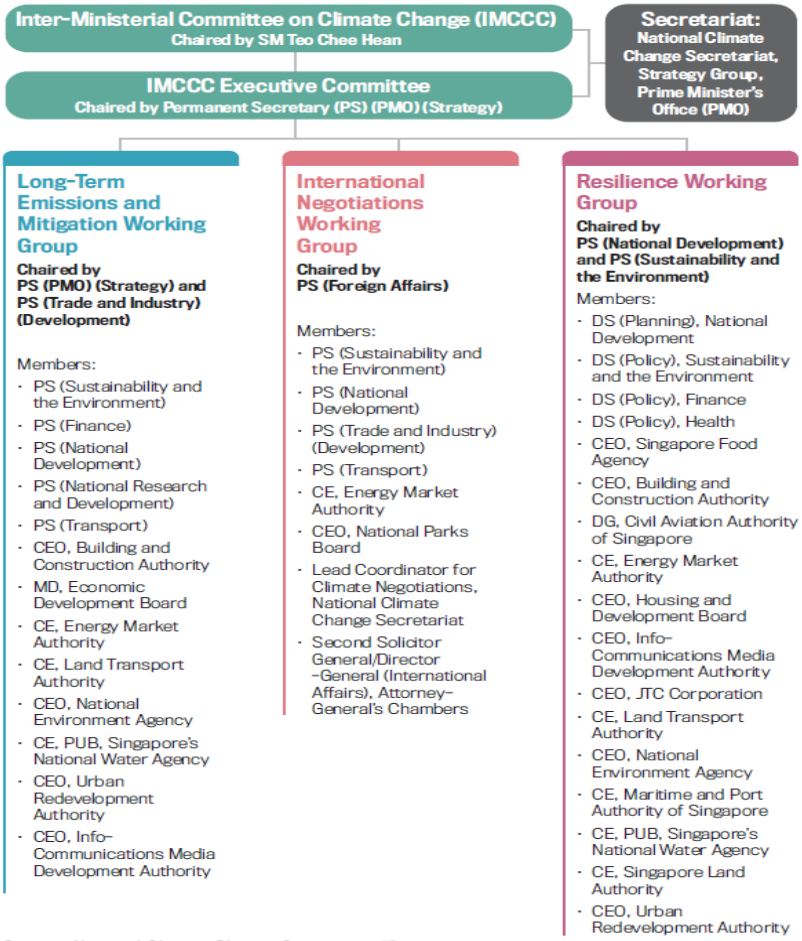
1.6. Governance & Institutional

1.6.1. Governmental structure

- Climate change action is overseen by the inter-ministerial committee on Climate Change (IMCCC) and IMCCC Executive Committee
- The two up mentioned committees are working with the National Climate Change Secretariat, Strategy Group and Prime Minister 's office
- The IMCC Executive Committee is supported by 3 working groups. (Long term emission and Mitigation Working group, International negotiation Working group, Resilience Working Group
- Park and trees committee established by public works department

- Working groups are joined by members working within diverse areas of expertise, secretariats, committees, authorities etc. to enable a truly cross disciplinary approach and to assure work on Climate change is followed up within their organization/ sector.

EXHIBIT 8
COMMITTEES, WORKING GROUPS AND MEMBERS UNDER THE IMCCC.



Source: National Climate Change Secretariat.[117]

1.6.2. Partnerships

- Innovating with the private sector (i.e. Green Building Council Public-Private-Partnership)
- 3P (Public, Private, People) partnership on green homes

1.6.3. Role at the international level

- Contribution to international climate conferences and negotiations
- Nationally Determined Contribution
- Promoting international collaboration to build capabilities and develop cross-border solutions (i.e. carbon markets, regional electricity grids)
- Regional engagement with Southeast Asian countries (Special ASEAN Ministerial Meeting on Climate Action (SAMCA)

2. Response

2.1. Summary

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

Following the timeline, progress within the different areas of action can be identified. Furthermore, continuous goal setting and structure improvement is underlined within the report.

The case of Singapore is interesting when looking at the potential in creating strong partnerships (at governmental level but also with the private sector and the communities) for climate change adaptation.

The framework for Resilience building looks at the interdependencies between key systems and aim to provide encompassing and innovative solutions to prepare against climate disasters.

The focus is on preparedness.

The importance of public health and ensuring resilience of the food supply is highlighted due to the specific context of Singapore.

There is a strong emphasis on the need to develop clear standards within the construction sector and incentivising the private sector to follow and lead best practices for building resilient infrastructures.

Synthesizer: Kevin KC Wong Reference ID: 86

Title of document being synthesized and year it was published**: Fort McMurray Wildfire: Learning from Canada's costliest disaster (2019)**
Author(s): **Institute for Catastrophic Loss Reduction**
Category of document: **Case Study**
Geographic focus of the document: **Canada**

Report Summary

The Zurich report on the 2016 Fort McMurrary Wildfire ("the 2016 Wildfire" or "the Wildfire"), written three years after the disaster, is a comprehensive review of all stages of the disaster. The 2016 Wildfire is one of the most significant wildfire events ever to occur in Canada. While there were shortcomings to some of the actions taken and decisions made by all levels of governments, organisations and individuals, it is believed that many lessons learnt in previous disasters were successfully applied in the management of the Wildfire and the subsequent community rebuild. Overall, the Fort McMurrary community was able to build back better by incorporating many principles and strategies of resilience into the rebuild process. As wildfire events occur more frequently across Canada, the 2016 Fort McMurray Wildfire offers many insights into actions, decisions and investments required to reduce damage and losses in a wildfire.

1. Preparedness

1.1. Summary

As wildfire becomes more frequent, long-lasting and severe across Canada, particularly in Western Canada, all levels of government, property and business owners and individuals must learn to live with fire. Prior to the 2016 Fort McMurrary Wildfire, some actions were taken to implement and promote FireSmart, Canada's wildfire resilience program. FireSmart risk mitigation strategies proved to be effective in protecting physical properties and assets. However, many homeowners and small business owners had little awareness of FireSmart or the threat of a wildfire, and ultimately lost their properties and assets in the Wildfire. It is recommended that the Province of Alberta and the Regional Municipality of Wood Buffalo ("Wood Buffalo") promote FireSmart strategies, fund related incentives and programs, and incorporate FireSmart measures into construction standards and development plans.

While Canada has an abundance of high-quality fire hazard data through federal and provincial forest agencies, there is a distinct lack of models or tools that provide insights into the likelihood or consequences of a wildfire. As a result, government agencies, business and property owners, as well as insurers could not properly understand the loss potential in the face of a wildfire. On top of that, fire behaviour modelling, which is typically deployed only when a wildfire is out of control, could have provided important information for preparations during the early parts of a wildfire season. It is recommended that the federal and provincial governments should invest in the development of a high-quality, up-to-date national wildfire risk model that incorporate the latest research and technology. Furthermore, provincial emergency or wildfire management agencies should provide regular and coordinated updates during wildfire season that include on the ground situation and a multi-day fire behaviour forecast.

1.2. Technical

- FireSmart risk mitigation guidelines were effective in mitigating risk under the Wildfire
    - Homes exhibited 'Low' to 'Moderate' overall hazard ratings were more likely to survive
    - Wind-driven embers were the most common source for early home ignitions
        - Once one structure begins to burn, fire spreads rapidly and quickly becomes uncontrollable
- Recommendation: Examine and affirm FireSmart recommendations through field studies
- Prior to the wildfire, many property owners did not understand the risks and loss potential of wildfire, and did not implement FireSmart on their properties, while the oil sands companies did so and implemented actions to protect assets from fire risks

- Installation of a pressurised water supply for fire suppression was important for wildfire protection
- Recommendation: Vegetation management on private property would reduce fire hazard
    - Zone 1 (Within 10 metres of home)
        - Should be free of all material that can easily ignite
        - Use: A green lawn, a wide range of plants with moist supple leaves, deciduous trees, and gravel and decorative crushed rock
        - Evergreen trees and shrubs, wood chips and bark mulch
        - Debris and burnable elements, such as dry twigs, branches and leaves should be regularly removed
        - Firewood should be stacked far away from a home
        - Burn barrels and fire pits should be located far away from any structures
    - Zone 2 (10 to 30 metre of home)
        - Trees should be spaced at least three metre apart
        - Deciduous trees are harder to ignite, but evergreen trees can remain if regularly trimmed and pruned
        - All branches and debris from the ground should be regularly removed
    - Zone 3 (30 to 100 metre of home)
        - A homeowner would have greater protection if they also maintain the lands further from the home
        - Increased spacing between trees, trimming lower branches and removal of debris
- Abundance of high-quality fire hazard data via Canada's forest agencies
    - For example, Canadian Wildland Fire Information System, Canada's Fire Danger Rating System, and Canadian Large Fire Database
- Lack of models/tools to understand the likelihood or consequences of fire
    - Governments at all levels, business and property owners and insurers have little insights into the consequences of fire in any given community and potential losses
    - Recommendation: Canada must develop a high-quality, up-to-date wildfire risk models that utilize the latest understanding of the hazard and the current technology
        - Similar to the recently launched RMS wildfire model for the U.S.
        - The model must consider ember transport
- Recommendation: Regular and active multi-day fire behaviour modelling during wildfire season
    - Planning Section, Alberta Wildfire Coordination Centre, be operational March 1 annually, to provide daily fire behaviour and wildfire occurrence predictions, multi-day fire behaviour forecasts and to coordinate situation updates
    - Opportunities to make provincial fire weather forecasts more informative and definitive
        - Provision of forecast products for five days and longer
        - Bringing together observations from Environment Canada weather and other stations
- Highway 63, the only highway for Fort McMurray, was expanded to four lanes for its full length just prior to the fire, which was vital for fire control and evacuation
- A second major road connection for Fort McMurray would increase capacity to cope with future fires as well as evacuate
- Design and maintenance of roads within the Regional Municipality of Wood Buffalo before the fire were deemed generally adequate to support firefighters
    - Local roads were of a sufficient width to carry fire apparatus and provide room to turn-around, including all-weather loops on dead-end roads
    - Wood Buffalo has been considering alternative egress routes for several smaller communities that have only one access route in and out

1.3. Financial

- After the disaster, the Government of Alberta tripled funding for FireSmart activities and provided grants to support research and innovation on related wildfire prevention and management
    - Recommendation: The Government of Alberta and Wood Buffalo should provide sustained and long-term investments into wildfire risk loss reduction
        - consider introducing financial incentives, perhaps including tax reductions, for property owners that implement FireSmart®.
    - Recommendation: All levels of government should fund research to develop a national wildfire risk model and better understand how to make structures and communities more resistant to wildfires
- A second major road connection for Fort McMurray has been identified, but not yet funded
    - Recommendation: The Government of Alberta should move forward with plans of the East Clearwater Highway
- The major energy companies operating near Fort McMurray made extensive investments following FireSmart guideline prior to the wildfire, which prevented physical damages

1.4. Policy & legal

- Vegetation management measure helped control the fire despite extraordinary conditions
    - FireSmart® vegetation management plan commissioned by Wood Buffalo and Alberta Forestry resulted in effective measures implemented prior to the fire
        - Fuel buffers at the margin of neighbourhoods investigated were effective in reducing home ignitions
    - The 2017 Wildfire Management Strategy provides vegetation management advice
        - Post-fire green islands in Fort McMurray require active fuel reduction and maintenance
        - Burnt trees within 100 metres of developed areas should be harvested immediately, as they will be more difficult and expensive to remove when they blow down and become overgrown
        - Effective fuel breaks between the hazardous wildland forests and interface structures
    - Recommendation: Flammable evergreens close to structures should be removed, wood chips and bark mulch should not be used in municipal parks and warned about wood fences adjacent to some parks.
- Majority of Alberta fires have human causes
    - Recommendations: Increased public awareness about fire prevention and risk mitigation by aggressively promoting all aspects of the FireSmart program
    - Recommendations: Increased use of fire bans and enforcement of transgressions
- Recommendation: Recommit to the Canadian Wildland Fire Strategy
- Recommendation: Actions should be taken to strength resilience in the face of not only wildfires, but also other hazards such as flood, severe wind and winter storm
- Recommendation: FireSmart requirements should be added for new developments
- Recommendation: The Municipal Development Plan should
    - Establish a minimum of two access routes, where feasible, in rural communities and urban neighborhoods
    - Promote FireSmart® communities designed in accordance with best practices
    - Ensure that wildfire is a primary consideration in land use decisions
    - Provide fire mitigation information to residents
- Recommendation: Area Structure Plans recognizing wildfire as a development hazard and incorporating recommendations from FireSmart® – Protecting Your Community from Wildfire
- Recommendation: Land use bylaw requiring that campground design and maintenance shall comply with wildland-urban interface recommendations in the FireSmart® manual
- Recommendation: Engineering Services Standards and Development Procedures should

  - Require wildfire risk assessments for all proposed developments adjacent to moderate, high or extreme hazard areas
  - Require access in conformance with National Fire Protection Association standard 1141
  - Require fire-hydrants for all urban developments and rural developments with piped water distribution system and fire pumps driven by diesel engines or electric motors with standby diesel generators
  - Require power to be underground for all urban and rural hamlet applications
  - Require all vegetation within 100 metres of a development to be treated in accordance with the wildfire risk assessment and/or FireSmart® recommended guidelines.
- Recommendation: Development in zones of high risk should be prohibited or protected.
- Recommendation: Wood Buffalo should
  - Include more comprehensive actions to address all aspects of the FireSmart recommendations
  - Adopt recommendations set out in the Wildfire Mitigation Strategy
    - including the proposal to revise its statutory planning documents to formally set out community expectations for new construction
  - Proposed specific tools for implementation of FireSmart® requirements for development in the Municipal Development Plan, Area Structure Plans, land use bylaw and local building codes
  - Approved for use as a guiding document for the community in 2018
- Recommendation: Fire-resistant structural elements recommended by FireSmart should be included in municipal zoning bylaws, until a national wildfire code is developed
  - Roofing: Should have asphalt or metal roofing resistant to fire, rather than unrated wood-shake rooting that also presents threat to ember ignition
  - Eaves, vents and soffits: Use modern construction practices to eliminate opening and prevent debris accumulation, which improves energy efficiency and prevents embers from penetrating homes
  - Siding: Fibre-cement, stucco, aluminium and brick siding are identified as fire resistant by FireSmart®, rather than vinyl or wood siding
  - Decks: Should use fire-resistant or non-combustible materials surrounding and underneath depending on their distance from buildings and area wildfire hazard class
  - Fences & Walkways: Should be built to not create a path to bring fire into homes, by using metal fencing and not using wood chip walkways
  - Windows: Tempered, thermal windows radiant heat from an advancing wildfire
  - Doors: Entry and garage doors should be fire rated
  - Sheds and other builds: Should be fire resistant like homes
- The Government of Alberta should:
  - Establish a wildland-urban interface wildfire code for the development and construction of new buildings

1.5. Socio-economic

1.6. Governance & Institutional

- Recommendation: All levels of government should
  - Improve public emergency awareness and preparedness
  - Recommit (or implement if yet to) to the Canadian Wildland Fire Strategy
  - Enhance commitment to FireSmart
  - Enhance horizontal collaboration and integration (view wildfire as integrated forestry, public safety, climate change and First Nation community issues)
  - Increase investment in innovation and wildfire research & modelling
  - Enhance prevention and mitigation capability
  - Increase preparedness capacity
- Recommendation: The province should
  - Continue investment in emergency management programs

  - Review the legislative framework for emergency management and develop a disaster resiliency strategy
  - Clarify and document processes for legislative delegation of authority in the Alberta Emergency Plan
  - Develop a Provincial Emergency Evacuation Framework and model to provide enhanced decision-making capabilities at the provincial level
  - Enhance internal communication and key stakeholder interoperability and technology
  - Develop a state-of-the-art Provincial Operations Centre
  - Establish a Wildland Fire Resilience Advisory Committee that bring together stakeholders from various background to anticipate and prevent future wildfires
- Need for collaboration among land managers, government agencies, local governments and across Canadian wildland fire jurisdiction
  - Increased focus on shared information and information systems, collaborative decision-making and decision-making tools and evidence-based analysis of strategic solutions

2. Response

2.1. Summary

Despite the extraordinary weather conditions and unprecedented scale of the Wildfire, several ex-post evaluations found that the response of the Wildfire was relatively well managed and organised. Lessons from previous disasters were successfully applied. Roles, responsibility and accountability of critical stakeholders were clearly defined and distributed among all levels of governments and other organisations. Alberta's pre-existing emergency management strategies and resources provided an important foundation for sustained response. Nevertheless, there is room for improvement on issues such as timelier and more integrated sharing of information, more integrated commanding and decision-making structure and agreement on measures to mitigate the fire. Courageous efforts of the firefighters and many others involved were critical to reduce the damage and loss from the fire.

