Good Practices for Integrated Climate Change Adaptation

IN CANADIAN COASTAL COMMUNITIES

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Aussi disponible en français : Pratiques exemplaires pour l'adaptation intégrée aux changements climatiques dans les collectivités côtières canadiennes.

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Contents

SUMMARY

Integrated adaptation is a holistic, systems-scale approach to addressing climate change impacts and building climate resilience. It requires collaboration between governments, Indigenous rights holders and organizations, landowners, businesses, non-government organizations as well as those most impacted by climate change and who may not historically have been involved in decision making. Integrated adaptation results in co-development of adaptation solutions across a range of scales, jurisdictions, and mandates. In coastal regions, integrated adaptation must recognize the coast as a dynamic and interconnected system, encompassing physical (land and water), ecological, social, and economic systems.

While integrated approaches to climate change adaptation have been applied in Canada and elsewhere, the development and implementation of integrative solutions remain challenging. This publication, targeted at adaptation practitioners and decision-makers, highlights six good practices that can assist the development of integrative solutions, namely:

1. Choosing an appropriate boundary/scale for analysis that considers complete natural and human systems;
2. Seeking or establishing collaborative governance mechanisms to support policy integration;
3. Defining adaptation pathways and avoiding unsustainable approaches;
4. Using an adaptive risk management approach supported by monitoring and evaluation;
5. Considering transformational adaptation options in addition to incremental actions; and
6. Leveraging nature-based solutions for added benefits and opportunities.

The checklist and case studies included in this report illustrate how these good practices have been applied in the development of adaptation plans. Despite a growing number of examples of successful processes, barriers to achieving transformational changes remain. Policy makers can take certain actions to overcome these barriers by making changes to legislation, regulations and funding mechanisms.

PREFACE

This publication has been adapted from a project commissioned by the Climate Change Impacts and Adaptation Division of Natural Resources Canada and conducted by Zuzek Inc.[1] The original reports from the project provide an extensive literature review,[2] summaries of interviews with adaptation practitioners, examples of completed projects and initiatives, and case studies from Canada and the United States.[1] The reports provide recommendations to policy and decision-makers on legislation, funding and capacity-building needs to improve integrated coastal adaptation management. For more information, readers are encouraged to access the complete **Zuzek Inc. reports, available at https://zuzekinc.com/resources/.**

This publication is designed for adaptation practitioners and decision-makers striving to enhance climate resilience in their jurisdictions. While based largely upon the content of Zuzek Inc.,[1, 2] it also includes concepts highlighted in other relevant publications, including the 6th Assessment Report of the Intergovernmental Panel on Climate Change.[3]

INTRODUCTION

The risks that climate change presents to coastal communities and environments are well documented, both within Canada and globally.[e.g., 4, 5] These include risks to critical infrastructure, ecosystems, and human health and well-being linked to changing water levels, increasing frequency and magnitude of extreme weather events (such as severe storms, storm surges, and heat waves), reduced ice cover, permafrost degradation, and other impacts. In 2019, an expert panel assembled by the Council of Canadian Academies concluded that impacts on coastal communities were among the greatest climate change risks facing Canada. Importantly, the panel emphasized that effective adaptation actions have the potential to significantly reduce these risks.[6]

About 40% of Canadians live either along a marine coast (6.5 million) or in the Great Lakes – St. Lawrence basin (8.5 million) (Figure 1). Assessments of climate change impacts and adaptation[7, 8] provide evidence of observed and projected climate impacts to natural, social, and economic systems. These studies also highlight practical knowledge and experience in adapting to these impacts. However, when it comes to coastal regions, Canada's efforts to adapt to climate change have mostly focused on critical infrastructure, leaving many gaps in Canada's overall preparedness for climate change.[9, 10]

The goal of this report is to highlight the importance of integrated adaptation planning for addressing the range of climate and non-climate risks facing Canada's coastal regions, as recently highlighted by Zuzek Inc.[1] (see Preface). The report emphasizes six good practices that should be considered during adaptation planning and implementation in coastal communities. It should be noted that these practices are relevant to all settings, not only coastal areas. The guidance in this report is most relevant when establishing adaptation planning processes or reviewing and updating existing processes. It is intended to complement more detailed resources and guidance documents available for community and coastal adaptation (see Annex 1). Definitions of key technical terms used in this report can be found in Box 1.

Key technical terms used in this paper (definitions are from Intergovernmental Panel on Climate Change assessment reports,[11, 12] unless referenced otherwise).

Adaptation – In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. Its overall aim is to maintain and increase the resilience and reduce the vulnerability of ecosystems, infrastructure, and people in the face of the adverse effects of climate change.

- **Incremental adaptation** – Adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale.
- **Transformational adaptation** – Adaptation that changes the fundamental attributes of a social-ecological system in anticipation of climate change and its impacts.
- **Integrated adaptation** – An inclusive process that relies on multi-disciplinary teams made of public, private, NGO, and Indigenous groups working together to co-develop coordinated adaptation actions at the appropriate scale needed to address climate change risks, along with other priorities.

Adaptive management – A process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change. It involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.

Integrated coastal management – A dynamic, multidisciplinary, and iterative process to promote sustainable management of coastal zones.

Maladaptation – Actions that may lead to increased risk of adverse climate-related outcomes.

Nature-based solution (NBS) – Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

Pathways – The temporal evolution of natural and/or human systems towards a future state. Pathway approaches typically focus on biophysical, techno-economic, and/or socio-behavioural trajectories and involve various dynamics, goals, and actors across different scales.

- **Adaptation pathways** – A series of adaptation choices involving trade-offs between short-term and long-term goals and values. These are processes of deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid potential maladaptation.

Resilience – The capacity of interconnected social, economic, and ecological systems to cope with a hazardous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential function, identity, and structure.

INTEGRATED CLIMATE CHANGE ADAPTATION

Integrated adaptation refers to "a holistic systems-scale approach to solve climate change challenges where there is co-development of adaptation solutions across a range of scales, jurisdictions and mandates as well as collaboration across the diversity of interests—governments, Indigenous communities and organizations, landowners, businesses, and non-government organizations". [1, p. 2] In coastal regions, it is important to acknowledge that the coast is a dynamic and highly integrated physical (land and water), social, ecological, and economic system. Knowledge of integrated adaptation planning in coastal regions benefits from over 50 years of global experience and learning in Integrated Coastal Zone Management (ICZM).