The Government of Alberta applied Fire Behaviour Analysis and Modelling which provided accurate predictions of the Wildfire's behaviour. However, this approach was only employed once fire was out of control. It is recommended that Fire Behaviour Analysis to be carried out for pre-suppression preparedness planning for both immediate and short-term (five-day) fire behaviour forecast.

The Red Cross's involvement during evacuation of the community is also noteworthy. The non-profit organisation was able to work with a variety of stakeholders, raise significant funds for the Wildfire, and facilitate reunion or temporary accommodation of evacuees.

2.2. Technical

- Damage from the fire would have been much more extensive but for the courageous efforts of firefighters and many others involved in the response
- Concurrent fires delayed response
  - The initial Horse River/Fort McMurrary Wildfire was reported while another fire was burning
  - The "other" fire (MMD-004) was given priority due to its closer proximity to Fort McMurrary urban centre
  - MMD-004 was successfully suppressed without structural damages, but delayed suppression of the Horse River fire
- Fire Behaviour Models/Analysis
  - Support real-time decision making of fire responses
  - The Government of Alberta used a well developed, high-resolution Fire Behaviour Model
    - Provided accurate prediction of the wildfire's behaviour
  - Fire behaviour specialists/models were deployed once fire was out of control

        - Recommendation: Consider model/analysis applications for pre-suppression preparedness decisions and planning
    - Models were predominantly used for daily planning and tactical decisions
        - Recommendation: Consider a daily five-day fire behaviour forecast and briefing
    - Recommendation: Information available during a fire needs to be better integrated
        - Fire behaviour analysis
        - Weather information
        - Current fire condition
- Wood Buffalo turned down offers from Alberta Emergency Management in the early stages of the fire, and requested them later in the response
    - Recommendation: Wildfire response planning should include a clear strategy about the use of sprinklers
        - Rapid deployment of sprinklers can effectively reduce damages to buildings

2.3. Financial

- Funds raised by the Red Cross for the Wildfire likely exceed the combined disaster relief funds raised by Red Cross from all other disasters in Canada over the past 100 years.
- Some insurance funds were paid while the community was under evacuation to support the immediate needs

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

- Several evaluations conducted after the fire found that the roles, responsibility and accountability of critical stakeholders – local, provincial, federal, industry, non-governmental agencies – were clearly understood and acted upon during the Wildfire
    - Alberta's Emergency Management Framework, the Alberta Emergency Plan and other provincial resources provided an important foundation for sustained response
    - Lessons learnt from previous disaster: Relatively quick evacuation
- Timely sharing of critical information to support better decisions is an emerging challenge for disaster management
- Recommendation: The Government of Alberta should
    - Mandate local authorities to implement and enhance use the Incident Command System and integrate across the agencies and services involved, to ensure that the Regional Emergency Operations Centre and emergency management partners have a unified command.
        - Improve airspace management when there are multiple aircrafts
    - Empower the Office of the Fire Commissioner to coordinate and deploy municipal firefighters.
    - Continue to support local authorities with the completeness and comprehensiveness of incident response and evacuation protocols
    - Enhance the use of technology and analytics in emergency management processes; and further operationalize the delivery of emergency social supports
- Red Cross's involvement in the evacuation was significant
    - Individuals and families in evacuation registered with Red Cross to facilitate reunion
    - Supports were put in place to provide shelter, food, necessities and information
    - Red Cross worked in close co-operation with local governments, the province, disaster response organizations, insurance companies and other stakeholders

3. Recovery

3.1. Summary

Recovery of the community of Fort McMurrary after the Wildfire was mostly administered and managed by the Regional Municipality of Wood Buffalo. Early in the recovery process, Wood Buffalo established clear objectives with a commitment to resilience and clarified responsibilities for recovery. The recovery of Wood Buffalo was also benefited by direct communications between the recovery team and elected officials, and by frequent and detailed communications between Wood Buffalo and the general public. These efforts culminated into an effective recovery process. While Wood Buffalo was able to leverage experiences of consultants and experts to guide the recovery process, it is recommended that Wood Buffalo develops a post-disaster recovery plan in preparation for future events.

The Red Cross was able to expand its role from evacuation into recovery with sizeable funds raised for the Wildfire. It provided direct financial assistance to individuals and small businesses and established programs that promote a more resilient recovery.

3.2. Technical

3.3. Financial

- Early adoption of the findings that strengthen resilience to wildfire damage allowed Wood Buffalo to access funding from a variety of sources to better protect the community
- Funds raised by the Red Cross for the Wildfire likely exceed the combined disaster relief funds raised by Red Cross from all other disasters in Canada over the past 100 years
    - Most of these funds were given in direct financial assistance to individuals and families
    - Remaining were provided to support community groups and small businesses
- Prior to the 2016 wildfire, the Red Cross did not have sufficient funds in disaster risk management to be active in recovery. Funds raised for the Wildfire allowed the Red Cross to aid in recovery

3.4. Policy & legal

- Experience from large disaster events shows that the strongest support to “build back better” (with increased resilience) is during the first 12 to 18 months after a major loss
- Commitment to FireSmart was an important success in the recovery and rebuild
    - Wood Buffalo commissioned an update of their wildfire strategy following the fire consistent with FireSmart
- Wood Buffalo’s Municipal Emergency Management Plan lacks a recovery plan
    - Decisions about governance, sources of funds to support recovery, performance indicators and other issues could have been informed by planning
    - Wood Buffalo instead engaged with experienced consultants to lead recovery

3.5. Socio-economic

3.6. Governance & Institutional

- Alberta’s Emergency Management Framework, the Alberta Emergency Plan and other provincial resources provided an important foundation for sustained response
    - Lessons learnt from previous disasters were successfully integrated
        - Actions to enable earlier re-entry and recovery
        - Communication to residents
        - Rapid damage assessments
        - Major donations from across Canada
    - Recommendation: The province should develop recovery plans for resiliency
- The Wood Buffalo Recovery Task Force was an important initiative contributing to building enhanced resilience in Fort McMurray during recovery
    - An early and sustained commitment to recovery
    - Development of a high-level Wildfire Recovery Campaign Plan

        - Identifies five action areas – people, environment, economy, rebuild and mitigate
        - Includes specific objectives and performance indicators
        - Establishes clear expectations and communicates that transition to the recovery was under way
        - Acknowledges that a full recovery would take time
        - Moves beyond the goal of a speedy recovery to focus on achieving a stronger and more resilient community
- Wood Buffalo clarified leadership for the recovery and rebuilding effort early in the process
    - On June 23, 2016, Wood Buffalo passed a bylaw to clarify that the mayor and council had lead responsibility and accountability for managing the recovery
    - A recovery committee was established to advise the mayor and council
    - A recovery team leader was hired to manage the process and reported directly to the mayor and council, which was found to be appropriate
        - An expert in leading wildfire management was hired for this role
    - The Chief Administrative Officer was responsible for running Wood Buffalo and the Recovery Team Lead for managing the rebuilding and reconstruction
- Frequent and detailed communication was important to the recovery for Wood Buffalo
    - Alleviated public and political pressure to rebuild quickly, which would hinder efforts to increase resilience and reduce risk
    - Communication helped to manage expectations about the time needed to fully clear away debris, remediate polluted soils, secure building permits and authority, inspect construction and other critical actions to ensure that new buildings comply with current regulations and owner expectations
    - Included a deliberate and thoughtful process to provide regular updates and community outreach with specific performance measures and active listening to identify evolving information needs
- With the funds raised for the wildfire, Red Cross expanded its role from evacuation into recovery:
    - Championed initiatives like FireSmart®
    - Provided financial assistance to uninsured small businesses and homeowners
    - Established a new position of Director, Disaster Risk Reduction

4. Rebuild

4.1. Summary

During the rebuild process, Wood Buffalo and the Government of Alberta showed a commitment to enhanced resilience by incorporating FireSmart into many aspects of the reconstruction. However, they should also consider protecting the community from other natural disasters, such as flooding and urban fire. Wood Buffalo also chose to rebuild some homes in the floodplain with defensive infrastructure rather than prohibiting reconstructive in the floodplain, a decision that would cost the community $300 million.

Insurance was an instrumental tool for most homeowners and business owners to rebuild their property and recover the losses. Most homeowners and business owners had “replacement cost insurance”, which allowed old and vulnerable structures be replaced by structures that are up to current codes. Nevertheless, some people, especially renters and small business owners, did not have insurance at all and were offered financial support by the Red Cross. Considering the importance of insurance in post-disaster rebuild, it is recommended that all levels of government promote the use of insurance, especially among groups that typically do not purchase insurance for their properties and assets.

It is also recommended that the Government of Alberta and Wood Buffalo establish partnerships local builders, insurance companies and other stakeholders to advance a more resilient recover and rebuild.

4.2. Technical

- Adjust forest management to increase carbon sinks and reduce greenhouse gas emissions, such as by improving regeneration of forests after natural disturbances, insect infestations and fire
- Temporary breaks established during the fire will soon grow back, but could be further widened, maintained and developed to provide added long lasting protection
- Some homes will not be rebuilt due to public safety concerns
    - 33 homeowners in the Waterways community were cautioned against rebuilding because of slope instability due, in part, to loss of forest cover and the risk of landslide triggered by intense rainfall
        - Many in the community are also at risk from flooding

4.3. Financial

- The decision to rebuild neighbourhoods in the floodplain instead of prohibiting reconstructing in the floodplain would cost the community $300 million
- Recommendation: The Government of Alberta and Wood Buffalo should invest in widening and maintaining temporary firebreaks constructed when fighting the fire

4.4. Policy & legal

- Commitment to FireSmart was an important success in the recovery and rebuild
- The recover/rebuild process included review options to enhance resilience from the risk of loss due to wildfire and other hazards including flood
- In the rebuild process, Wood Buffalo chose to rebuild neighbourhoods that are in the current floodplain with defensive infrastructure rather than prohibiting reconstruction in the floodplain
- Recommendation: Wood Buffalo and the Government of Alberta should study how homeowners, tenants and small businesses use insurance and promote the purchase of insurance to ensure the capacity to recover from future wildfire, flooding, urban fire, and other hazards

4.5. Socio-economic

- Some homeowners, renters and small business were more likely to be uninsured and experienced great hardship, requiring financial aid from the Red Cross.

4.6. Governance & Institutional

- Insurance plays a crucial role in rebuilding new and more resilient homes
    - Prior to the wildfire, most homeowners and businesses in Fort McMurray purchase insurance, and most buy replacement cost insurance
    - Replacement cost insurance supported ‘new for old’: Old and more vulnerable homes damaged or destroyed by fire were replaced by homes built following current design and construction practices, and were therefore more fire resistant
    - Insurance payout was also offered for other losses including spoiled food, replacement refrigerators, vehicle damage and repairs, and business and commercial losses.
    - Some homeowners, renters and small business were uninsured and experienced great hardship.
        - The Canadian Red Cross provided relief for some of those affected
        - Previous extreme events show that many small businesses and renters did not purchase insurance
- Recommendation: Wood Buffalo and the Government of Alberta should also establish a mechanism to partner with local builders, insurance companies and other stakeholders to champion resilience in recovery by investing in risk prevention and reduction measures

Conclusions, Observations and Commentary

Despite the scale of the disaster, the Government of Alberta and Wood Buffalo managed reasonably successful response and recovery processes for the Fort McMurray community. The Alberta and Wood Buffalo governments were receptive to lessons learnt from previous disasters and relatively quick to adapt recommendations into future disaster planning and response. As large-scale natural disaster becomes more frequent and catastrophic, adaptive and responsive governing and decision-making are important to minimise losses and damage. Future wildfire response could benefit from enhanced coordination between various emergency management organisation and wildfire monitoring agencies.

Individual households and business owners play a crucial role in preventing wildfire and minimising damage and losses in the event of a spreading wildfire. Nevertheless, all levels of government could and should influence individual decision-making through a combination of regulations, incentives and public messaging. Government agencies could aggressively promote and provide sustainable funding for FireSmart programs and create tools that allow all stakeholders to better understand the risks and hazards of a wildfire event. They could provide rebates for homeowners who upgrade their house to be more fire resistant. They could inform the public, especially renters, low-income households and small businesses, about the importance of home insurance. Sustained and comprehensive government interventions are necessary to drastically reduce the impact of future wildfires in communities.

Lastly, as emphasis in the report, build back better requires a thorough evaluation of all potential hazards in the community during the recovery and rebuild process, and not solely focusing on the previous disaster event.

Synthesizer: Aysia Stante (aysia.stante@ibigroup.com) Reference ID: 87

Title of document being synthesized and year it was published**: Case Study of the 2013 Southern Alberta Floods (2014)**
Author(s): **Expert Management Panel on River Flood Mitigation; The Conference Board of Canada**
Category of document: **Case Study**
Geographic focus of the document: **Alberta**

Report Summary

In 2013, over 30 communities in Southern Alberta were subject to a State of Emergency in one of the worst flooding events in the province's history, and one of the largest natural disasters in Canadian history. The estimated total cost of recovery was enormous, at over $5 billion, and five lives were lost in an evacuation of over 100,000 people.

In Calgary alone, the 2013 flood was the costliest disaster in the city's history with an estimated cost to rebuild of $530 million. Although one life was lost, contrary to many large-scale disasters, there was no major loss of life, no looting or civil disturbances, and no deliberate spreading of misinformation.
In the wake of the floods, the City of Calgary, through the Calgary Emergency Management Agency (CEMA) as well as the Alberta Emergency Management Agency (AEMA) and the Government of Alberta both hired independent agencies to conduct post-event reviews to see what went right and what went wrong. The City of Calgary also established the Expert Management Panel on River Flood Mitigation - an independent body to investigate managing flood risk; watershed management; event forecasting; storage, diversion, and protection; infrastructure and property resiliency; and changing climate (Expert Management Panel on River Flood Mitigation, 2014).

During response and recovery, volunteers were one of the most valued resources available to help evacuate people from their homes, communicate essential information, organize resources, clean up after the flood, and provide necessary resources to evacuees.

Post-event analysis and jurisdictional reviews of the 2013 flood showed that Alberta was aligned with, and in some cases ahead of global best practices for emergency response and recovery.

1. Preparedness

1.1. Summary

Of all the municipalities affected in the 2013 floods, the city of Calgary in particular bounced back remarkably quickly after having learned lessons from flooding in 2005, having invested in emergency preparedness, and making good use of social media and news outlets to provide a unified message to the public. Similarly, after fires in Slave Lake in 2011, measurable improvements were made to the province of Alberta's response capability.

The existing storage on the Bow and Elbow Rivers was used to buffer the 2013 flood and the flood would have been much more severe in Calgary had it not been for these reservoirs.

1.2. Technical

The Alberta and Calgary Emergency Management Agencies (AEMA and CEMA respectively) receive ongoing training and the CEMA Emergency Operations Centre (EOC) is continually upgraded to be ready for any emergency. The Calgary EOC itself is updated with new technology as it becomes available, and the people that work there are given continuous training. Prior to major flooding in 2005, the CEMA EOC was primarily staffed by firefighters who would not have been able to respond appropriately to the 2013 flood.

Partially a technical solution, partially policy, and partially institutional, a new Emergency Operations Centre was built in late 2012 that co-locates City of Calgary IT infrastructure, the emergency call back-up system, and a modern media centre, in addition to being able to host all relevant stakeholders in an emergency, along with a significant media presence under the same roof.

As of the time of the 2013 floods, the Provincial EOC and the supporting software was found to be inadequate to handle an emergency of that magnitude. Recommendations were made to acquire new software and systems that could assist with situational awareness, coordinating efforts and resources, and reporting.

Dams and reservoirs that existed on the Bow and Elbow watersheds at the time had limited flood reduction potential and are used to balance several watershed objectives such as drought management and drinking water storage. These multi-purpose reservoirs were pushed to their limit in 2013 and were used to buffer the damage caused to Calgary and downstream municipalities in 2013.

1.3. Financial

1.4. Policy & legal

1.5. Socio-economic

CEMA, in conjunction with other municipal and provincial organizations, has developed a free online course on emergency preparedness, response, and recovery. *Ready Calgary* is a free course for families and individuals to help them better prepare for future disasters such as floods and fires.

1.6. Governance & Institutional

The Calgary EOC has been set up to function as a multi-agency coordinating body, providing training for over 300 member agencies, to enable the streamlining of decisions and coordination of responses in case of an emergency. It enables decision-makers to create a common operating picture, ensure resources are allocated effectively, and send out consistent messaging to the public and other stakeholders.

2. Response

2.1. Summary

Reviews of both the City of Calgary's response and the Alberta-wide response found the same thing: that the efforts of all involved were most effective when guided, informed, and supported by established frameworks, structures, and plans.

The strong capacity of CEMA's EOC enabled it to coordinate the response and communications across all municipal departments. Additionally, the use of a pre-established, standardized incident management approach, ensured that people, resources, and facilities were incorporated into the response in an organized manner. The Government of Alberta and the rest of the province also have extensive emergency management skills that ensured that the appropriate frameworks and plans were in place for an emergency response.

The City of Calgary, as well as CEMA, used social media in both their response to the flood and in the recovery effort to communicate to and reassure the public, lead the conversation, and explain their decision-making process.

One recommendation received in the aftermath of the review was that some breakdowns in communication occurred where technology and training were lacking, or where everyday roles had to be set aside to take on emergency response roles. Additionally, while many external partners that were

invited into the Calgary EOC were impressed with the level of situational awareness while in the Calgary EOC, many of them noted that after they left the building, they heard nothing about the situation.

Stakeholders may need different information than the public at large, and so these stakeholders may not have received the information they needed.

2.2. Technical

CEMA's EOC was equipped with updated technology, including GIS maps that could deliver an overview of the situation on large display screens so that everyone could simultaneously be kept aware of the situation.

There were some failures with the technology early on, but staff were able to adapt quickly. Some issues arose where stakeholders, such as first responders, did not have the same technological capabilities and training as staff at the Calgary EOC, leading to frustration and a breakdown in communication.

Additionally, communication flows between affected municipalities and provincial authorities was challenging because of conflicting messages and communication delays.

2.3. Financial

2.4. Policy & legal

The province of Alberta has created the Emergency Management Act and supporting regulations, including the Alberta Emergency Act, which were implemented during the 2013 floods. They were deemed to be an effective way of responding to the emergency at a regional level.

On a municipal level, during a state of local emergency, CEMA implements an Incident Command System commonly used across other jurisdictions and other private sector companies. It is a standardized, on-site incident management approach appropriate for all hazards that:

- Allows for the integration of facilities, equipment, personnel, procedures, and communications within a common organizational structure
- Enables a coordinated response among various jurisdictions and agencies
- Establishes common processes for managing resources

(The Conference Board of Canada, 2014)

2.5. Socio-economic

Bringing media into the Calgary EOC provided the public with unprecedent access to city leadership and conveyed to the public a level of reassurance, confirming that authorities were in control of the crisis. At a grass-roots level, however, communication could have been improved. Community Associations reported that they were not being contacted in advance for assistance and felt ignored and disrespected as a result (The Conference Board of Canada, 2014).

2.6. Governance & Institutional

The response and coordination of the Calgary EOC helped immensely to cut down on response times and miscommunication.

While employees of CEMA's EOC understood the emergency process very well, not all partners and stakeholders recognized how the implementation of a state of local emergency changed CEMA's authority. One recommendation made in the Conference Board of Canada's report (2014) was to add a formalized process for identifying agencies that arrived at the Calgary EOC, to indicate why they are there

and who they are supposed to report to. This was intended to help everyone present understand each other's roles, responsibilities, and authorities.

3. Recovery

3.1. Summary

Overall, recovery was deemed to be effective. Recovery and repatriation of evacuees began immediately across all communities. The CEMA model dictates that the intensity of recovery should match the intensity of response.

When is came to recovery, social media was an indispensable tool used to provide direction and organize volunteers, guiding them to clean-up locations, and helping the city rally together. The City of Calgary discovered that volunteers are a valuable but fragile resource, and the authorities involved in the recovery effort made use of community associations and citizens as soon as the state of local emergency was lifted.

3.2. Technical

Approximately 7% of Calgary's population was displaced during the 2013 flood. Many of these people would therefore be relying on cell phones, smart phones, the news, and social media to receive communication and directions. Authorities like the City of Calgary and the Calgary Police Service made use of platforms like Facebook and Twitter and the hashtag #yycflood to make information easily accessible (The Conference Board of Canada, 2014).

A problem that was addressed in the aftermath of the flood was the way that social media was used by affected citizens and public groups to express their wants and needs. Those with the time and resources to express their needs were given more attention, simply because they were the loudest, not necessarily because they had the most need, highlighting the need for authorities to remain vigilant in the response and recovery phases when receiving information through social media (The Conference Board of Canada, 2014).

3.3. Financial

3.4. Policy & legal

The widespread use of volunteers raised legal issues among some parties, particularly when it came to the recovery and rebuild phase. There was common agreement that no volunteers would be used in the response phase unless specifically trained to do so (such as volunteer firefighters). However, when lifting heavy debris and cleaning up potentially contaminated spaces, volunteers who assisted through the city with YYCHelps were asked to fill in registration forms granting them coverage under the City's accident insurance program. Other programs, or those helping friends and family on an individual basis may not have had such coverage.

3.5. Socio-economic

Repatriation of evacuees was swift to enable their self-recovery and help rebuild the community, along with civic pride and a sense of community.

3.6. Governance & Institutional

During the flood, Calgary enabled its citizens to perform self-assessments of their properties by providing them with both the knowledge and authority to do so so that most of the properties could be re-entered without any inspections. The Building and Approvals department then performed rapid damage assessments to those homes requested by homeowners and buildings where damage was previously

noted. This dramatically cut down on the amount of inspections required and expedited the time in which people could re-enter their homes.

4. Rebuild

4.1. Summary

The Government of Alberta previously had a Disaster Recovery Program in place designed to help rebuild and restore public works and community infrastructure, which generally worked well in the past, however it was not designed to meet the needs of a disaster of this magnitude.

4.2. Technical

Calgary's flood risk communication strategy has been expanded to be able to enhance communication channels to keep Calgarians informed of conditions that may lead to high water levels and flooding. The Province of Alberta and City of Calgary have been comparing three major flood mitigation capital projects on the Elbow River since the 2013 flood and recently decided on an off-stream diversion and storage site upstream of Calgary.

The Province has gradually been publishing updated flood risk mapping up to the 1:1000-year flood return period and publishing it on a publicly accessible website. As these get published, flood risk assessment reports for each municipality have also been created, a precursor to flood management and mitigation plans (Expert Management Panel on River Flood Mitigation, 2014).

4.3. Financial

A large part of the rebuilding process is acquiring the funding needed to rebuild, whether it is repairing property damage, repairing infrastructure, or putting in flood mitigation. Since the 2013 floods, the Government of Alberta has committed significant time and resources to improving the Disaster Recovery Program to help ease the process and support individual claimants (MNP LLP, 2015).

4.4. Policy & legal

In the wake of the 2005 flood in Calgary, land planning recommendations were made that were further reinforced after the 2013 floods to protect communities, infrastructure, and private property to a higher flood level than previous policy. An independent body recommended that the City perform a triple bottom line analysis to evaluate the need to increase the minimum flood protection level above the 1:100-year flood return period that was previously being used for land use planning and structural protection across the city. After this was perform the new standard was increased to the 1:1000-year flood return period (Expert Management Panel on River Flood Mitigation, 2014).

A number of municipalities have developed a time-phased approached to removing buildings and property from the flood plain altogether. In Calgary, the Province has purchased a number of properties along the river. In the Town of High River the Town and Province have paid land owners a lump sum and placed easements on their land where they are not allowed to build permanent structures and cannot claim flood losses on insurance moving into the future.

4.5. Socio-economic

As soon as the state of local emergency was lifted, Tourism Calgary launched a campaign titled "Our Doors are Open" leveraging the mayor as its spokesperson, a positive mindset, and a sense of pride to draw people in. Many events that were considering cancellation, such as the Calgary Stampede, were able to go on because of the expediency of this campaign and the will of the city to rebound so quickly (The Conference Board of Canada, 2014).

4.6. Governance & Institutional

Conclusions, Observations and Commentary

The strong response and ability to rebuild after the 2013 flood was facilitated largely by lessons learned and actions taken after previous natural disasters. Both the city of Calgary and the province of Alberta learned lessons from previous disasters and strengthened their response capabilities. One form of emergency preparedness used in Calgary was the Emergency Operations Centre. The Calgary Emergency Management Agency invested in the capacity of Calgary's Emergency Operations Centre and worked together with multiple stakeholders, including municipal agencies and private businesses towards a common goal, ensuring all stakeholders understood their place in each stage of an emergency.

Clear communication was facilitated by the use of social media as a means of responding quickly and directly to citizen concerns, while the Emergency Management Centre ensured that the message being sent out was clear and consistent.

During the recovery phase, citizens were empowered to perform assessments of their property and take control of the recovery process, which greatly hastened the recovery after the 2013 flood, and also made citizens and businesses more prepared for future floods and other hazards.

In post-event interviews and reviews, multiple reports and organizations noted organizational resilience and business continuity as one area of improvement. It was noted that getting people out was not the problem, but rather getting people back in, especially when it came to small- and medium-sized business who may not have had the resources to invest in recovery. Ensuring that the public's immediate needs were met in a timely manner sped up crisis recovery.

While communication between the Calgary EOC, the City of Calgary, and the public was applauded, inter-governmental communication was found lacking. Where multiple jurisdictions are involved, resources and responsibilities should be assigned ahead of time so that resources can be allocated as soon as they arrive.

Finally, there was a recommendation to increase emergency management capacity in First Nations by building capacity and ensuring enough specially trained field officers are deployed. A crucial missing link when it comes to many rural and First Nations communities is communication – not only the willingness for authorities to communicate, but the ability to communicate. There is currently a digital divide that exists between urban centres and rural and Indigenous communities, due to lagging investments in technology and resulting poor connectivity. To respond properly to an emergency, First Nations communities must first be connected and informed.

In a flood of this magnitude, it is amazing that there was no major loss of life. This is because the emergency management system allowed evacuation of the at-risk areas in a timely and effect manner. The most important message when it comes to emergency management, is not necessarily the amount of time or money invested in emergency operations, but that communities and municipalities should not become complacent. With increasing populations and weather-related emergencies due to climate change, more people and infrastructure need to be protected and it is important not to be caught off guard.

References

Expert Management Panel on River Flood Mitigation. (2014). *Calgary's Flood Resilient Future.* Calgary.

MNP LLP. (2015). *Review and Analysis of the Government of Alberta's Response to and Recovery from 2013 Floods.*

The Conference Board of Canada. (2014). *Forewarned and Foreamed: The Calgary Emergency Management Agency and the 2013 Flood.* Independent Review, Ottawa.

Synthesizer: Simon Kates Reference ID: 28

Title of document being synthesized and year it was published**: Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada (2021)**
Author(s): **Sjoukje Y. Philip, Sarah F. Kew, Geert Jan van Oldenborgh, Wenchang Yang, Gabriel A. Vecchi, Faron S. Anslow, Sihan Li, Sonia I. Seneviratne, Linh N. Luu, Julie Arrighi, Roop Singh, Maarten van Aalst, Mathias Hauser, Dominik L. Schumacher, Carolina Pereira Marghidan, Kristie L Ebi, Rémy Bonnet, Robert Vautard, Jordis Tradowsky, Dim Coumou, Flavio Lehner, Michael Wehner, Chris Rodell, Roland Stull, Rosie Howard, Nathan Gillett, Friederike E L Otto**
Category of document: **Case Study**
Geographic focus of the document: **North America West Coast**
Other: Additional information to provide context of the 2003 European heat wave and adaptation efforts:

- https://www.csmonitor.com/World/Europe/2019/1104/Heat-waves-How-France-has-cut-death-toll-90-since-2003
- https://solidarites-sante.gouv.fr/IMG/pdf/pnc_actualise_2017.pdf
- https://solidarites-sante.gouv.fr/sante-et-environnement/risques-climatiques/article/le-plan-national-canicule
- http://eknygos.lsmuni.lt/springer/154/131-140.pdf

Report Summary

Between June 27 and June 29, 2021, Oregon, Washington, and the western provinces of Canada experienced an extreme heatwave that was unprecedented for the pacific northwest region. During this extreme weather event, record high temperatures were recorded throughout this region that typically experiences more moderate temperatures. For example, the Village of Lytton, Canada recorded a temperature of 49.6° C, which is the highest temperature recorded in Canada. Maximum temperatures in the region ranged from 16° C to 20° C higher than normal maximum temperatures.

Impacts

- Health
- Excess deaths

Issues

- Only about 50% of households have air conditioning
- Need for improved communication about call centers (Multnomah County, OR, calls were dropped, people given inaccurate info)
- Need for more equitably situated cooling centers.

The objective of the report summarized here was to “investigate the role of human-induced climate change in the likelihood and intensity of this extreme heatwave.” Note that the report evaluates the extreme heat component of the impacts of this event. Impacts, such as excess deaths, also result in part from exposure and vulnerability, factors which were not evaluated in this report.

The report concludes that the intensity of this heat wave would have been “virtually impossible without human-caused climate change.” The authors estimate that this event is a once-in-a-millennium event. However, given rising temperatures due to climate change, such events could occur as frequently as once every five to ten years in the coming decades. The potential that extreme heat events could become even more frequent raises the necessity for governments to implement adaptation measures to prepare and to prevent the worst outcomes.

Since this extreme weather event happened recently, there are limited academic resources available to evaluate response by various local, regional, and national governments, as well as limited recommendations for adaptation measures in the future. However, the authorities in Oregon, Washington, and British Columbia can benefit from the lessons learned of prior extreme heat waves. The synthesis

below explores the measures taken in France in response to the 2003 heatwave that impacted several countries in Europe. This August 2003 extreme heat even is estimated to have caused more than 30,000 deaths, including approximately 15,000 in France alone. Following the 2003 event, France adopted the *Plan National Canicule*, or the National Heatwave Plan. This document has been updated over the years, with the most recent update in 2017.

The synthesis below outlines the key efforts taken in France following the 2003 event in order to better prepare the population for future extreme heatwaves. France has experienced subsequent heatwaves in recent years, some of which were even more severe. For example, in 2015, France experienced a heatwave with temperatures around 40° C in some regions. The heat wave alert systems implemented after 2003 has received praise for preventing health complications among vulnerable populations, but doesn't address other impacts of extreme heat, such as strained electrical grids, poor air quality, transit delays, emergency room capacity, and risks to outdoor workers.

The heatwave in 2019 brought maximum temperatures to a national record of 46° C, but the death toll in France was limited to approximately 1,400—still a high number, but substantially lower than the 15,000 or more who died in France during the 2003 heat wave. Despite even more extreme heatwaves in recent years, including 2019, the number of deaths have not been nearly as high as during the 2003 event. Some studies—and French officials—have attributed these improved outcomes to the adaptation measures that were taken in the years after the 2003 event.

Measures adopted in France in the aftermath of the 2003 event are summarized below.

1. Preparedness

1.1. Summary

The key approach following the 2003 heatwave in France, which provides a pathway forward for the Canadian context, is acknowledging that such extreme heat events are likely to become even more common in the coming decades. These extreme events can no longer be viewed as unlikely outlier events—rather, than need to be anticipated and government must have measures in place to help regions, cities, towns, and individuals prepare. The National Heatwave Plan in France was a preparedness measure on its own, but it also recommended and required a series of measures that also contributed to preparedness and response for future extreme heat events.

1.2. Technical

- The heatwave plan included Structural Measures, which involved alterations to existing structures or regulations for new development. Examples include:
  - Playgrounds—remove asphalt and replace with less absorbent materials, plant more greenery
  - Construction regulations require better insulation
  - Strong recommendation that establishments for the elderly have an air-conditioned area for residents. France allocated approximately 60 million euros to health establishments for the elderly to install air conditioning.