While integrated approaches to climate change adaptation have been applied in Canada and elsewhere for more than a decade, the development and implementation of integrative solutions remain challenging. One of the reasons is that there is no single entity responsible for coastal zone or climate change adaptation. Instead, governments with coastal zone mandates are organized into different sectors. A highly integrated approach to climate change adaptation would be best supported by an equally integrated legal, policy, institutional, and management framework. This framework would enable coordinated and complementary responses to climate change adaptation.[1] Such a framework would facilitate linkage of different policy responses, such as spatial and urban planning, to reducing risks from disasters, from ecosystem conservation and restoration to infrastructure planning and construction, and from climate adaptation to agriculture and resource management.

GOOD PRACTICES

1 – Choosing an appropriate boundary/scale for analysis that considers complete natural and human systems

Most adaptation plans correspond with geo-political boundaries such as communities, cities, and regional districts due to institutional arrangements. Integrated adaptation requires considering factors outside those boundaries that directly influence climate resilience. When planning for a city or community, it is important to consider the actions taken by adjacent communities and by provincial and federal governments. Broader economic factors such as the vulnerability of supply chains should also be taken into account. While integrating policies across multiple levels of government is challenging, the influences of each level need to be considered in the analysis.

In natural systems, it is generally easier to define system boundaries. Drainage basins, or watersheds, are a common area of focus for adaptation, particularly in Ontario where the boundaries of conservation authorities are defined by drainage basins. We tend to overlook defining similar units in the nearshore environment, where the land meets the coast. A littoral cell defines all new sediment sources (sand and gravel), transport pathways, and depositional areas crucial to the sustainability of coastal landforms such as beaches and barrier beaches. In normal conditions (excluding storms), sediment is transported alongshore through the process of littoral drift, with erosion and/or deposition rates within the cell depending on various natural and human factors.[13] When we interrupt natural flows in drainage basins, we inadvertently make changes to downstream ecosystems, erosion, and sedimentation. Similarly, interruptions made in one area of a littoral cell (such as building structures or jetties on the coast) affect the natural movement of sediment, ultimately affecting the functionality of nearshore ecosystems. Failure to consider the natural dynamics of drainage basins and littoral cells often leads to ineffective adaptation efforts.

Integrated coastal adaptation planning can expand these concepts by eliminating the perceived boundary between land and water interfaces. This is because the flow of water, sediment, and nutrients from land to water and along the coast forms a single dynamic system. The need and benefits of integrated land and water management were recognized as part of the Canadian Great Lakes Nearshore Assessment.[14] Zuzek Inc.[15] introduced the term “littoralshed” to refer to integrated land/water systems. A single littoralshed consists of one or more drainage basins and one or more littoral cells (Figure 2). Zuzek Inc.[15, 1] considers littoralsheds to be the most practical unit for integrated coastal adaptation

planning. Working with larger scales and units like this is important when examining physical processes, coastal and terrestrial ecosystems, societal values and assets, and economic factors.

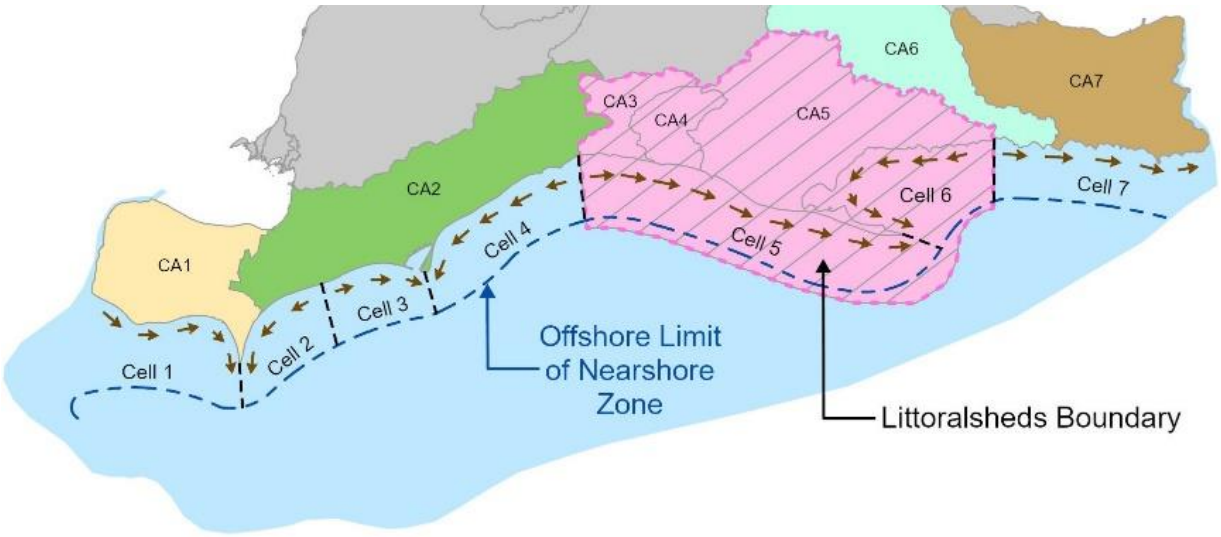

Figure 1 – Conceptual illustration of a littoralshed management unit. Littoralsheds are defined by the natural movement of water and sediment in the coastal region. A littoral shed includes one or more drainage basins (labelled CA 1–7) and one or more littoral cells (labelled Cell 1–7). Source: Zuzek Inc. (2023).[1]

Maintaining the integrity of natural systems can increase resilience to climate change. One of the primary themes of the "Making Room for Movement" initiative is respecting the dynamic nature of coastal processes across the land- water interface. This initiative highlights how it is possible to provide coastal systems with the space they require while still protecting infrastructure and people from hazards.[16] In relation to this concept, the International Union for the Conservation of Nature[17] published new guidance for the protection of natural areas and the importance of geodiversity conservation. Geodiversity includes the variety of rocks, sediments, and landforms together with the natural processes that form and alter them. **Allowing for dynamic shoreline movement is an internationally recognized strategy that increases the resilience of coastal systems and enhances their protective function.**

Practitioner voices*

(Questions remain regarding) integrated management processes along areas in the lake; how to get started, how to cope with the complexity (players, jurisdictions). Even in government, structures are divided by land and water.