1.3. Financial

Following the 2003 extreme heat event, France instituted a Heat Tax to fund programs to protect vulnerable citizens.

1.4. Policy & legal

1.5. Socio-economic

- Town halls required to keep a register of senior citizens so that health workers can check on them

- Training health workers about heat stroke

1.6. Governance & Institutional

- National Heat Wave Plan:
  - Developing the National Heat Wave Plan in 2004 to coordinate government response and communications. The Plan has been revised and updated periodically since 2004, with the most recent version adopted in 2017.
  - Four levels of preparedness
    - Level 1 – Seasonal monitoring (green)
      - Automatically activated June 1 – September 15
      - Verification of operational systems, implementation of meteorological and health surveillance, system and opening of the national telephone platform
    - Level 2 – Heat warning (yellow)
      - Heightened monitoring, preparation for increased energy load.
      - Targeted communications
    - Level 3 – Heat wave alert (orange)
      - Prevention and management actions implemented by government agencies, including communication about individual actions to mitigate heat impacts (hydration, shelter from heat, etc.), triggering of “blue plans” in establishments for the elderly and disabled, mobilization of outpatient services, activation by Town Halls of municipal registers to proactively provide assistance for the elderly and disabled, measures for homeless people, etc.
    - Level 4 – Maximum mobilization (red)
      - Activated in the event of an exceptional, intense, long-lasting heatwave with collateral effects on various sectors, e.g., drought, drinking water supply, saturation of hospitals and funeral homes, power failure, forest fires, etc.
      - Activation of Interministerial Crisis Unit (CIC)
  - Organizations involved in the National Heat Wave Plan
    - National
      - Directors/delegates from the ministries of health, social affairs, interior, labor, national education and higher education, youth and sports, defence, justice, the environment, agriculture
      - Health safety agencies, e.g., Public Health France, National Agency for the Safety of Medicines and Health Products, National Agency for Health, Food, Environment, and Occupational Safety
      - National bodies, e.g., Meteo-France, Nuclear Safety Authority, Institute for Radiation Protection and Nuclear Safety
      - Health professionals, e.g., National Council of the Order of Physicians (CNOM), National Council of the Order of Pharmacists (CNOP), Federation of Hospitals and Private Assistance Establishments (FEHAP), French Hospital Federation (FHF), Federation of Private Hospitalization (FHP), French Society of Geriatrics and Gerontology (SFGG), French Society of Emergency Medicine (SFMU), SAMU Social de Paris (SSP)
      - Associations, e.g., Association of Mayors of France (AMF), Assembly of French Departments (ADF), French Red Cross, France Volunteering, Order of Malta, Little Brothers of the Poor, Union of Homes for Young Workers (UFJT), Social Union for the Habitat (USH), National Union of Communal Centers for Social Action (UNCCAS), National Interfederal Union of Private Health and Social Works and Organizations (UNIOPSS)
    - Local
      - Regional Health Agencies (ARS) and Regional Units of the French Public Health Agency (CIRE)
      - General tips

- Regional Councils
- Regional Councils of the College of Pharmacists
- Regional unit of the French Public Health Agency
- Departmental delegation of the French Red Cross
- Regional Directorates for Food, Agriculture and Forestry (DRAAF), Regional Service for Training and Development (SFRD)
- "Social Samu" type mobile teams
- Health facilities
- Institutions for the elderly/disabled
- Social establishments (accommodation and social reintegration centres, reception centers for asylum seekers), emergency accommodation centers and day care centers
- Army Training Hospitals
- Town halls – Communal social action center
- Doctors/Departmental Council of the College of Physicians/Regional Union of Liberal Physicians
- Social protection (Health insurance: Regional union of health insurance funds and its network, mutual insurance companies, Regional health insurance fund, Family allowance fund, Supplementary pension funds)
- Rectorates
- UAS
- Departmental fire and rescue services
- Home care nursing services – Home help associations

▪ https://solidarites-sante.gouv.fr/sante-et-environnement/risques-climatiques/article/le-plan-national-canicule

2. Response

2.1. Summary

The National Heat Wave Plan included a series of measures to improve response to extreme heat events. These responses were especially targeted at vulnerable populations, such as senior citizens, people with disabilities, and children.

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

- Heat wave alert system to warn vulnerable populations
  - Leaflets, posters, radio and TV commercials, internet advertisements
- Cabinet minister messages on TV
- Assisted living for elderly required to provide a "cool room"
- Cancel school outings and sporting events
- Allow more work-from-home to reduce the electric load on the metro system
- Creation of "Blue Plans" for collective residential establishments for elderly people
  - Blue Plans provide specific measures each institution should take in the event of a heat wave alert.
  - Blue Plans should:
    - Appoint a specific lead contact person
    - Establish agreements with health facilities to facilitate transfers
    - Installation of a cooled room

- Establish procedures to issues alerts to mobilize staff
- French government provided funding to assist senior homes to assist in preparation of Blue Plans and hire staff to implement them.

2.6. Governance & Institutional

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

Creation of a national heat wave plan was a critical step in reducing deaths due to heat waves in France. This model could be replicated in Canada. However, a crucial lesson from the successes in France is the substantial coordination that must occur between the national government, regional/local officials, and private institutions. In addition, the success appears to be due in part to improved public health education and communication about extreme heat events.

Synthesizer: Simon Kates Reference ID: 30

Title of document being synthesized and year it was published**: Adapting to Climate Change in the Upper Mississippi River Basin: Exploring Stakeholder Perspectives on River System Management and Flood Risk Reduction (2020)**
Author(s): **Tamsen Reed, Lisa Reyes Mason, and Christine C. Ekenga**
Category of document: **Case Study**
Geographic focus of the document: **Midwest US; Upper Mississippi**

Report Summary

Midwest flooding of the Missouri River and the Upper Mississippi River Basin in March 2019 impacted Nebraska, Iowa, Missouri, North Dakota, South Dakota, Minnesota, Wisconsin, and Michigan, causing an estimated $12.1 billion in damage. The flood was triggered by a heavy precipitation storm even that intensified snow melt, which exacerbated flooding. The event inundated millions of acres, impacting agriculture and municipalities, and caused damage to roads, bridges, levees, and dams. Offutt Air Force Base in Nebraska was severely flooded.

The January to May months in 2019 were the wettest on record in the U.S., with higher than average rainfall and snow melt causing regional flooding that began in March 2019.

The study synthesized below sought to provide stakeholders perspectives on challenges and opportunities to increased adaptation for the region. The researchers conducted interviews with flood management stakeholders during the summer/fall of 2019 and compiled interview data based on themes. Five themes emerged from the interviews:

1. River flooding in the Midwestern U.S. is a different experience than U.S. coastal flooding.
2. River flooding in the Midwestern U.S. is a regional experience that requires a regional response.
3. Local actors face constrained resources for flood risk protection and recovery.
4. Differentiated responsibility across levels of governments makes recovery and response difficult to navigate.
5. Competing stakeholder goals challenge cooperative flood hazard management.

A total of eight stakeholders were interviewed from the following groups:
1. U.S. Army Corps of Engineers (Federal)
2. State government
3. Non-profit environmental advocacy
4. Local government, Agricultural operations
5. Local leadership, agricultural interests

The study concludes that adaptation efforts that are either broadly dictated or locally fragmented are inadequate. Regional cooperation and collaboration are required to put adequate adaptation measures in place. In particular, the case of river systems that cross local, county, and state borders further require cooperative planning and decision-making. Prior hazard mitigation efforts in the region, including buyout programs, flood insurance, levees, retaining basins, wetland restoration, and flood resilient infrastructure have largely been implemented at the local level with limited regional coordination.

1. Preparedness

1.1. Summary

1.2. Technical

1.3. Financial

- Challenge: Local levees are part of a regional flood risk management system, but repairs are funded by local tax districts. How can local taxation recognize the common challenges faced across the region, and the need to repair, maintain, and elevation levees, in addition to other mitigation measures such as dredging?
- Challenge: Lack of funding at the local level to adequately maintain and repair existing infrastructure, let alone construct new facilities. The need for increased funding for Recovery efforts doesn't make this challenge any easier—it forces local government to prioritize the immediate needs (recovery) rather than long-term needs (preparedness).
- Challenge: The majority of the levees in this region are managed and funded locally, by individual levee districts. These districts rely on local taxes for maintenance and repairs, not federal funding. Even when federal funding is available, small municipalities may lack the staff capacity to apply or administer a grant award.

1.4. Policy & legal

1.5. Socio-economic

1.6. Governance & Institutional

- Challenge: Existing levee systems are managed in a patchwork fashion. This decentralized management of flood mitigation tools creates further concern given that levees were constructed to old standards that did not account for higher water levels and more severe rain events.
  - "Our flood-control system was designed in the Civil War. It's not adequate for today and it's certainly not adequate for the future with climate change."
- Challenge: Installing or improving levees in one location could increase the flood risk on downriver communities. This is becoming a greater issue due to larger cities developing waterfronts as a source of economic development AND FEMA providing flood insurance benefits for communities that are protected by mitigation measures that are certified for a 500-year flood. Again, solutions conceived at the local level create unintended consequences at the regional level. Local management of flood mitigation measures may create greater harm to other communities.
  - "I think we're headed for disaster if we continue…operating as independent communities doing what's best for them, because what they're doing is probably best for them, but not best for the system."

2. Response

2.1. Summary

In terms of flood response and management, the common theme expressed by the interviewees was that different stakeholders have different priorities. This is reflected in goals that are not aligned and require different flood mitigation strategies.

2.2. Technical

2.3. Financial

2.4. Policy & legal

2.5. Socio-economic

2.6. Governance & Institutional

- Challenge: varying goals among different stakeholders
  - Army Corps of Engineers: Maintaining navigability
  - Agricultural interests: economic growth, stability, limiting environmental regulations

- Conservatists: Maintaining environmental and water quality, restoring wetlands
- Recreation advocates: maintaining water levels in reservoirs
- Residents: Avoiding buyout programs, improving flood resilience infrastructure

3. Recovery

3.1. Summary

3.2. Technical

3.3. Financial

- Challenge: FEMA buyout programs are targeted at buyout out homes in urban neighborhoods, but the Midwest economy is driven by agriculture. Buyout programs don't help address issues related to agricultural land that's located in the floodplain.

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

- Challenge: The slow-moving nature of rain and river flooding creates a lag in declaration of federal emergencies, leading to slowly delivered disaster aid. Coastal floods, by contrast, tend to be more acute events that receive aid more quickly.

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

- There is value in developing locally-driven flood and severe weather adaptation. However, with regional events such as floods, these local programs create challenges that need to be addressed at the regional level.
- States and regional agencies should incentivize cooperative action and also provide funding and professional capacity for planning. The federal government and state agencies should consider unintended consequences downriver when implementing flood mitigation measures upstream.
- While this paper largely focuses on states taking actions to improve outcomes on the local level, it is important to recognize that the Midwest flooding in 2019 impacted multiple states. Action should be considered on the regional level based on river basins and watersheds, rather than administrative boundaries.

Interesting element

In the framework of the NAS a tool was developed to visualise the effects of climate trends: https://nas-adaptatietool.nl/

The visualization of climate adaptation can be tailored in three steps. Choose which climate trend(s) and/or sectors are important to you, then filter on the impact and the nature of the possible climate consequences.

As an accessible alternative to using the NAS adaptation tool, you can download the data for the visualization of the NAS adaptation tool as an Excel file or the data for the visualization of the NAS adaptation tool as a PDF file.

Example figures are given on the following pages for Warmer, Wetter and Drier.

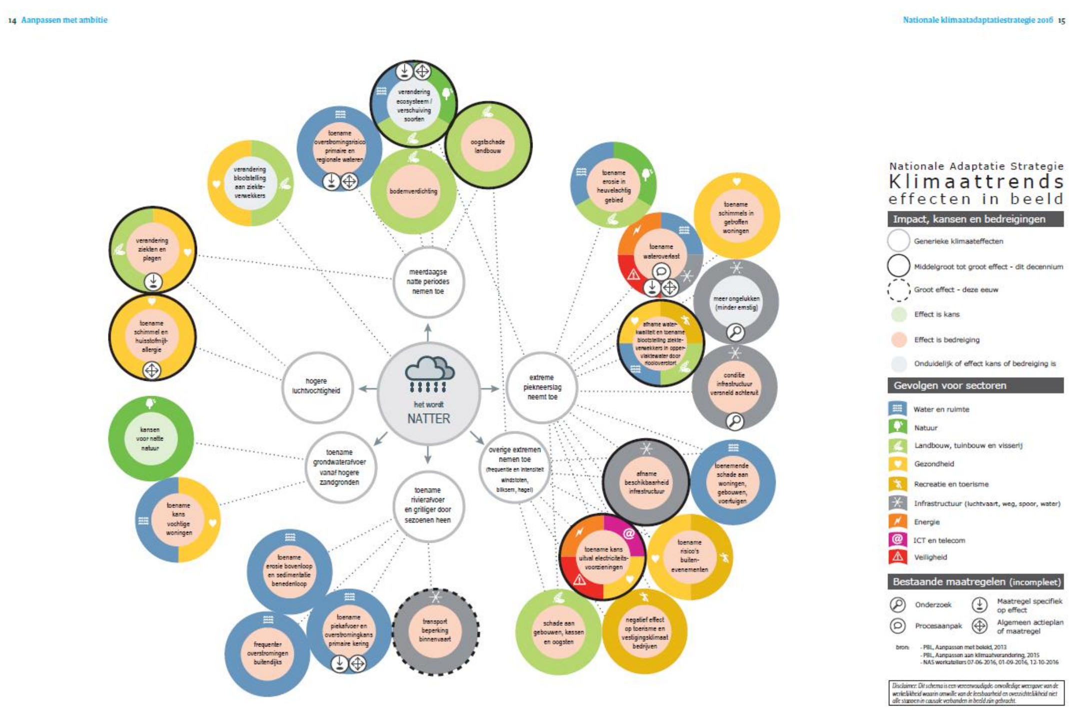
A number of primary effects are shown in black and white for each climate trend, which are then elaborated in colour into concrete effects for sectors. The following information is included in the schedules for each concrete effect:

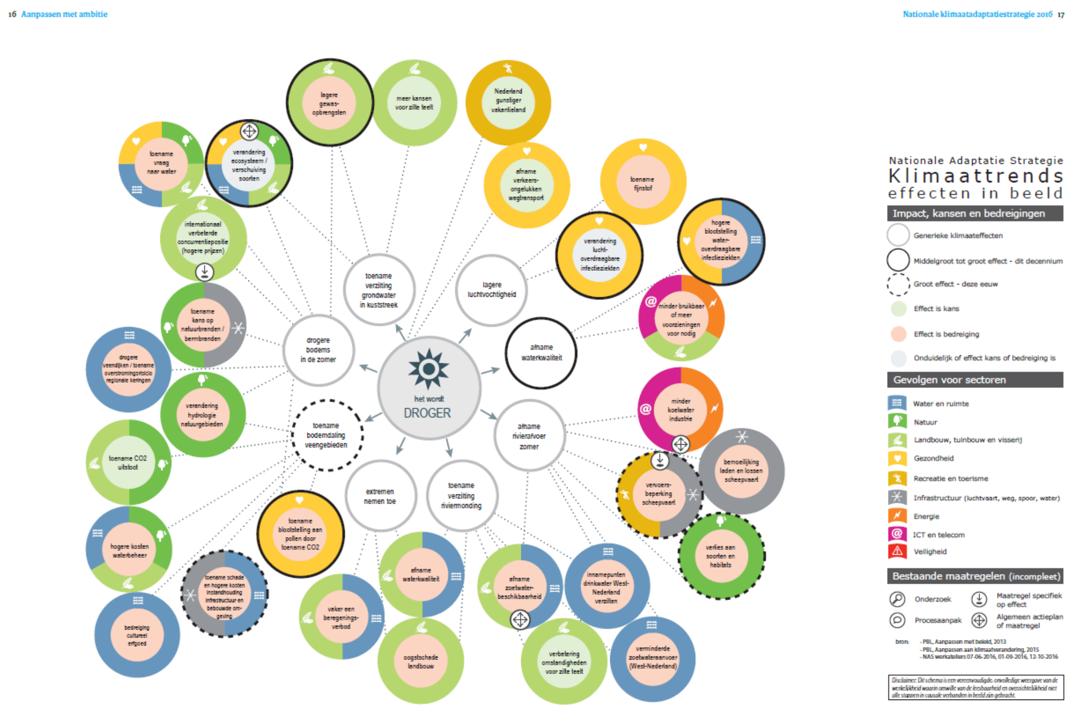
- The colour in the edge of the sphere indicates which sectors are involved.
- The colour in the centre of the orb indicates whether the effect is an opportunity (green), or a threat (red). The heart is grey if it is unclear whether the effect is an opportunity or a threat.
- A black border around the sphere indicates a medium-to-large effect, already occurring or expected to occur this decade. A broken black border indicates a major effect that will occur in the course of this century. The remaining orbs fall into lower impact categories.
- Symbols indicate whether measures have already been taken (as far as is known).

The diagrams in this NAS are a simplified representation of reality and therefore not complete. At the same time, the diagrams clearly show the complexity of the issue.

The schemes offer starting points for a joint approach, for example where several sectors are dealing with the same effect. They are limited to the Netherlands. The schedules will be made available digitally and at a later stage a complete overview will be made per sector of the effects per climate trend.


12 Aanpassen met ambitie
Nationale klimaatadaptatiestrategie 2016 13
het wordt
WARMER
Nationale Adaptatie Strategie
Klimaattrends
effecten in beeld
Impact, kansen en bedreigingen
Gevolgen voor sectoren
Water en ruimte
Natuur
Landbouw, tuinbouw en visserij
Gezondheid
Recreatie en toerisme
Infrastructuur (luchtvaart, weg, spoor, water)
Energie
ICT en telecom
Veiligheid
Bestaande maatregelen (incompleet)
Onderzoek
Procesaanpak


14 Aanpassen met ambitie
Nationale klimaatadaptatiestrategie 2016 15
het wordt
NATTER
Nationale Adaptatie Strategie
Klimaattrends
effecten in beeld
Impact, kansen en bedreigingen
Gevolgen voor sectoren
Water en ruimte
Natuur
Landbouw, tuinbouw en visserij
Gezondheid
Recreatie en toerisme
Infrastructuur (luchtvaart, weg, spoor, water)
Energie
ICT en telecom
Veiligheid
Bestaande maatregelen (incompleet)
Onderzoek
Procesaanpak



16 Aanpassen met ambitie
Nationale klimaatadaptatiestrategie 2016 17
het wordt
DROGER
drogere bodems in de zomer
toename verzilting grondwater in kuststreek
lagere luchtvochtigheid
afname waterkwaliteit
afname rivierafvoer zomer
toename verzilting riviermonding
extremen nemen toe
toename bodemdaling veengebieden
lagere gewas-opbrengsten
meer kansen voor zilte teelt
Nederland gunstiger vakantieland
afname verkeers-ongelukken wegtransport
toename fijnstof
verandering lucht-overdraagbare infectieziekten
hogere blootstelling water-overdraagbare infectieziekten
minder bruikbaar of meer voorzieningen voor nodig
minder koelwater industrie
bemoeilijking laden en lossen scheepvaart
vervoers-beperking scheepvaart
verlies aan soorten en habitats
innamepunten drinkwater West-Nederland verzilten
verminderde zoetwateraanvoer (West-Nederland)
verbetering omstandigheden voor zilte teelt
afname zoetwater-beschikbaarheid
afname waterkwaliteit
oogstschade landbouw
vaker een beregenings-verbod
toename blootstelling aan pollen door toename CO2
toename schade en hogere kosten instandhouding infrastructuur en bebouwde om-geving
bedreiging cultureel erfgoed
hogere kosten waterbeheer
toename CO2 uitstoot
verandering hydrologie natuurgebieden
drogere veendijken / toename overstromingsrisico regionale keringen
toename kans op natuurbranden / bermbranden
internationaal verbeterde concurrentiepositie (hogere prijzen)
toename vraag naar water
verandering ecosysteem / verschuiving soorten
Nationale Adaptatie Strategie
Klimaattrends
effecten in beeld
Impact, kansen en bedreigingen
Generieke klimaateffecten
Middelgroot tot groot effect - dit decennium
Groot effect - deze eeuw
Effect is kans
Effect is bedreiging
Onduidelijk of effect kans of bedreiging is
Gevolgen voor sectoren
Water en ruimte
Natuur
Landbouw, tuinbouw en visserij
Gezondheid
Recreatie en toerisme
Infrastructuur (luchtvaart, weg, spoor, water)
Energie
ICT en telecom
Veiligheid
Bestaande maatregelen (incompleet)
Onderzoek
Maatregel specifiek op effect
Procesaanpak
Algemeen actieplan of maatregel
bron: - PBL, Aanpassen met beleid, 2013
- PBL, Aanpassen aan klimaatverandering, 2015
- NAS werkateliers 07-06-2016, 01-09-2016, 12-10-2016
Disclaimer: Dit schema is een vereenvoudigde onvolledige weergave van de werkelijkheid waarin omwille van de leesbaarheid en overzichtelijkheid niet alle stappen in causale verbanden in beeld zijn gebracht.

Synthesizer: Koen Broersma Reference ID: 65

Title of document being synthesized and year it was published**: High Water 2021 Facts and Interpretation**
Author: **Flood risk management expertise network ("Expertisenetwerk waterveiligheid": TUDelft, Deltares, Wageningen University, Erasmus Medical Center, HKV, Universiteit Utrecht, Institute for Environmental studies, Vrije Universiteit Amsterdam, KNMI, University of Twente)**
Category: **Case study**
Geographic: **Europe / Netherlands**

Report Summary

In July of 2021, large areas in the province of Limburg in the Netherlands (as well as Germany & Belgium) were affected by extreme rainfall and floods. Also, large parts of particularly Belgium and Germany were flooded, which led to high damages, losses and hundreds of casualties. The floods are considered an extreme event with enormous impact and an exploratory fact-finding study has therefore been conducted to collect and analyse information. A broad consortium of knowledge institutes participated in this effort: Delft University of Technology, Deltares, HKV Consultants, VU Amsterdam, University of Utrecht, KNMI, Wageningen University and Research, Erasmus MC and University of Twente. The project was commissioned and supported by the Dutch Expertise Network for Flood Protection (ENW). The regional water authority Limburg and Rijkswaterstaat (executive body of the Dutch Ministry of Infrastructure and Water Management) contributed by providing information, accompanying field visits and participating in interviews. A flood has an effect on society as a whole. Therefore, not only hydrological and civil engineering topics were considered, but also the social consequences of flooding, the crisis response and the health effects.

In the tributaries of the Meuse in Belgium and the Rhine in Germany and Luxembourg, an extremely large amount of precipitation fell in a short period of time over a much larger area than in the Netherlands. The rain fell in hilly areas and almost immediately came to surface runoff and collected via the shortest route in the rivers. The riverside villages at the bottom of the slopes in the narrow river valleys of the Vesdre, Ahr and Sauer have been badly damaged or completely destroyed. Major damage was also done to infrastructure. Hundreds of thousands of residents have been affected, more than 200 fatalities have been counted, tens of billions of euros in damage has been estimated. The damage is greatest in Belgium and Germany. Only in these countries casualties occurred. The situation here was more catastrophic than in the Netherlands, partly due to the higher amounts of precipitation and the steeper – faster-draining – rivers.

1. Preparedness

1.1. Summary

On Tuesday and Wednesday 13 and 14 July 2021 there was exceptionally heavy precipitation in the Belgian, German and Dutch parts of the river basins of the Meuse and Rhine, which led to flooding of the rivers and tributaries in many places. The 1- and 2-day precipitation amounts (160 – 180 mm in 2 days) and discharges from the rivers are very rare, especially in the summer season. For both precipitation and peak discharges, the probability is much smaller than can be deduced directly from the measurement series, and is estimated to be less than 1:100 to 1:1000 per year. A few days in advance, large amounts of precipitation were predicted; discharge expectations were revised upwards until shortly before the event. Without the measurements from July 2021, the precipitation generator of the GRADE instrumentation could not generate the 2-day precipitation sum as it occurred. GRADE is used to determine the discharge statistics and thus the design discharges on the major rivers in the current and future climate. A recently published KNMI report indicates that the probability of an event such as this has increased as a result of climate change, but the quantitative estimates of the climate contribution to the probability of such an event range from +20% to a factor of 9 compared to the climate without human influence.

1.2. Technical

The peak discharge on the Meuse at Eijsden and a number of tributaries is the highest discharge ever measured. Water levels on the Meuse downstream from Roermond are lower than during previous high waters and also lower than expected based on previous model calculations. This is partly due to the construction of Maaswerken, but also to the strong top flattening that was related to the pointed wave shape. The probability of occurrence of the measured water levels is approximately 1:200 per year on the Meuse near Borgharen and decreases, due to top flattening, to a probability of occurrence of 1:15 per year at Gennep. The probability of exceedance of the measured water levels also varies greatly in the tributaries. In many places along the Geul, the Geleenbeek and the Roer, the probability of occurrence is estimated at 1:100 to 1:1000 per year.

The high water has also resulted in morphological changes. For example, breaking up the plaster layer on the Grensmaas resulted in several deep erosion pits (3 meters deep or more). Bank erosion has also taken place and large amounts of sand have been deposited on the banks. The high water also makes a major contribution to the transport of materials carried by the water, including plastic. Of all plastic that is transported through the Meuse in an average year, 95% has now been moved within 2 days.

The Limburg Water Board has more than 4 kilometres of demountable flood defences that must be built during high water as described in the scenarios. In the entire management area, this concerns more than 200 openings and walls. In addition, emergency barriers with a total length of 2 to 3 kilometres were built at 23 locations. These emergency barriers consist of approximately 2000 big bags and 120,000 sandbags. A total of 140 pumps were installed prior to the high water to reduce water hazards and seepage, among other things. Finally, a large number of passages with valves (such as spindle gates) in the flood defences are closed by the municipality and the water board.

The scenario normally provides for 5 days for the build-up. Due to the speed at which the discharge wave developed, a faster build-up was necessary. Construction started on Wednesday 14 July at 2:00 PM. The entire construction was ready on Friday 16 July at 7:00 PM. This was done in phases; the walls that are lowest in the water column (and therefore must be the first to be closed) are built first, and the higher defences are built last. In total, the construction took 53 hours (instead of 120 hours) and the work continued 24 hours a day in instalments.

Some of the emergency measures were taken in response to reports from dike guards. Inspections by dike guards took place on all primary flood defences. The inspection frequency depended on the water level and was once every 4 hours during the peak for the most vulnerable spots. The first inspection took place at sunrise (around 6:00 a.m.) and the last at dusk and dawn (around 11:00 p.m. to midnight).

1.3. Financial

1.4. Policy & legal

1.5. Socio-economic

1.6. Governance & Institutional

2. Response

2.1. Summary

About 50,000 people, spread over many places in the area, including Valkenburg, Maastricht, Roermond and Venlo, were evacuated. There was no preventive evacuation along the Geul, especially in Valkenburg, prior to the high water. Exceptions to this are a few campsites and 193 people from care institutions. The rest of the inhabitants in the flooded area were evacuated after the flood. Most people along the Meuse have been successfully evacuated before the expected moment of possible dike failure.

Ultimately, there were no fatalities and most of the people responded to the evacuation call in a timely manner. Self-reliance was stimulated with the call for evacuation and also the installation of emergency measures to protect against a flood, and this worked well. The number of people rescued by emergency services is limited, including among the people in Valkenburg. Although these rescues receive a lot of media attention, most people seem to have left the area on their own. In addition to the planned management measures carried out by the water board along the Maas (mostly demountable defences), various emergency measures have been taken by volunteers with instructions from professionals. A risk inventory was the basis for the decision-making about evacuation and emergency measures. This inventory was frequently updated as new information became available. In the considerations about measures, a prioritization has been drawn up in which the safety of people and animals came first, and testing and vaccination due to Corona temporarily as priority 2. There was a lot of uncertainty about the discharge for the evacuations along the Maas. Both the expected discharge and the upper limit in the forecast were considered. This means that measures were taken for areas where there was an increased risk of flooding in order to guarantee the safety of people and animals as well as possible.

2.2. Technical

The primary flood defences have withstood the high load well. Incidents have occurred at various places in the system. These are described in overview and in detail in this report. This concerns, among other things, sand-carrying wells (leaching of the sand under the dike), overflow at Aasterberg and damage to the weir at Bosscheveld near Maastricht. The dike breach near Meersen and Bunde, reported in the media, turned out to be in reality a water flow from the Kleine Geul via a culvert that had not been mapped at that time. Further research is being carried out on this. Two local (non-primary or regional) flood defences were breached: the emergency dike at Horn and a barrier near Roermond.

Based on the high water reports, it was decided to take numerous protective measures and evacuation. The demountable barriers (which were prepared) were built faster than anticipated. Emergency measures have also been determined on the basis of analyses due to a shortage of height and strength of these defences. These emergency measures were carried out by the water board.

Sandbags were placed at a large number of locations along the Meuse to increase the retaining height of the flood defence. Because the water level forecasts were publicly available and because of the visibility of the retaining height, municipalities and local residents made an important contribution to the initiation and implementation of emergency measures that increase the retaining height of the dike (normally sandbags on the crown). Sandbags have been made available by the water board, municipalities and local contractors. In some cases, residents have used their own equipment to take emergency measures. The sandbags are often made available by the municipalities at the municipal yards and moved to the flood defences by local residents. This has locally led to traffic jams to the municipal yard.

There are various locations on the main road network that were blocked for a shorter or longer period of time. The duration of the blockage, as far as is known, varies from a few hours (for example the A2 between the Kerensheide and Kruisdonk interchanges) to a number of days (on the A79). In the morning rush hour on Thursday 15 July, approximately 50 km of traffic jams were caused by road closures and hindrance from water on the road.

The rail track from Maastricht to Liège was closed for several days because the track at Eijsden - near the Belgian border, was under water. The track from Weert to Roermond and from Maastricht to Sittard was also closed for a short time, which resulted in blocked train traffic on these routes.

Shipping has been shut down to limit the risk of accidents caused by floating debris.

The power supply and especially fixed internet, telephone and television connections failed at various locations during the high water. An estimated 6,000-7,000 households have been affected.

Within a few days, the power supply by Enexis and the telecom providers is restored (Enexis and KPN, 2021). In Valkenburg, a large KPN street cabinet, which serves about 700 customers, went out on Friday. A number of smaller street cabinets, for less than 65 customers per cabinet, were also flooded. In other locations, power outages also led to telecom outages after some time. This was mainly because the emergency batteries were empty, and an emergency generator could not be installed in time.

Damage to bridges and displacements of bridges and subsoil caused approximately 5 fibre optic and 100 copper cable failures. With fibre optic there was enough redundancy to prevent malfunctions, with copper cables a maximum of a few dozen customers were affected per malfunction, because the failure occurred in the capillaries ('last mile') of the system.

As a result of flooding and/or power failure, there were problems in five pylons. The result was a temporary dip in the coverage of the mobile network. Due to the redundancy in the network, KPN radio planners were able to quickly restore full coverage by 'tuning' the remaining masts.

2.3. Financial

The costs associated with the infrastructure obstructions are difficult to estimate and are not included in the damage amounts mentioned.

2.4. Policy & legal

2.5. Socio-economic

During the entire high water event, self-reliance and personal initiative were also strongly encouraged. This means that people often evacuated themselves and arranged their own reception on the basis of information and warnings. In addition, they have contributed to the placement of sandbags in numerous places. In total, approximately 50,000 people were evacuated in Limburg because of the high water on the streams and the Meuse. Emergency shelters were made available in various places, such as sports halls. However, very limited use has been made of this. Most people found their own shelter. The more than 400 patients from the hospital in Venlo and other care institutions are almost all spread over other institutions, some were sent home if the medical situation allowed.