(We) are land managers. Our sphere of autonomous influence ends at lake, border of the land-water-wetland interface. The impacts, the system, is much larger than the place.

(We) recognize we don't need to protect all of the coast; we do not need to worry about uninhabited areas. (But) we don't know enough about how the system works (coastal cells).

A long-term permanent solution has been elusive for several reasons, (including the) absence of an integrated littoral cell management framework in the Great Lakes that would provide a mandate for governments to work together, (and the absence of) legal or legislative mechanisms to ensure downdrift harbour impacts are mitigated.

* All quotations are from interviews with practitioners conducted as part of the study by Zuzek Inc.

2 – Seeking or establishing collaborative governance mechanisms to support policy integration

Successful adaptation processes enable input from a wide range of stakeholders.[30] Such processes promote inclusiveness and transparency and broaden leadership on adaptation solutions. To fully understand the vulnerabilities that underlie environmental, social, and institutional needs to strengthen climate resilience and the capacity to address those needs, it is necessary to establish common mechanisms such as working groups, advisory, technical and/or policy committees. These mechanisms must allow for meaningful input from all those affected, including groups that are often the most vulnerable to both climate impacts and the actions taken to address those impacts. This should include input from a diverse range of stakeholders with varying perspectives. Effective mechanisms will have clear objectives and operate under the principles of transparency, equity, inclusivity, and respect. Many guidebooks and toolkits are available to undertake participatory processes and include techniques for facilitation and conflict resolution.[e.g. 18]

However, participatory approaches often fall short of ensuring true policy integration because every organization participating in adaptation processes has a specific focus or mandate for single components of integrated coastal systems. This is particularly true of governments, where there are ministries and departments responsible for human health, land-use planning and development, fish, migratory birds, water quality, wetlands, navigation and harbours, protected areas, and socio-economic development, among others. This sectoral approach creates barriers to integrated adaptation planning and can even

result in maladaptation, where an action taken to reduce climate impacts at one site leads to increased climate vulnerability in nearby areas. For example, poorly designed structures made from hard materials such as concrete that are built along the coast can lead to increased erosion and sediment deposition elsewhere, negatively affecting ecosystems, transportation, tourism, and other socioeconomic activities.

That being said, there are ways to support practical integrated adaptation planning in Canada. For example, the Integrated Flood Hazard Management Plan (IFHMP) – District of Squamish, British Columbia, uses partnerships from all orders of government to provide a wide variety of benefits, including sharing data, information, and capital costs and coordinating regulatory processes. These approaches can be transformational (Figure 6). Government leaders can promote integrated adaptation through legislation and regulations,[2] and agreements such as memoranda of understanding between government departments, multiple levels of government, and other organizations can help facilitate policy integration. A motivated and resourceful political leader or government official can become an effective local champion, leveraging their position within the decision-making process and leading inter-jurisdictional coordination.[16]

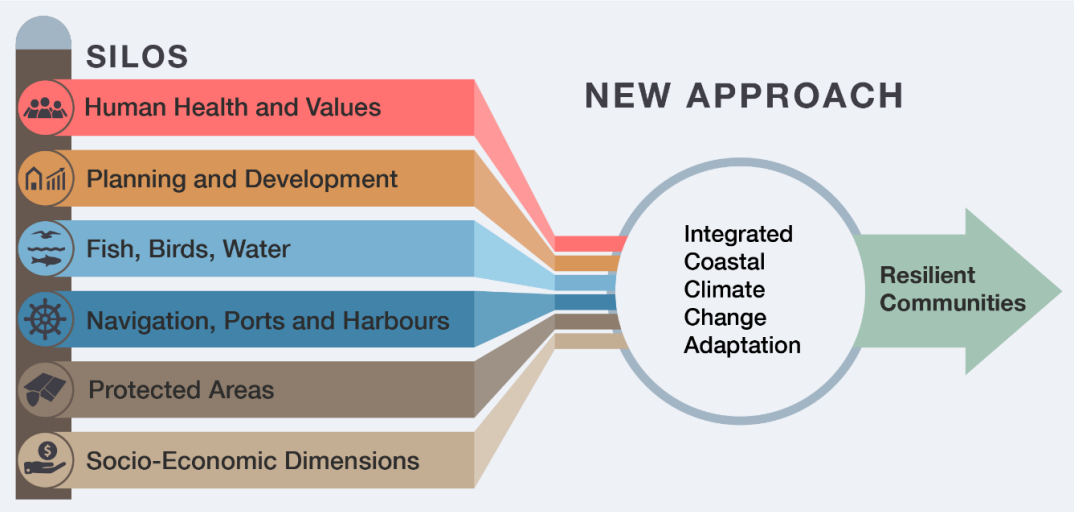

Figure 2 – Siloed (existing) versus integrated (recommended) approaches to coastal climate change adaptation. Source: Zuzek Inc. (2023).[1]

Practitioners and non-governmental organizations can help promote integrated adaptation planning by advocating for and demonstrating the value of regulatory and legislative changes that can enhance integrated adaptation. Practitioners, community groups, academia, and private industry can also promote integrated adaptation planning by ensuring all relevant stakeholders are part of the adaptation process, and by encouraging all participants to communicate to the highest levels of their organizations

the strong interdependencies between sectors and the need to consider a complete systems perspective when making adaptation decisions. This must also include finding ways to facilitate the participation of communities that have historically been marginalized or excluded from decision making, and those at greatest risk from the impacts of climate change.

Practitioner voices*

One of the main pieces is the need for integration across sectors, scales, government. (There is) no mechanism to work together.

After decades of working on single agency mandates (fish, migratory birds, navigation), government is lacking institutional capacity to collaborate on complex transformational adaption solutions in the Great Lakes.

We need multiple municipalities working together or larger bodies with responsibility at the landscape scale.

(For the) intertidal zone there is a range of different acts and departments with jurisdiction. (There is) no governance framework. There is no overarching coordination or coordinated response.

Working in silos is definitely a problem. (We are) always learning about new people doing work even with a good network.

* All quotations are from interviews with practitioners conducted as part of the study by Zuzek Inc.

3 – Defining adaptation pathways and avoiding unsustainable approaches

Adaptation is often viewed as the process of identifying a concern and implementing a measure to fix it. However, this approach fails to recognize that impacts will continue—and in most cases worsen—over time. There is also a large degree of uncertainty about the future. These uncertainties include not only the magnitude of climate impacts, but also its changes to society, technology, and responses over time. For example, people living in marine coastal regions are concerned about sea level rise, but their concerns overlook the long-term nature of sea level rise, which can span centuries to millennia. Instead of asking how much the sea level will rise, it's more important to consider when a specific amount of sea level rise will occur.[19]

Instead of looking at adaption as a series of one-time, stand-alone actions, it should be viewed as a journey with many steps necessary to ensure a climate-resilient future. These are called adaptation pathways—iterative, continuously evolving processes involving a series of choices and trade-offs between short-term and near-term goals[20, 21] (Figure 3). Rather than there being a single, correct pathway to reach desired goals, there are multiple pathways, with the most appropriate often

depending on political, cultural, and economic factors. For example, the community of Tuktoyaktuk in the Northwest Territories is experiencing first-hand the effects of more intense storm surges, melting permafrost, and coastal erosion. Homes and businesses most at risk have already been relocated to less vulnerable locations while erosion mitigation efforts continue. This provides the community with time to decide what the next steps are in their adaptation pathway. While there is no "right" path to achieving a particular goal (e.g., climate resilience), certain choices can present an undesirable pathway that may hinder reaching that goal.[22] For example, hard armouring, which refers to constructing physical structures such as seawalls, revetments, and bulkheads to protect the coast from the sea, may limit future options, become costly to maintain, and ultimately not be successful.

The IPCC developed a fact sheet on responding to sea level rise that includes discussion of generic adaptation pathways for coastal cities and settlements.[23]

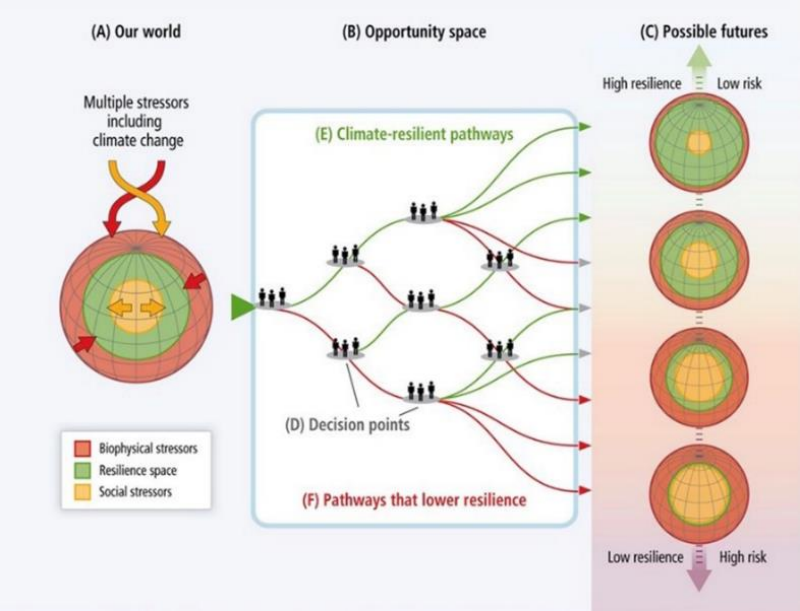

Figure 3 – Opportunity space and climate-resilient pathways. (A) Our world [Sections A-1 and B-1] is threatened by multiple stressors that impinge on resilience from many directions, represented here simply as biophysical and social stressors. Stressors include climate change, climate variability, land-use change, degradation of ecosystems, poverty and inequality, and cultural factors. (B) Opportunity space [Sections A-2, A-3, B-2, C-1, and C-2] refers to decision points and pathways that lead to a range of (C) possible futures [Sections C and B-3] with differing levels of resilience and risk. (D) Decision points result in actions or failures-to-act throughout the opportunity space, and together they constitute the process of managing or failing to manage risks related to climate change. (E) Climate-resilient pathways (in green) within the opportunity space lead to a more resilient world through adaptive learning, increasing scientific knowledge, effective adaptation and mitigation measures, and other choices that reduce risks. (F) Pathways that lower resilience (in red) can involve insufficient

mitigation, maladaptation, failure to learn and use knowledge, and other actions that lower resilience; and they can be irreversible in terms of possible futures. Source: IPCC, 2014.[24]

A pathways approach is crucial for integrated adaptation planning, especially when multiple organizations are working towards a common future, but on different timelines. This approach involves broad engagement and embraces equity and social justice considerations to help define long-term goals based on societal values. Pathways shift the focus from one-time, short-term responses to a series of adaptation actions that are sequenced and timed according to a long-term vision. This allows for adjustments as circumstances change. The initial steps on a pathway to high climate resilience may involve low-regret options that enhance flexibility rather than limiting future options.[22] For example, shoreline naturalization provides immediate benefits for biodiversity, tourism and recreation, while enabling a range of additional adaptation measures, such as planned retreat. The adaptation pathways approach allows us to adjust as the magnitude of future coastal changes becomes clearer.

Practitioner voices*

(Communities and the public sector) often "see" a one-time intervention or solution for a problem that will evolve over 100 years. We need to "chunk up intervention", break it into parts so the community can see a path forward.

It's about starting with values. What we value as a society and how can we make sure to develop solutions that are not locked into a (single) pathway. Adapt over time; change over time. Make sure values are maintained moving forward.

(Need to understand) how does this unfold over time, (what) succession of interventions is planned.

Using landscape architecture creates positive visions for the future.

* All quotations are from interviews with practitioners conducted as part of the study by Zuzek Inc.

4 – Using an adaptive risk management approach supported by monitoring and evaluation

Coastal management and climate change adaptation are ongoing efforts that require approaches that emphasize monitoring, learning, and adjusting management strategies to build long-term coastal resilience. As scientific knowledge and technology advances, and as available resources and societal/political priorities change, preferred actions to address climate risks may also evolve. Therefore, an adaptive risk management approach (Figure 4) that supports "learning by doing" is critical. The International Joint Commission has adopted an adaptive management strategy to foster a binational

technical network, support performance evaluation, and provide a cost-effective way to improve project outcomes in addressing multiple risks from climate and non-climate factors in the Great Lakes – St. Lawrence basin.[25] Adaptive risk management such as this is an essential component of an adaptation pathways approach.