The most important health complaints in patients reported by health professionals (via a questionnaire) are psychological complaints such as stress, worry and anxiety. In addition, an increase in patients with complaints of gastroenteritis, respiratory complaints, and infections of the skin has been reported. Children and the elderly were identified as risk groups and the main causes of absenteeism were psychological complaints. The impact on drinking water extraction was minor at Dunea, but substantial at Evides and WML. Both chemical and microbiological contaminants in the water of the Meuse and at the flooded extraction wells at the Eyserbeek have temporarily stopped the intake. Due to the wet and not so warm summer, the reserve capacity was sufficient to prevent interruptions in the drinking water supply. The province of Limburg has the highest COVID-19 risk ratio of the provinces in the Netherlands, which means that Limburg has had the largest increase in the number of new coronavirus cases after the flooding.

2.6. Governance & Institutional

For the streams in particular, the contingency plans were not based on such extreme events as occurred, so that areas such as Valkenburg were not evacuated before the high water and many were surprised. It was estimated that about 1000 people were present in the flooded area.

Along the tributaries of the Meuse and along the brooks (eg the Roer, the Geul and the Geleenbeek), emergency measures are mainly coordinated and implemented by municipalities and local residents (supported by the fire brigade and defence).

general lesson that can be learned from the events concerns the provision of information. It turned out to be very important to have the information available about the condition of the flood defences based on inspections and assessments, locations where additional measures are most needed, but also completeness with regard to the components of the system - such as in particular with the water flow. has emerged at the Juliana Canal near Bunde. It is therefore recommended that knowledge about the objects of, in and around flood defences (and infrastructure in general) be improved and made accessible.

3. Recovery

3.1. Summary

A lot of nuisance and damage occurred in the flooded area in the Netherlands. It is estimated that more than 2,500 homes, 5,000 residents and about 600 businesses were located in the directly flooded areas. With the standard method for damage determination (SSM2017), experience, and based on international sources, the total damage is currently estimated in the range of € 350 – 600 million. Household and building damage to homes and businesses, business failures, damage to infrastructure and agriculture are the largest damage items. The variation in damage from different homes and businesses is very large. The estimated damage for the total flooded area is clearly greater than for the floods of 1993 and 1995 (converted to price level 2021: approximately €200 million and €125 million, excluding damage due to business interruption); on the understanding that during the recent flooding most of the damage did not take place along the Meuse, but along the tributaries of the Meuse (particularly Geul). In order to further investigate the high variation in (commercial) damage, it is proposed that the above estimates eventually be improved with the damage data from insurers and the WTS (Disaster Compensation Act). It is also recommended that a structured questionnaire be conducted this year by means of a large sample in the area in order to learn more about experienced flooding and damage, recovery, effectiveness of risk reduction measures taken, evacuation behaviour and compensation.

3.2. Technical

3.3. Financial

3.4. Policy & legal

3.5. Socio-economic

3.6. Governance & Institutional

4. Rebuild

4.1. Summary

4.2. Technical

4.3. Financial

Damage caused by high water can be partly compensated by insurers through household contents, building or (all-risk) motor vehicle insurance, by the government, which can provide compensation for uninsured damage through the 'Wet Compensation for Damages in Disasters', and the disaster fund. Damage to homes and commercial properties caused by extreme rainfall and damage to homes due to overflowing streams are usually covered by insurance, but for large customers this may depend on the type of policy (NRC, 2021) and therefore not be insured. Damage to vehicles is covered for precipitation and flooding by all-risk and hull insurance, but not if only third-party coverage has been taken out. On 13 August, the cabinet published the conditions of the claims settlement for compensation for uninsured damage (Rijksoverheid, 2021). The disaster fund has promised a compensation of 1,000 euros to affected households (National Disaster Fund, 2021).

4.4. Policy & legal

4.5. Socio-economic

4.6. Governance & Institutional

Conclusions, Observations and Commentary

Given the short time period available, limited capacity of the project team and the fact that more detailed evaluations and model studies are not yet available, it is emphasized that this is a preliminary exploration. Follow-up studies and evaluations will follow and contribute to get a more complete insight in the causes and consequences of the floods. Given the transboundary nature of floods in this region, international and river basin wide cooperation is crucial. Based on follow-up evaluations, all concerned stakeholders can draw lessons for the future and – where needed – adapt and improve the river system, flood defences, flood warning, spatial planning and governance. This learning process should start today: new floods will come but should never be allowed to surprise us with something we could have learned from past events.

Appendix B – List of Nominated References

The references collected in this Appendix were categorized as follows:

CATEGORY	NOTES
Systems Based Approaches for Climate Resilient Infrastructure (SBA-CRI)	Can be at the country, state or province, or large city level Should include approaches to climate change resilience that are scalable to national, provincial or territorial levels
Case Studies	To address extreme weather event disasters, with discussion regarding climate preparedness, response, recovery, and rebuilding, focusing on Big and costly disasters Extensive and far reaching events Relevance to Canada (i.e. Could it happen in Canada?) Disasters resulting from a combination of events
General Literature	On climate preparedness, response, recovery and rebuilding Professional opinion articles, academic papers, or studies

Reference ID	Name	Author	Reference Category	Region	Summary	Shortlisted for synthesis
1	Disaster Risk Reduction Pathways Project in Canada	Geological Survey of Canada-Natural Resources Canada	SBA-CRI / Framework	Canada	Multiyear report with various independent reports, geared towards 3 objectives: increase capabilities to model systemic risk, recovery and resiliency, enable evidence based disaster risk reduction, and strengthen governance of disaster information and risk management.	**NO**
2	System mapping for UK infrastructure systems decision making	Arup	SBA-CRI / Framework	UK	This report maps the interconnectedness between the four main economic infrastructures in the UK: energy, digital communications, water and wastewater, and transport; under 2 scenarios: existing policy frameworks and future frameworks based on recommendations.	**NO**
3	Making the mistakes of the past: Building back better or digging in our heels?	Ebbwater Consulting	General Literature	Canada	Opinion article discussing alternative ways to rebuild post-recovery to incorporate resilience and avoid the mistakes of the past.	**NO**
4	Investigations in Support of Flood Strategy Development in British Columbia	Red Dragon Consulting	General Literature	Canada	Investigation into two key emergency management topics in the Frasen River: flood emergency response and flood recovery.	**NO**
5	Lifelines: The Resilient Infrastructure Opportunity,	World Bank Group	General Literature	Global	In-depth investigation into global resilience of resilience of four essential infrastructure systems: power, water and sanitation, transport, and telecommunications. Includes various case studies, makes the financial case for resilient infrastructure and provides recommendations for resilient infrastructure development.	**YES**
6	Our resilient Whole System Approach	National Grid	General Literature	UK	Whole system analysis (including interactions between different energy sources and uses) for developing a green and resilient grid.	**NO**
7	Systems Approach to Management of Disasters – A Missed Opportunity?	Slobodan P. Simonovic	General Literature	Canada	Background on why systems approach to disaster management have not succeeded in Canada, and discussions of how systems theory can be deployed to improve disaster management.	**YES**
8	System analysis of interdependent network vulnerabilities	Environmental Change Institute	General Literature	UK	Report on pilot project to develop a systems of systems modelling approach for vulnerability assessment of infrastructure.	**NO**
9	Fourth National Climate Assessment - Vol II: Impacts, Risks, and Adaptation in the US	US Global Change Research Program	General Literature	US	Report analyzing effects of human welfare, societal, and environmental elements of climate change and variability for 10 regions in the US and 18 national topics, with specific focus on projected risks, impacts, consideration of risk reduction, and implications of different mitigation pathways. CH 17 in particular discusses interconnectedness between sectors and systems.	**NO**
10	A comprehensive review of climate adaptation in the United States: more than before, but less than needed	Bierbaum, R., Smith, J.B., Lee, A. et al.	General Literature	US	Peer reviewed paper in a published journal (Mitigation and Adaptation Strategies for Global Change) evaluating existing and planned adaptation activities of federal, tribal, state, and local governments and the private sector in the US to understand types of adaptation activities are underway across sectors and scales throughout the country.	**NO**
11	Multi-Model Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment	USEPA	General Literature	US	Technical report quantifying physical and economic damages to multiple US Sectors using a consistent set of climate and socioeconomic scenarios and assumptions.	**NO**
12	Europe Adapts to climate change: Comparing National Adaptation Strategies	Global Environmental Change, Vol 20, Issue 2, Aug 2010	General Literature	Europe	Subscription required to access/ need to purchase article	**NO**
13	Shaping Climate-Resilient Development: A Framework for Decision-Making	Economics of Climate Adaptation Working Group	General Literature	Global	Report to guide decision-makers in a systemic approach to climiate adapation and resilience. Presents a practical framework that national and local decision-makers can use to quantify the risk that climate poses to their economies, and to minimize the cost of adapting to that risk.	**NO**
14	National Security Implications of A Changing Climate	US Department of Defense	General Literature	US	Report reviews findings of selected Federal reports addressing national security implications of climate change, from a systems-based perspective. Appears to have good discussions of cascading failures and affects.	**NO**
15	Adaptation opportunities and constraints in coupled systems: Evidence from the US energy-water nexus	Environmental Science & Policy, Vol 70, April 2017	General Literature	US	Subscription required to access/ need to purchase article	**NO**
16	Surface Transportation Interdependencies & Convergence with the Power Sector	National Association of Regulatory Utility Commissioners	General Literature	US	Report analyzes intersecting and interdependent nature of electric power and transportation sectors.	**NO**
17	Climate Change and Infrastructure, Urban Systems, and Vulnerabilities	US Department of Energy	General Literature	US	Need to purchase report . Examines the known effects and relationships of climate change variables on American infrastructure and risk-management policies	**NO**
18	Climate Change Adaptation: A Priorities Plan for Canada	Intact Insurance and University of Waterloo	General Literature	Canada	Part of the Climate Change Adaptation Project (Canada), designed to identify and operationalize practical, meaningful, and cost-effective adaptation solutions to the most challenging impacts of climate change facing Canada.	**YES**
19	Climate Resilience Strategy, Mitigation & Adaptation Action Plans	The City of Calgary	SBA-CRI / Framework	Canada	A report for the City of Calgary including the Climate Resilience Strategy (which provides the main direction for Climate Resilience in Calgary); The Climate Mitigation Action Plan (identifying the role and actions of the City to ensure services and operations are provided to reduce emissions and enable the low carbon economy); and The Climate Adaptation Action Plan (which identifies the risks and vulnerabilities from severe weather events and an iterative process of risk assessment).	**NO**
20	Canadian Communities' Guidebook for Adaptation to Climate Change	Environment Canada and UBC	SBA-CRI / Framework	Canada	Published by Env Canada in 2014, but we should still be aware of it. The Guidebook provides a process tied to ongoing planning cycles to help decision-makers incorporate climate science, impacts, adaptation, and mitigation solutions into their sustainable development initiatives. A tool for planners, decision-makers, local practitioners, and investors to build more resilient communities.	**NO**
21	NY Governor's Office of Storm Recovery (NY Rising)	New York Governor's Office of Storm Recovery	SBA-CRI / Framework	US	The Governor's Office of Storm Recovery (GOSR) was established by New York State in 2013 to centralize the state's recovery and rebuilding efforts following three major storm events in 2011 and 2012: Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy. The objective of GOSR was to address the most urgent needs of impacted communities while also identifying innovative solutions to make New York's infrastructure and critical systems more resilient. GOSR managed the NY Rising program with funding from the U.S. Department of Housing and Urban Development (HUD) Community Development Block Grant Disaster Recovery (CDBG-DR) program. Funding through the NY Rising program was focused on Housing Recovery, Small Business, Community Reconstruction, and Infrastructure. GOSR also coordinated with HUD's Rebuild by Design competition to develop innovative green infrastructure solutions to mitigate the impacts of climate change on coastal communities. One of the key innovations of the NY Rising Program was to involve local communities in a participatory planning process to identify how funding should be distributed among implementation actions within each community.	**YES**

22	Climate Ready Boston	City of Boston	SBA-CRI / Framework	US	Climate Ready Boston was developed in response to the city experiencing 21 events between 1991 and 2016 that triggered federal or state disaster declarations—and the expectation that climate change will increase the likelihood of coastal and riverine flooding, stormwater flooding, and extreme heat events. The report includes four components: updated climate projections, vulnerability assessment, focus areas, and climate resilience initiatives. The climate resilience initiatives are policy, planning, and financial initiatives to address the risks identified elsewhere in the report. Climate resilience initiatives were identified to achieve five principles: generate multiple benefits; incorporate local involvement in design and decision-making; create layers of protection by working at multiple scales; leverage building cycles; and design in flexibility and adaptability.	**NO**
23	California Climate Adaptation Strategy	State of California	SBA-CRI / Framework	US	The California Climate Adaptation Strategy is a platform to link the state's existing and planning adaptation efforts into a common framework. The Strategy is based around six climate resilience priorities, with a focus on outcomes and an integrated approach to climate resilience. The six climate resilience priorities are: Strengthen protections for climate vulnerable communities; Bolster public heath and safety to protect against increasing climate risks; Build a climate resilient economy; Accelerate nature-based climate solutions and strengthen climate resilience of natural systems; Make decisions based on the best available climate science; and Partner and collaborate to leverage resources. The first Climate Change Assessment in California was produced in 2005 and the first Climate Change Adaptation Strategy was produced in 2009. Therefore, this current Climate Adaptation Strategy reflects nearly two decades of evolution and revisions.	**YES**
24	Louisiana Climate Action Plan	State of Louisiana, Climate Initiatives Task Force	SBA-CRI / Framework	US	The Louisiana Climate Action Plan was released in February 2022. The state's first Climate Action Plan, this document recognizes that Louisiana is "among the most vulnerable states in the United States to the impacts of Climate Change," including impacts such as poor air quality, repetitive flooding events, and extreme heat. The document includes strategies and actions to reduce GHG emissions as well as initiatives to guide climate mitigation efforts.	**YES**
25	Minnesota Climate Adaptation Framework	Minnesota Pollution Control Agency	SBA-CRI / Framework	US	The Minnesota Climate Adaptation Framework was developed in 2018 by the Minnesota Pollution Control Agency and paleBLUEdot. The report provides climate adaptation assessment and funding for 23 cities throughout Minnesota, recognizing the need for locally specific strategies within a common framework. The report addresses the impacts of climate change on heat stress, extreme weather events, air quality, flooding, vector-borne disease, water quality, water supply, and waterborne illness. The report also addresses issues related to capacity building and economic resilience. These are both important considerations when developing a nationwide systems-based approach—local communities may not have built-in capacity to fund or manage climate adaptation projects; and implementation of climate adaptation projects must also be sensitive to impacts on local economies. The report includes a brief, 22-page menu of Climate Adaption Strategies, as well as in-depth (100+ pages) Climate Adaptation Framework reports for each of the 23 cities included in the assessment.	**NO**
26	Hurricane Ida (2021)		Case Study	US	In August 2021, Hurricane Ida made landfall near Port Fourchon, Louisiana with maximum sustained winds of 150 mph. The storm caused significant damage to homes and infrastructure in Louisiana—for example, 100% of homes in Grand Isle were damaged and 40% were destroyed. Damage to energy infrastructure caused widespread, long duration power outages to millions of people. The remnants of Ida travelled northeast, impacted southern, middle Atlantic, and northeastern states. In the Northeast, Ida merged with a frontal system, creating severe weather and flash flooding in eastern Pennsylvania and New York, causing dozens of fatalities. Central Park recorded	**NO**
27	Midwest Derecho and Tornado Outbreak (2021)		Case Study	US	In December 2021, a rare derecho and tornado outbreak caused widespread damage in Kansas, Nebraska, Iowa, Minnesota, and Wisconsin. Derechos, which are widespread, long-lived windstorms, are more common during the summer months. This event was the first December derecho on record in the United States, and also produced the first December tornado on record in Minnesota since 1950. During the event, there were reports of hurricane-force wind gusts and more than 50 tornados. Damage to homes, vehicles, businesses, and infrastructure was estimated and $1.8 billion.	**NO**
28	Pacific Northwest Heatdome (2021)		Case Study	US	In late-June 2021, the U.S. Pacific Northwest and Western Canada experienced several days of temperatures over 100 degrees. Record-breaking temperatures melted power cables and caused roads to buckle. The event caused at least 138 deaths in Washington State. The U.S. Centers for Disease Control and Prevention (CDC) estimated approximately 600 deaths caused by the heat wave in the U.S., while Canadian officials reported more than 400 heat-related deaths in British Columbia.	**YES**
29	2020 Western Wildfire Season (2020)		Case Study	US	The 2020 California Wildfire Season is arguably the worst fire year on record on the U.S. west coast. In California along, the 2020 Fire Siege caused 31 fatalities (including three firefighters), destroyed 9,248 structures, and burned 4.2 million acres. In total, this fire season resulted in 10.2 million acres burned, 46 fatalities, and approximately $17.9 billion in damage. These wildfires destroyed several small towns in California, Oregon, and Washington. Dense wildfire smoke produced hazardous air quality that affected millions of people for several weeks. During wildfire events, public utilities in California are allowed to proactively cut power to electrical lines to reduce the risk of electrical infrastructure causing wildfires. During the 2020 wildfire season, as with other recent years, power utilities such as PG&E shut off power to hundreds of thousands of homes to prevent additional wildfires.	**NO**
30	Missouri River and North Central Flooding (2019)		Case Study	US	Missouri River flooding in March 2019 impacted Nebraska, Iowa, Missouri, North Dakota, South Dakota, Minnesota, Wisconsin, and Michigan, causing an estimated $12.1 billion in damage. The flood was triggered by a heavy precipitation storm even that intensified snow melt, which exacerbated flooding. The event inundated millions of acres, impacting agriculture and municipalities, and caused damage to roads, bridges, levees, and dams. Offutt Air Force Base in Nebraska was severely flooded.	**YES**
31	Building a Climate-Resilient City	Prairie Climate Centre	General Literature	Canada	Series of reports on multiple aspects of building a climate resileint city, split by sectors	**NO**
32	Advancing the Climate Resilience of Canadian Infrastructure: A review of literature to inform the way forward	IISD	General Literature	Canada	Report summarizing lessons learned from literature review on strategies to increase resiliency of Canadian Infrastructure	**NO**
33	Federal Adaptation Policy Framework for climate change	Government of Canada	General Literature	Canada	Federal guideline to guide domestic action by the GCC to address adaptation to the impacts of climate change, setting out a vision, roles of the Federal government. **Important source to benchmark policy recommendations for NAS.**	**NO**
34	Canada National Adaptation Strategy	Government of Canada	General Literature	Canada	Website with the current background of the NAS development. Necessary context for our report.	**NO**
35	An Emergency Management Framework for Canada - Third Edition	Government of Canada	General Literature	Canada	Framework to support legal and policy frameworks, programs, activities and standards to enable and inspire emergency management partners to improve emegrency management practices.	**NO**
36	RESILIENCE STRATEGIES AND APPROACHES TO CONTAIN SYSTEMIC THREATS	OECD	General Literature	Global	Research paper / report discussing how to incorporate resileincy in complex, interrelated systems to address systemic threats.	**NO**
37	A systemic resilience approach to dealing with Covid-19 and future shocks	OECD	General Literature	Global	Paper discussing how an insular approach to managing risk and responses to crisis is ineffective to address systemic risks posed by events such a pandemic as it does not address the complex interconectedness of various systems	**NO**