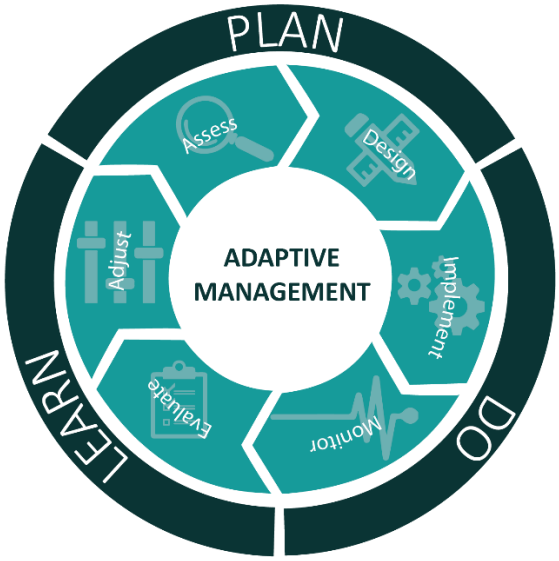

Figure 4. Components of adaptive management. Source: Natascia Tamburello of ESSA Technologies, Ltd.

Monitoring and evaluation are crucial for adaptive management. Both Canada and the United States emphasize the importance of monitoring and evaluation in their national climate change adaptation strategies. Canada has focused more on monitoring changing climate risks, with examples of innovative approaches that benefit from the inclusion of Indigenous knowledge and peoples. However, less effort has been placed on the systematic evaluation of adaptation measures, partly because many large-scale adaptation initiatives remain in the planning stage, with few examples of implementation.[9] Additionally, securing resources for long-term monitoring and reporting systems is challenging.

While monitoring and evaluation are important for all adaptation measures, there is a lack of data on the performance and economic benefits of nature-based solutions, which has hindered its broader use. To address this, we need to establish peer-to-peer sharing systems to apply lessons learned from the implementation of adaptation measures. Additionally, we must strengthen monitoring and evaluation efforts in conservation initiatives to foster climate change adaptation and build adaptive capacity.

Practitioner voices*

We don't have enough monitoring in Canada.

(We need) examples and proof that it works. We are not there. Not having experience in monitoring (is a significant problem).

(Adaptive management) allows for continued community development while managing flood risk.

(We need) municipal tools that can monitor impacts and inform reactive maintenance.

* All quotations are from interviews with practitioners conducted as part of the study by Zuzek Inc.

5 – Considering transformational adaptation options in addition to incremental actions

Transformational adaptation measures are necessary to address the growing threat of climate change impacts on existing systems. While the majority of adaptation measures currently being planned and implemented in Canada are incremental,[9, 10] there is a need for more transformational options. Incremental actions are only effective in maintaining the essential features of an existing system, but in many cases, climate change impacts threaten the viability of those systems. Transformational adaptation measures[26, 27] involve radical restructuring, replacement, or abandonment of practices that are no longer viable under new climatic conditions. These measures require large-scale policy shifts developed through formal decision-making processes.[28] For example, the HalifACT 2050 initiative is including climate resilience considerations into financial decision-making to ensure investments contribute to reducing risk throughout the region. Integrated adaptation planning is an example of a transformational adaptation measure that represents a fundamental shift away from individual mandates, and towards collaborative decision-making for the greater good.

Inequity based on socioeconomic status and systemic marginalization is a persisting problem. Many people living in vulnerable areas may have lower incomes or be socially marginalized. These populations may be more vulnerable to physical and mental health impacts and have less access to both the financial resources to adapt individually and the political voice to advocate on their own behalf. Integrated approaches should include opportunities for diverse voices of all ages, backgrounds, identities, and income levels to collaborate, co-design, plan, and implement innovative transformative coastal climate change adaptations actions.

Incremental and transformational adaptation measures should not be considered as distinct, unrelated approaches, and can be complementary when considered as part of adaptation pathways. For example, incremental actions can serve to expand the potential for future, more transformational, solutions.

In addition to the example of transforming institutions through integrated adaptation planning, physical measures that may represent transformational changes include utilizing nature-based adaptation solutions for adaptation and relocating coastal residents, communities, and critical infrastructure away from high-risk flood and erosion areas. The following section discusses nature-based solutions as good practice. Planned coastal retreat is already an important tool of adaptation planning in many areas of the world, with a small number of examples available in Canada.[28] Planned retreat is a complex process that involves various social aspects and raises questions regarding societal values and acceptable losses.[29] It inevitably requires the involvement of multiple levels of government, making integrated adaptation planning highly beneficial. Additionally, planned retreat serves as an excellent example of how incremental and transformational measures can work together. By implementing incremental adaptation actions to reduce short-term climate risks, we can buy time for retreat to be planned effectively (see Table 1).

Table 1 – Example of possible incremental and transformational adaptation responses to address impacts of sea level rise in a small coastal community. Source: UNFCCC,[30] Major and Juhola (2021).[31]

Time period	Actions	Type of change	Notes
Immediate	Improve evacuation plans	Incremental	Based on local knowledge; inexpensive
Short-term (<5 years)	Make locally-constructed adjustments, join available early warning systems, review retreat and temporary refuge options	Incremental	Some outside assistance needed for temporary refuge options
Medium-term (5-15 years)	Moderate protection for some buildings and roads, retreat and relocation of most critical/vulnerable buildings and roads	Incremental	Moderate costs; some local, institutional and property issues; access to projected climate impacts data
Long-term (>15 years)	Plan and implement full retreat	Transformational	High cost; complex institutional and property issues

Practitioner voices*

When we think of resilience we need to bounce forward to a different state. Should be understood as transformative change.

Integrated transformative change (involves) getting everyone in a room and people being able to see themselves in the solution. One solution can hit multiple problems, save time and money and duplication.

The community, they are aware of the increasing sea levels. Once we get this protection in place, we can look at how the community can relocate.

Concepts like retreat and managed retreat (are) not part of conventional approach or component, (but they) need to be.

I don't think we are going to be transformative without … doing some work at the larger scale.

* All quotations are from interviews with practitioners conducted as part of the study by Zuzek Inc.

6 – Leveraging nature-based solutions for added benefits and opportunities

Nature-based solutions (NbS) can play a key role in managing coastal flood and erosion risk while providing additional benefits such as enhancing biodiversity, carbon sequestration (capturing and storing carbon dioxide from the atmosphere), and opportunities for recreational activities.[e.g. 27] Furthermore, NbS strongly align with the principles and objectives of integrated adaptation planning. Examples of these adaptation measures include maintaining and/or restoring beaches, coastal wetlands, and coastal vegetation (e.g., naturalization of the shoreline), as shown in Figure 5. These efforts contribute to the replenishment of coastal sand dunes and the stabilization of salt marshes / wetlands that offer significant protection for the coast.[32] NbS often draw upon well-established knowledge and practices in managing coastal climate risks, with valuable Indigenous knowledge being particularly relevant. In addition to providing a range of ecosystem services, NbS tend to be less expensive than traditional hard engineering approaches (referred to as "grey" infrastructure) and offer greater flexibility in managing increasing climate risks over time.

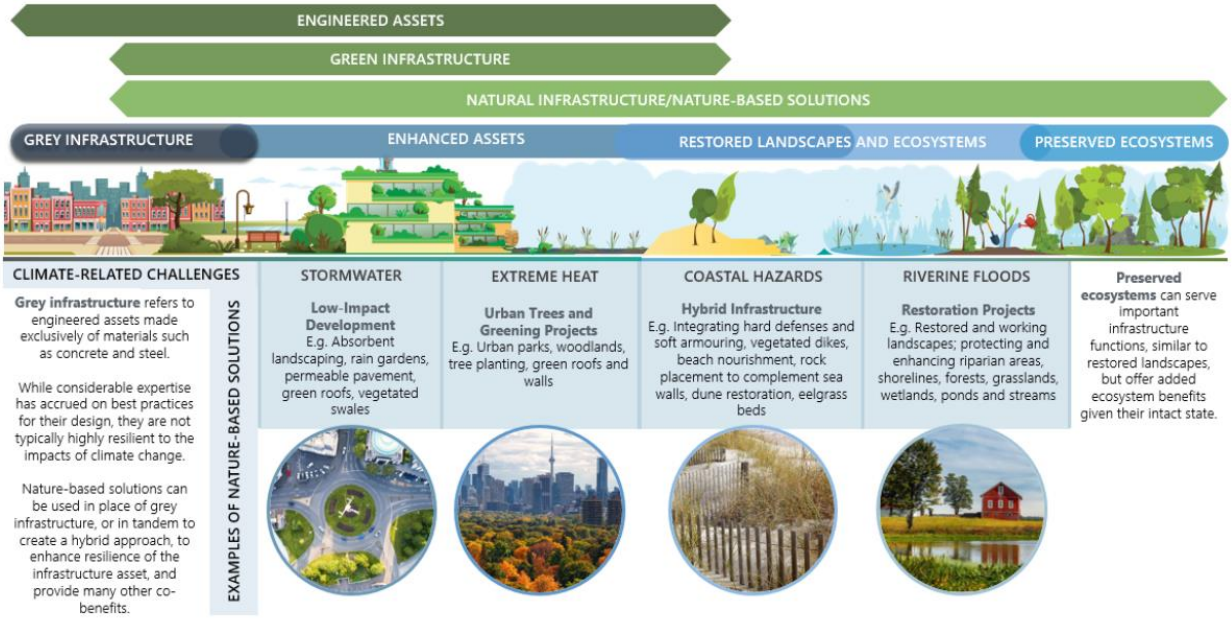

Figure 5 – Typology of Infrastructure Types. Source: Canadian Council of Ministers of the Environment.[33]

It is worth noting that in addition to encompassing natural and nature-based features, NbS also includes approaches that combine natural and gray elements, known as hybrid or integrated solutions (Table 2). Globally, there are numerous examples of NbS for coastal climate change adaptation, and significant bodies of literature exist to help guide practitioners.[e.g. 34,35] While isolated examples of NbS are found on all of Canada's coasts, nature-based approaches remain underutilized in most adaptation planning.[27] The absence of such approaches in a major study of adaptation on the Chignecto Isthmus[36] (New Brunswick / Nova Scotia), one of Canada's most vulnerable transportation corridors to sea-level rise, suggests that implementing NbS would represent transformational adaptation in many areas.

Table 2: Examples of engineered, NbS and hybrid solutions to address coastal flooding and erosion
Source: Modified from Wood Canada Limited (2022),[34] Inter-American Development Bank (2020).[32]

Challenge	Engineered (gray) solution	Nature-based solution	Example of hybrid (integrated) solution
Coastal flooding, storm surge, sea level rise, and erosion	Seawalls, dikes, permanent artificial walls, and temporary storm barriers Improved drainage systems	Conservation, management, restoration, or creation of: - coastal wetlands and salt marshes - sand dunes and beaches - living breakwaters (subtidal boulders)	Establishment of salt marshes seaward of dikes and other hard armouring projects to reduce wave energy

According to practitioners, the existing regulatory framework tends to prioritize dike and seawall solutions, making it challenging to gain approval for alternative approaches such as living dikes or breakwater solutions. Furthermore, securing funding for NbS is perceived to be more difficult compared to traditional gray engineering projects. To enhance understanding and appreciation of the value of natural assets, the Municipal Natural Asset Initiative (MNAI) created a coastal toolbox to facilitate more integrated municipal planning and management decisions.[37] Recent reports have put forward recommendations to increase the use of nature-based solutions along Canada's marine coasts[38] and Great Lakes.[39]

Practitioner voices*

We are making a positive turn in thinking about conventional "grey" infrastructure or NBS not as "either/or" but as an "AND" together.

The community will not be able to get out of their challenges by pouring concrete.

We need to combine both and move on from thinking of grey alone; it is not an either/or solution.

The beauty (of NbS) is that they are place-based, but you can't just copy a solution from one place to another. They will differ depending on location (different soils, tides etc.).

* All quotations are from interviews with practitioners conducted as part of the study by Zuzek Inc.