38	National Cross Sector Forum 2021-2023 Action Plan for Critical Infrastructure	Government of Canada	General Literature	Canada	Action plan outlining some of the strategies being taken to update the "National Strategy for Critical Infrastructure" Canada's approach for strengthening the resilience of critical infrastructure.	**NO**
39	Rural Climate resiliency in Latin America	FAO	General Literature	LATAM & Africa	Brief case studies of rural community based climate adaptation meassures in LATAM	**NO**
40	Anticipate, react, recover: Resilient infrastructure systems	National Infrastructure Commission	General Literature	UK	Independent committee recommdations for a resiliency 'framework' that better anticipates future shocks and stresses (by facing up to uncomfortable truths); improves actions to resist, absorb and recover from shocks and stresses (by testing for vulnerabilities and addressing them); and values resilience properly in order to drive adaptation.	**YES**
41	National Infrastructure Assessment - Baseline Report	National Infrastructure Commission	General Literature	UK	Summary of current state of national systems (digital, energy, flood resilience, water waste & transport); with a forward, strategic focus on 3 items: reaching net zero, climate resilience, and leveling up.	**NO**
42	Eyre Peninsula (Australia)	Coast Adapt	Case Study	Asia & Oceania	A strategy was developed to address climate impacts, including increasingly frequent inundation of coastal infrastructure. A plan was developed using participatory techniques for decision-making under uncertainty to produce sequenced pathways combining management and structural measures to adapt to increasing risks.	**NO**
43	Sponge City (Hong Kong)	Richard Leung, Drainage Service Department	Case Study	Asia & Oceania	Prone to tropical cyclones and with an average annual rainfall of 2400mm, Hong Kong is one of the world's wettest cities. Considering future climate impacts, the Drainage Services Department (DSD) of Hong Kong, China is implementing a nature-based drainage system with the aim of building up flood resilience and improving public spaces, instead of constructing flood resistance infrastructure.	**NO**
44	National Climate Adaptation Strategy 2016 (Dutch: Nationale klimaatadaptatiestrategie 2016-NAS)	Ministry of Infrastructure and Environment, Kingdom of The Netherlands	SBA-CRI / Framework	Europe	The NAS charts the effects of climate change for nine sectors in four schemes - warmer, wetter, drier and sea level rise - water and space; nature; agriculture, horticulture and fishing; health; recreation and tourism; infrastructure (road, rail, water and also aviation); energy; IT and telecom; safety. The NAS is the prelude to a Climate Adaptation Implementation Programme, which builds on all implementation that has already been initiated, such as by the Delta Programme. Where supplementation and acceleration is necessary, the Implementation Program will provide for this, with sufficient capacity and resources from the parties involved. The Delta Program also contributes to implementation, for example by drawing up the Delta Plan on Spatial Adaptation. Together with the knowledge institutions, the Ministry of Infrastructure and the Environment will explore how a basic facility can be set up, within which central government, provinces, municipalities, water boards and the other parties involved can monitor their progress in the implementation programme. Coordination with the monitoring program for the Delta Program is the starting point.	**YES**
45	Implementation program 2018 – 2019 National climate adaptation strategy (Dutch: Uitvoeringsprogramma 2018 – 2019 Nationale klimaatadaptatiestrategie-NAS)	Ministry of Infrastructure and Environment, Kingdom of The Netherlands	SBA-CRI / Framework	Europe	The aim of the document is that climate adaptation becomes part of policy, policy implementation and relevant activities of governments, civil society organisations, residents and companies. In 2020, it must be clear who has or assumes which responsibility for the urgent climate risks. In this way, the consequences of climate change remain manageable. Together with partners, the authorities make agreements about concrete goals, actions to be taken, the division of tasks and responsibilities. This is mainly done through action-oriented climate adaptation dialogues. In these dialogues, the parties involved give substance to the action lines from the NAS2016. The bulb diagrams – a representation of the climate effects per climate trend – provide a substantive basis.	**NO**
46	National Delta Program 2022 (Dutch: Nationaal Deltaprogramma 2022)	Ministry of Infrastructure and Environment-Ministry of Agriculture, Nature and Foodsecurity-Ministry of Interior, Kingdom of The Netherlands	SBA-CRI / Framework	Europe	The Delta Program contains three Delta Plans with studies, measures and facilities for flood risk management, spatial adaptation and freshwater supplies in the Netherlands. The programming of the measures is detailed for the first six years and indicative for the twelve years thereafter, with a look ahead to 2050. In Delta Program 2022 you will find the following topics: Chapter 1: the administrative introduction and outlines for continuing to work effectively on a climate-proof Netherlands Chapter 2: about the working method of the program, including attention to knowledge development, the relationship with other transitions, participation and international developments Chapter 3: progress in the field of flood risk management, including the Delta Plan on Flood Risk Management Chapter 4: progress in the field of freshwater, including the Delta Plan on Freshwater Chapter 5: progress in the field of spatial adaptation, including the Delta Plan on Spatial Adaptation	**NO**
47	National perspective climate adaptation - Evaluation NAS 2017-2019 (Dutch: Nationaal perspectief klimaatadaptatie)	Programteam NAS (Several ministries, regional governments, NGO), Kingdom of The Netherlands	SBA-CRI / Framework	Europe	In 2017, an implementation program was made for the period 2018-2019 (UP NAS). The implementation of the NAS focuses on important climate impacts that are not yet addressed (in other programs). The NAS Program Team reflects on the first three years (2017-2019) of the NAS with the National Climate Adaptation Perspective. The report also offers guidelines and starting points for the follow-up.	**NO**
48	German adaptation strategy to climate change (German: Deutsche Anpassungsstrategie an den Klimawandel)	Federal Government, Germany	SBA-CRI / Framework	Europe	The German Adaptation Strategy (DAS-2008) creates a framework for adapting to the consequences of climate change in Germany. This strategy primarily represents the contribution of the federal government and thus offers orientation for other actors. It lays the foundation for a medium-term process in which the risks are identified step by step with the countries and social groups, the possible need for action is named, the corresponding goals are defined and possible adaptation measures are developed and implemented. The German Adaptation Strategy thus follows an integral approach to assessing risks and the need for action, it supports sustainable development and reflects Germany's international responsibility.	**NO**
49	Monitoring report 2019 on the German adaptation strategy to climate change (German: Monitoringbericht 2019 zur Deutschen Anpassungsstrategie an den Klimawandel)	Federal Government, Germany	SBA-CRI / Framework	Europe	As part of the DAS, the federal government is now presenting the second monitoring report for 2019. It underpins the effects of climate change with scientifically verified data and informs the public and decision-makers in all areas of social life about the observed consequences of climate change. The 2015 monitoring report will be updated as a result, further updates are to be made every four years in the future. Using indicators selected by experts and measured data from the 15 fields of action, the report shows which changes can already be identified in Germany due to climate change and which countermeasures are already taking effect.	**NO**
50	Climate impact and risk analysis 2021 for Germany (German: Klimawirkungs- und Risikoanalyse 2021 für Deutschland)	Ministry of Environment, Federal Government of Germany	SBA-CRI / Framework	Europe	This report contains the summary of the "Climate Impact and Risk Analysis 2021 for Germany" (KWRA 2021). The KWRA 2021 is an essential basis for the further development of adaptation in Germany, in particular for the development of the next adaptation action plans of the federal government.	**NO**

51	Belgium National Adaptationplan 2017-2020 (Flemish: Belgisch Nationaal Adaptatieplan 2017-2020)	National Climate Committee	SBA-CRI / Framework	Europe	The NKC's (National Climate Committee) Adaptation working group was charged with drafting this NAP to: ◗◗ to be able to provide clear and concise information about the adaptation policy and its implementation in Belgium; ◗◗ to be able to identify measures of national scope to strengthen cooperation and develop partnerships between the different governments (federal, regions) in the field of adaptation.	**NO**
52	Belgium National Adaptationplan 2017-2020: Final evaluation of the implementation (Flemish: Belgisch Nationaal Adaptatieplan 2017-2020: Eindevaluatie van de implementatie)	Federal Government of Belgium	SBA-CRI / Framework	Europe	When developing the national adaptation plan, monitoring indicators have been proposed to facilitate monitoring of implementation. A work plan and, if relevant, a budget was also determined for each measure. For each measure in the plan, a monitoring sheet was drawn up by the person responsible for the implementation of the measures (as in the mid-term evaluation and determined in the plan). The monitoring sheets for the 11 measures can be found under "Fiches final evaluation NAP"	**NO**
53	EVALUATION OF THE SOCIO-ECONOMIC IMPACT OF CLIMATE CHANGE IN BELGIUM	National Climate Committee	SBA-CRI / Framework	Europe	This report provides an overview of the socio-economic impact of climate change in Belgium, resulting from a literature-based study conducted between November 2019 and July 2020	**NO**
54	Cloudburst Management Plan 2012, City of Copenhagen	City of Copenhagen	SBA-CRI / Framework	Europe	This Cloudburst Management Plan is an offshoot of the Copenhagen Climate Adaptation Plan. The Cloudburst Management Plan outlines the methods, priorities, and measures recommended for the area of climate adaptation including extreme rainfall. With this Plan, we have taken decisive steps forward to protect Copenhagen against high-intensity rain like the ones witnessed in August 2010 and again in July and August 2011.	**YES**
55	COPENHAGEN CLIMATE ADAPTATION PLAN	Miljø Metropolen	SBA-CRI / Framework	Europe	Outline the challenges the city faces in the short and medium terms as a result of changes expected in the future climate. Identify solutions that, based on present-day knowledge, appear to be most appropriate and reveal the opportunities climate change may also present to the city	**NO**
56	How to manage cloudburst and rain water, Action Plan for a climate Proof Denmark, Dec 2012	Danish Nature Agency	SBA-CRI / Framework	Europe	This Action plan for a climate-proof Denmark provides an overview of the initiatives that the government has either planned, or already set in motion, to ensure that Denmark will become more resilient to climate change.	**NO**
57	French National Climate Adaptation Plan 2, 2018-2022 (French: PNACC 2), Dec 2018	MINISTER FOR THE ECOLOGICAL AND INCLUSIVE TRANSITION	SBA-CRI / Framework	Europe	The objective of the second French National Adaptation Plan for Climate Change (PNACC-2) for the period 2018-2022 is to better prepare the French society to climate change, involving the main sectors of the economy (agriculture, industry, tourism) and territories. Based on the recommendations of the assessment of PNACC 2011-2015, the development of PNACC-2 was based on a national consultation that mobilized over 300 representatives from civil society, experts and representatives of local authorities and ministries.	**YES**
58	Working towards a 2nd French National Adaptation Plan for Climate Change: Challenges and Recommendations	MINISTER FOR THE ECOLOGICAL AND INCLUSIVE TRANSITION	SBA-CRI / Framework	Europe	Challenges and recommendation towards the second Nartional climate adaptation plan	**NO**
59	CLIMATE ACTION PLAN OF THE MINISTRY FOR THE ECONOMY, FINANCE AND THE RECOVERY, FRANCE	MINISTRY FOR THE ECONOMY, FINANCE AND THE RECOVERY	SBA-CRI / Framework	Europe	Although this Climate Action Plan is not exhaustive, it marks the first time that MEFR's key climate-related programmes and initiatives have been compiled in one place. It addresses each of the points contained in the Prime Minister's letter. As requested, it places particular emphasis on how the ministry is working with the business community to make the environmental transition a reality (point 2). It also includes a set of indicators for monitoring progress (Appendix 7).	**NO**
60	Nordic Sustainable Debt State of the Market 2020	EBRD	General Literature	Europe	This report describes and analyses the latest developments in the Nordic sustainable debt finance landscape. Following from the inaugural Nordic Green Bond State of the Market report published in 2018, this paper provides an updated and extended overview of the shape and size of the green, social and sustainability (GSS) themed debt market in all five regional countries: Sweden, Norway, Denmark, Finland, and Iceland. The analysis also covers the growth potential of GSS bonds and climate finance, including through unlabelled investments into climate change solutions. Finally, the report includes an in-depth look into the policy landscape and other drivers of the Nordic sustainable finance agenda. All data in the report is up to the end of 2020, as of February 28th, 2021, unless otherwise specified.	**NO**
62	Reflecting on Queensland's 2018 recovery	Brendan Moon, Queensland Reconstruction Authority	Case Study	Asia & Oceania	In 2018, 48 of Queensland's 77 local government areas received natural disaster assistance following multiple flood events. The Queensland Reconstruction Authority, Australia's only permanent disaster recovery organisation, reflects on recovery successes and challenges from these events	**NO**
66	An Unmitigated Disaster: Shifting from Response and Recovery to Mitigation for an Insurable Future (Australia)	Springer	Case Study	Asia & Oceania	This article critically examines the call for a shift in funding priority towards pre-disaster mitigation measures, in the context of growing concerns around the ability of households to access and afford insurance. It examines mitigation measures in the context of three prominent Australian disasters: the Black Saturday bushfires (Victoria, 2009), the	**NO**
75	Energising Singapore: Balancing Liveability and Growth	Center for liveable cities Singapore	Case Study	Asia & Oceania		**NO**
64	Final and partial evaluations of the Room for the River program (Dutch: Eind- en deelevaluaties programma's Ruimte voor de Rivier)	Ministry of Infrastructure and Environment, Kingdom of The Netherlands (Berenschot / REBEL)	Case Study	Europe	On 19 December 2006, with the unanimous approval of the Key Planning Decision - Room for the River (part 4), both the Senate and the House of Representatives started the Room for the River programme. The House of Representatives has requested the final evaluation Room for the River. Partial evaluations carried out to: 1. Water safety target range. 2. Spatial quality target range. 3. Administrative cooperation. 4. Program Control. 5. Communication strategy. Evaluations have also been carried out at the theme level, into Archaeology, Nature Realisation, Innovation and Soil.	**NO**
65	High Water 2021 Facts and Interpretation (Dutch: Hoogwater 2021 Feiten en Duiding)	Expert Network Watersafety (Ministry of Infrastructure and Environment, Kingdom of The Netherlands)	Case Study	Europe	In July of 2021, large areas in the province of Limburg in the Netherlands (as well as Germany & Belgium) were affected by extreme rainfall and floods. Also large parts of particularly Belgium and Germany were flooded, which led to high damages, losses and hundreds of casualties. The floods are considered an extreme event with enormous impact and an exploratory fact-finding study has therefore been conducted to collect and analyse information. A broad consortium of knowledge institutes participated in this effort: Delft University of Technology, Deltares, HKV Consultants, VU Amsterdam, University of Utrecht, KNMI, Wageningen University and Research, Erasmus MC and University of Twente. The project was commissioned and supported by the Dutch Expertise Network for Flood Protection (ENW). The regional water authority Limburg and Rijkswaterstaat (executive body of the Dutch Ministry of Infrastructure and Water Management) contributed by providing information, accompanying field visits and participating in interviews. As flooding impacts all parts of a community, this fact-finding study not only includes hydrological and civil engineering topics, attention is also given to the societal impacts of the floods, evacuation and response and the health impacts from the floods.	**YES**
76	Key Elements of Attentions for Enhancing Urban Resilience: A Comparison of Singapore, Hong Kong and Hangzhou		Case Study	Asia & Oceania		**NO**
67	Rotterdam adaptation strategy 2013 (Dutch: Rotterdamse adaptatiestrategie 2013)	Municipality of Rotterdam, The Netherlands	SBA-CRI / Framework	Europe	The Rotterdam adaptation strategy sets out the course along which Rotterdam wants to adapt to climate change. The aim is a climate-proof city for the inhabitants of Rotterdam today and for future generations. This is a city that is also attractive and economically vital.	**NO**