DISCUSSION

The good practices outlined above have been applied, to varying degrees, in numerous adaptation initiatives across Canada over the past decade. Many of these have been documented in previous publications, including the case studies and interviews undertaken by Zuzek Inc.[1] That analysis provides examples of how these good practices have been implemented (Table 3, Case studies 1, 2 and 3), as well as barriers encountered and keys to success.

Table 3: Good practice checklist for integrated adaptation

Practice	Considerations
Choosing an appropriate boundary/scale for analysis that considers complete natural and human systems	• Consider an area that is larger than the geographic extent of the planning region • Use boundaries of natural systems (drainage basins, littoral cells) as appropriate • Consider the land-water interface as a component of the broader system rather than a boundary
Seeking or establishing collaborative governance mechanisms to support policy integration	• Emphasize an inclusive stakeholder process, possibly through an advisory committee • Build planning teams with representatives from multiple governments and key organizations, supported by technical experts • Ensure the meaningful inclusion of marginalized communities • In the absence of legislated/regulated integration, establish MOUs or similar mechanisms to formalize goals and approaches
Defining adaptation pathways and avoiding unsustainable approaches	• Establish a shared long-term vision and associated goals • Identify key decision points related to development or updating of planning documents, lifespan, and maintenance of key infrastructure • Recognize options available at each decision point, strive to retain flexibility to respond to future changes and avoid locking in unsustainable paths
Using an adaptive risk management approach supported by monitoring and evaluation	• Incorporate the value of learning as part of a long-term vision • Ensure that monitoring expands beyond analysis of climate impacts and includes performance of adaptation measures once implemented • Ensure that formal monitoring and evaluation requirements are part of official plans along with the long-term resourcing required to undertake them • Enhance community engagement and support through citizen monitoring activities
Considering transformational adaptation options in addition to incremental actions	• Ensure a strong link to adaptation pathways • Where transformation is necessary, identify conditions and steps necessary to achieve them • Recognize that incremental changes are often needed to buy time for planning and gaining broad acceptance of transformational measures
Leveraging nature-based solutions for added benefits and opportunities	• Consider alternative approaches to hard engineering solutions that can provide important co-benefits related to biodiversity, carbon sequestration, human health and well-being, economic development (tourism/recreation) • Quantify value of natural assets as part of infrastructure planning • Recognize that hard engineering and nature-based solutions can be complementary through well-planned hybrid approaches

Case Study 1. HalifACT 2050/Acting on Climate Together – Halifax Regional Municipality, Nova Scotia[40]

In June 2020, the Halifax Regional Council unanimously adopted HalifACT 2050, a long-term action plan to reduce emissions and help communities adapt to a changing climate. It is considered one of Canada's most comprehensive and ambitious climate plans to date. The plan includes short-, medium-, and long-term actions under three broad themes: decarbonized and resilient infrastructure (including preparing for coastal challenges); building prepared and connected communities; and improving governance and leadership. Initial actions are focused on reducing greenhouse gas emissions, while actions related to adaptation and resilience relate more to improving knowledge and developing strategies. Actions related to the good practices identified here include:

GOOD PRACTICE CHECKLIST	
Practice	Brief description of action
Choosing an appropriate boundary/scale for analysis that considers complete natural and human systems	The focus is on the regional scale and how to build action at the community or neighbourhood scale. The development of a coastal-specific adaptation strategy with coastal communities provides opportunity to consider complete natural and human systems.
Seeking or establishing collaborative governance mechanisms to support policy integration	The planning development involved advisory groups of municipal employees and community members, and broader public engagement.
Defining adaptation pathways and avoiding unsustainable approaches	The defined pathways provide strong community vision and recognize that building resilience is an iterative process. There will be opportunities to explore pathways further when developing adaptation strategies and action plans.
Using an adaptive risk management approach supported by monitoring and evaluation	The plan is a living document that will be updated during implementation to 2050. It recognizes the need to try solutions, which will sometimes fail, and to learn. There will be annual indicators report to track both climate action and its impact, supported by monitoring and evaluation.
Leveraging nature-based solutions for added benefits and opportunities	The plan includes specific actions related to natural areas and green infrastructure with the objective of protecting, restoring, maintaining, and expanding natural areas and green infrastructure assets

Case Study 2. Integrated Flood Hazard Management Plan – District of Squamish, British Columbia.[41, 42]

The District of Squamish, a coastal town at the head of Howe Sound, faces challenges from both coastal and riverine flooding, which are expected to worsen with climate change and rising sea levels. To address this, a three-year process was undertaken to update the Integrated Flood Hazard Management Plan. Adopted by the district council in October 2017, the plan combines land use planning, structural protection, river management, public education, and emergency planning to inform capital and community planning. Its objectives are to reduce flood risks and share equitably among floodplain users; to identify opportunities for economic, environmental, and social development; and to promote long-term social and environmental sustainability. Actions related to the good practices identified here include:

GOOD PRACTICE CHECKLIST	
Practice	Brief description of action
Choosing an appropriate boundary/scale for analysis that considers complete natural and human systems	The analysis is predominantly land-based at drainage basin scale. The objectives are to reduce flood risks and share equitably between multiple floodplain users; to identify opportunities for economic, environmental, and social development; and to promote long-term social and environmental sustainability.
Seeking or establishing collaborative governance mechanisms to support policy integration	The update involved input from the Squamish Nation and community stakeholders, supported by a technical working group with representatives from all orders of government as well as non-government stakeholders. Policy integration includes strong linkages with hazard and development plans.
Defining adaptation pathways and avoiding unsustainable approaches	A long-term (multi-generational) vision to build a safe, sustainable, and resilient community was developed. This vision stresses importance of taking steps now to protect the community from current hazards, while ensuring works will be easy to upgrade in the future.
Using an adaptive risk management approach supported by monitoring and evaluation	The district has a target of updating the plan every 10 years with each comprehensive update incorporating new data, new approaches, and new development, learning from the success and failures of past actions.
Considering transformational adaptation options in addition to incremental actions	The initial focus is on incremental actions (dike upgrades), but also includes retreating vulnerable development from areas where current risks are not acceptable.