77	A climate resilient singapore for a sustainable future, Climate Action Plan	Ministry of the Environment and Water Resources	Case Study	Asia & Oceania		**NO**
69	Climate-resilient Infrastructure	OECD	General Literature	Global	Key sections of the reports are: 1) Defining climate-resilient infrastructure, 2) Planning and designing climate-resilient infrastructure , 3) Strengthening the enabling environment for climate-resilient infrastructure, 4) Mobilising investment in climate-resilient infrastructure,5) Coverage of infrastructure in national climate risk assessments in OECD and G20 countries, 6) Useful tools and reports	**YES**
70	INTERNATIONAL GUIDELINES ON NATURAL AND NATURE-BASED FEATURES FOR FLOOD RISK MANAGEMENT	U.S. Army Engineer Research and Development Center	SBA-CRI / Framework	Global	This report showcases the International Guidelines on Nature and Nature-Based Features (NNBF) for Flood Risk Management which intends to provide practitioners with the best available information concerning the conceptualization, planning, design, engineering, construction, and maintenance of NNBF to support resilience and flood risk reduction for coastlines, bays, and estuaries, as well as river and freshwater systems.	**NO**
71	A Catalogue of Nature-Based Solutions for Urban Resilience	World Bank	General Literature	Global	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. The document is structured as follows: Chapter 2 describes generic principles for integrating NBS into urban environments. Chapter 3 provides a reader's guide and holds the Catalogue of the fourteen NBS families.	**YES**
72	Zwolle is preparing for the new climate: An adaptation strategy for every resident of Zwolle (Dutch: Zwolle maakt zich op voor het nieuwe klimaat; Een adaptatiestrategie voor iedere Zwollenaar)	Municipality of Zwolle, The Netherlands	SBA-CRI / Framework	Europe	The changing climate will affect everyone. Especially in the delta city of Zwolle, where the water comes from five sides: from the air, via the soil, via the Rhine and IJssel, from the IJsselmeer and via the Vecht and the Sallandse weteringen. The city center may be subject to flooding due to increasingly extreme weather conditions. In order to be a climate-robust, green, liveable city by 2050, Zwolle has developed its own adaptation strategy: the Zwolle Adaptation Strategy. With this strategy and the possible solutions it contains, Zwolle wants to offer residents and companies the prospect of a resilient and adaptively designed Zwolle.	**NO**
73	Nature-based solutions for adapting to water-related climate risks	OECD	SBA-CRI / Framework	Global	This policy paper focuses on the role of nature-based solutions (NbS) in limiting and managing the current and future impacts of climate change, focusing on water-related risks. It will highlight how NbS may also support a greening of the recovery from the COVID-19 crisis.	**NO**
78	A resilient Singapore	Center for liveable cities Singapore	Case Study	Asia & Oceania		**NO**
79	Towards a sustainable and resilient singapore	Ministry of Foreign Affairs	Case Study	Asia & Oceania		**NO**
80	Sustainability Report 2020-2021	Singapore National Water Agency	Case Study	Asia & Oceania		**NO**
61	Queensland, Prevention, Preparedness, Response and Recovery Disaster Management Guideline, Jan 2018	Queensland Fire and Emergency Services	General Literature	Asia & Oceania	This guideline outlines a comprehensive end-to end process for the steps to be undertaken through each of the phases of disaster management, specifically addressing roles and responsibilities of disaster management stakeholders, prevention and mitigation strategies, preparedness arrangements and considerations for planning, the activation of response arrangements, the recovery process and financial arrangements	**NO**
74	Preparing for a Climate Resilient Singapore	Center for liveable cities Singapore	General Literature	Asia & Oceania	This Urban Systems Study documents Singapore's efforts to address climate change. Since its independence, Singapore has sought to balance economic development with concern for a clean and sustainable environment. As the seriousness of climate change becomes clearer, efforts have been stepped up to mitigate carbon emissions and adapt to projected changes. Working domestically and cooperating internationally, Singapore has adopted innovative, forward-looking and integrative solutions to address this existential challenge, recognising that ultimately, a liveable city must be a climate resilient one. This book highlights Singapore's past and ongoing efforts to reach this goal.	**YES**
101	Elaborating a systems methodology for cascading climate change impacts and implications	Cradock-Henry, Nicholas; Connoly, Justin; Blacket, Paula; Lawrence, Judy	General Literature	Asia & Oceania	Paper discussing how to account for interconnectedness of systems	**NO**
63	TACKLING CLIMATE CHANGE, BUILDING CLIMATE AND DISASTER RESILIENCE, AND ENHANCING ENVIRONMENTAL SUSTAINABILITY, 2019–2024	ADB	SBA-CRI / Framework	Asia & Oceania	This operational plan builds on the general thrusts and emerging lessons learned from the implementation of the Climate Change Operational Framework, 2017–2030; Integrated Disaster Risk Management Operational Plan, 2014–2020; Environment Operations Directions, 2013–2020; and Water Operational Plan, 2011–2020, while taking a more integrated and holistic approach to reflect the varied and crosscutting nature of actions required for tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability.5 In addition, the operational plan supports the implementation of ADB's action plan for healthy oceans and sustainable blue economies, 2019–2024.6	**NO**
81	EU technical guidance on climate-proof infrastructure	European Commission	SBA-CRI / Framework	Europe	The purpose of this Notice is to give technical guidance on the climate proofing of investments in infrastructure covering the programming period 2021-2027	**NO**
82	10 case studies How Europe is adapting to climate change	European Environment Agency	SBA-CRI / Framework	Europe		**NO**
83	Sustainable Development Strategy (for Highways)	Highways England	General Literature	UK	Brief strategy covering the approach to sustainable development across five factors: Financial, Human, Natural, Social & Manufactured	**NO**
84	Climate Change Strategy 2021-2024	UK Export Finance	SBA-CRI / Framework	UK	UK Export Finance is a government department that exists to support overseas investments, complementing private sector financing. Climate change impact is a key factor in their investment decision making process; this report sets out the enabling factors used in their assessment approach.	**NO**
85	Hurricane Sandy Rebuilding Strategy	Hurricane Sandy Rebuilding Task Force	SBA-CRI / Framework	US	In August 2013, the Hurricane Sandy Rebuilding Task Force issued the "Hurricane Sandy Rebuilding Strategy" to support the rebuilding of the region affected by the 2012 hurricane. The report contains policy recommendation on ensuring a regionally coordinated and resilient approach to infrastructure investment. It aimed to build back smarter and stronger infrastructure by: aligning federal funding with local rebuilding visions; reducing excessive regulation; coordinating the efforts of the federal, state, and local governments, with a region-wide approach to rebuilding; and ensuring the region's climate change and disaster resilient rebuilding.	**NO**
86	Fort McMurray Wildfire: Learning from Canada's costliest disaster	Institute for Catastrophic Loss Reduction	Case Study	Canada	The Fort McMurray wildfire was, at the time, the costliest disaster in Canada's history. This document is a post-event disaster review, providing a comprehensive assessment of resilience actions taken before the fire, during the recovery, and after the fire.	**YES**

87	Forewarned and Forearmed: The Calgary Emergency Management Agency and the 2013 Flood by the Conference Board of Canada Calgary's Flood Resilient Future by the Expert Management Panel on River Flood Mitigation Review and Analysis of the Government of Alberta's Response to and Recovery from 2013 Floods by MNLP LLP	https://www.calgary.ca/UEP/Water/Documents/Water-Documents/Flood-Info-Documents/Expert-Management-Panel-Report-to-Council.pdf https://www.conferenceboard.ca/e-library/abstract.aspx?did=6329 https://open.alberta.ca/dataset/48bd39ee-2a5a-4846-944d-6004e0a8a498/resource/8404f003-1bde-49d9-a953-d37e0d671dac/download/2013-flood-response-report.pdf	Case Study	Canada	In 2013, over 30 communities in Southern Alberta were subject to a State of Emergency in one of the worst flooding events in the province's history, and one of the largest natural disasters in Canadian history. The estimated total cost of recovery was enormous, at over $5 billion, and five lives were lost while approximately 100,000 people were asked to evacuate their homes. The Alberta Emergency Management Agency (AEMA) and the Government of Alberta (GoA) both conducted independent post-event reviews. The City of Calgary also established the Expert Management Panel on River Flood Mitigation - an independent body to investigate managing flood risk; watershed management; event forecasting; storage, diversion, and protection; infrastructure and property resiliency; and changing climate.	**YES**
88	Independent Assessment of UK Climate Risk	Climate Change Committee (UK)	General Literature	UK	An Independent Assessment of UK Climate Risk, prepared as Staututory Advice for the Government, sets out the priority climate change risks and opportunities for the UK; drawing on an extensive programme of analysis & consultation. Includes 10 recommended principles for good adaptation planning. All outputs from the UK Climate Risk Independent Assessment (CCRA3) are hosted at www.ukclimaterisk.org	**NO**
68	A SYSTEM-WIDE APPROACH FOR INFRASTRUCTURE RESILIENCE, Jan 2021	ADB	SBA-CRI / Framework	Asia & Oceania	This report highlights three key recommendations to help build infrastructure systems that will be resilient to the changing climate as well as lowering costs, supporting fiscal stability, and facilitating growth and development. However, this is only the start of a discussion on this new agenda and there is much more to learn. This report is therefore a call for action, and encourages the piloting, testing and learning of these new approaches in planning, delivering, financing, and managing national infrastructure plans.	**NO**
89	National Disaster Risk Reduction Framework, 2018	Commonwealth of Australia	SBA-CRI / Framework	Asia & Oceania	The National Disaster Risk Reduction Framework ('the framework') guides national, whole-of-society efforts to proactively reduce disaster risk in order to minimise the loss and suffering caused by disasters.	**NO**
90	THE FIRST NATIONAL ACTION PLAN To implement the National Disaster Risk Reduction Framework	Australian Government, Department of Home Affairs	SBA-CRI / Framework	Asia & Oceania	On 13 March 2020, the Council of Australian Governments endorsed the Framework and tasked emergency management ministers to develop a National Action Plan to implement the Framework.	**NO**
91	AUSTRALIAN DISASTER PREPAREDNESS FRAMEWORK, 2018	Australian Government, Department of Home Affairs	SBA-CRI / Framework	Asia & Oceania	The Australian Disaster Preparedness Framework (the Framework) will support Australia to develop the required capability to effectively prepare for and manage severe to catastrophic disasters	**NO**
93	Global Compendium of good practices on post disaster recovery	EU, UN, WB	General Literature	Global	This systemization prepared by the United Nations Development Programme (UNDP) compiles Good Practices on Post Disaster Recovery, to disseminate and highlight the work and recovery processes that are being carried out in different countries of the following regions: Africa, Asia, East Europe (ECIS) and Latin America and the Caribbean (LAC)	**YES**
94	Sustainable Reconstruction & Recovery Framework For The Southern & Eastern Mediterranean	EBRD and UN Habitat and World Green Building Council	SBA-CRI / Framework	Global	Sustainable Reconstruction and Recovery Framework is a toolkit for building back better through a sustainable built environment	**NO**
95	A Framework and Principles for Climate Resilience Metrics in Financing Operations	AIIB-EBRD, IDB, EIB, IDFC, ISDB, ADB	SBA-CRI / Framework	Global		**NO**
96	Final Report ADVISORY TABLE ON RESILIENT NATURAL AND BUILT INFRASTRUCTURE	Government of Canada	General Literature	Canada	Report outlining the transofrmational goals for the NAS	**NO**
97	Resilience Assessment of Interdependent Infrastructure Systems: A Case Study Based on Different Response Strategies	Kong, K.; Slobodan; S., Zhang Ch.	General Literature	Canada	Taking advantage of network theory, this paper models street network, water supply network, power grid and information infrastructure network as layers that are integrated into a multilayer network. This study can assist municipal decision makers in (i) better understanding the effects of different response strategies on the resilience of interdependent infrastructure system, and (ii) deciding which strategy should be adopted under different types of disasters	**NO**
98	A Two-Stage Restoration Resource Allocation Model for Enhancing the Resilience of Interdependent Infrastructure Systems	Kong, K.; , Zhang Ch.; Slobodan; S.	General Literature	Canada	To enhance the resilience of infrastructure systems after a large-scale disruptive event, determining where and when to invest restoration resources is a challenge for decision makers. The results show that: (1) the restoration resource allocation strategy obtained from the proposed approach balances the recovery time and the overall losses to infrastructure systems; and (2) the value of the usage cost of the unit restoration resource has a significant impact on the recovery time and the overall losses under different strategies. The proposed model is both effective and efficient in solving the post-disaster resource allocation problem and can provide decision makers with scientific decision support.	**NO**
99	Lineamientos de Operación Específicos del Fondo de Desastres Naturales publicados el 31 de enero de 201	Government of Mexico	General Literature	LATAM & Africa	Legislation outlining processes to federally finance post disaster efforts at the statal level.	**NO**
100	Fraser Basin Council Floodplain Manaagement	Fraser Basin Council	Case Study	Canada	Strategy for Floodplain management at the lower mainland. Involves multiyear projects and various reports.	**NO**
92	National Strategy for Disaster Resilience, 2011	Council of Australian Governments	SBA-CRI / Framework	Asia & Oceania	The purpose of the Strategy is to provide high-level guidance on disaster management to federal, state, territory and local governments, business and community leaders and the not-for-profit sector.	**NO**
102	Australian Emergency Management Arrangements	Australian Government	SBA-CRI / Framework	Asia & Oceania	The handbook establishes a set of principles that are intended to underpin and guide emergency management activities. It also describes the emergency management roles and responsibilities of all levels of government, non-government organisations (NGOs), businesses, communities and individuals. Arrangements and responsibilities for the comprehensive approach to emergency management - prevention, preparedness, response and recovery (PPRR) are discussed. These arrangements support emergency management in Australia through the concepts of an 'all hazards' approach and 'shared responsibility.	**YES**