Case Study 3. Climate Change and Coastal Erosion – Hamlet of Tuktoyaktuk, Northwest Territories[43]

Tuktoyaktuk is a small community with less than 1000 residents located on a peninsula along the coast of the Beaufort Sea, just east of the Mackenzie River Delta. About 90% of residents consist of Inuvialuit people who have a deep cultural connection to the land and sea. Many residents still live on the land, hunting caribou and beluga whales. However, coastal erosion is a major problem for the community. Long-term erosion rates are around 1 to 2 metres per year, and parts of the townsite experienced more than 100 m of erosion between 1935 and 1971, forcing relocation of buildings and residents. The territorial government and the Hamlet have explored a range of alternatives for the future, including possible site abandonment. Actions related to the good practices identified here include:

GOOD PRACTICE CHECKLIST	
Practice	Brief description of action
Choosing an appropriate boundary/scale for analysis that considers complete natural and human systems	The very strong cultural recognition that all parts of the environment are interconnected provides the ideal foundation for integrated planning.
Seeking or establishing collaborative governance mechanisms to support policy integration	Planning involved collaboration between the hamlet and territorial government, with input from full community, including youth. Supporting work was enhanced through partnerships between the Tuktoyaktuk Community Corporation and researchers and institutions in the Inuvialuit Settlement Region.
Defining adaptation pathways and avoiding unsustainable approaches	The starting point involves developing a vision for the future of Tuktoyaktuk based on values and identity, then to identify acceptable and appropriate adaptation options and determine thresholds at which the transition to alternative options must be considered.
Using an adaptive risk management approach supported by monitoring and evaluation	The approach used includes community and institutional monitoring of many environmental factors, as well as strong efforts to learn from experience of other communities with similar problems.
Considering transformational adaptation options in addition to incremental actions	The current focus is on reducing rate of coastal erosion through hard engineering approaches (incremental), with long-term need for relocation (transformational). To quote Mayor Erwin Elias: “The idea is to buy us some time so we can plan for the next stage moving forward.”

Policy integration to the degree envisioned by Zuzek Inc.[1] continues to be a challenging goal with many institutional barriers. These barriers include issues related to legislative and regulatory frameworks, funding limitations, capacity restraints, and the complexities surrounding the implementation of transformational adaptation measures, such as planned retreat, which involves the strategic relocation of communities and infrastructure away from high-risk areas prone to natural hazards or environmental risks. Even when good practices are applied, achieving consensus from a diverse community on best responses remains challenging.

The case studies above demonstrate how regional governments have formally adopted plans that include climate change adaptation as part of a broader climate change strategy (HalifACT 2050[40]) and disaster risk reduction / emergency management (Integrated Flood Hazard Management Plan[41]). They also highlight that the holistic approach of Indigenous communities is significantly more conducive to integrated planning than the sectoral approaches of most governments.[43] Integrated solutions to climate change adaptation are still developing rapidly in Canada, and barriers and opportunities will vary among projects and local contexts. This report outlines good practices, such as inclusive community engagement, working groups or committees, and collaborative approaches, which provide practitioners with an opportunity to gain support and encourage integration and collaboration among stakeholders. By adopting a comprehensive approach, these practices contribute to addressing climate change impacts.

ANNEX 1 – ADDITIONAL RESOURCES

The following is a selection of available resources that support integrated coastal adaptation.

Overviews

Lemmen, D.S., F.J. Warren, and C.S.L. Mercer Clarke. (2016). Canada's Marine Coasts in a Changing Climate. Government of Canada, Ottawa, ON, 274 p. https://natural-resources.canada.ca/climate-change/impacts-adaptations/canadas-marine-coasts-changing-climate/18388

Mercer Clarke, C.S.L., and A. Clarke. (2018). Facing Rising Waters. The Adaptation Primers, Primer 4; Canadian Society of Landscape Architects and the Interdisciplinary Centre for Climate Change, University of Waterloo, 81 p. https://www.csla-aapc.ca/sites/csla-aapc.ca/files/Climate/VOLUME%204%20Facing%20Rising%20Waters%202018.pdf

Websites – Data and Tools

National – Canadian Centre for Climate Services: https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services.html
Climate Data for a Resilient Canada: https://climatedata.ca/

East Coast – CLIMAtlantic: https://climatlantic.ca/
Ouranos: https://www.ouranos.ca/en

West Coast – Pacific Climate Impacts Consortium: https://www.pacificclimate.org/

Ontario / Great Lakes – Climate Risk Institute: https://climateriskinstitute.ca/
Ontario Climate Data Portal: https://lamps.math.yorku.ca/OntarioClimate/
US Climate Resilience Toolkit: https://toolkit.climate.gov/regions/great-lakes

North – ArcticNet: https://arcticnet.ulaval.ca/about-us/

Tools and Guidance Documents – General

PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change [author: PROVIA, 2013]. https://www.adaptation-undp.org/sites/default/files/downloads/provia-guidance-nov2013.pdf

Guide for Municipal Climate Change Staff [author: Federation of Canadian Municipalities, 2022]. https://data.fcm.ca/documents/programs/MCIP/guide-municipal-climate-change-staff.pdf

Guidelines for Geoconservation in Protected and Conserved Areas [authors: Crofts, R., J.E. Gordon, J. Brilha, M. Gray, J. Gunn, J. Larwood, V.L. Santucci, D. Tormey, and G.L. Worboys, 2020; International Union for Conservation of Nature (IUCN), Best Practice Protected Area Guidelines Series No. 31]. https://portals.iucn.org/library/sites/library/files/documents/PAG-031-En.pdf

Coastal Adaptation Toolkit [author: CLIMAtlantic]. https://climatlantic.ca/coastal-adaptation/

Climate Change Guidance Framework [author: International Joint Commission].
https://ijc.org/en/what/climate/framework
https://ijc.org/sites/default/files/2021_IJC_CCGF_Highlights.pdf

Adaptation Pathways

Enabling Adaptation Pathways [author: CSIRO (Australia's national science agency)].
https://research.csiro.au/eap/

User Guide for the Climate Change. Adaptation Pathways Framework. Supporting Sustainable Local Food in B.C. [author: British Columbia Ministry of Agriculture]. https://www2.gov.bc.ca/climate-action

Nature-based solutions – General

Cold Regions Living Shorelines [author: Coastal Zone Canada Association].
https://coastalzonecanada.org/crls/

Nature-based Solutions by Design [author: Canadian Society of Landscape Architects, no date].
https://www.csla-aapc.ca/sites/csla-aapc.ca/files/NBS%20Paper%20Final%20Draft%20May%2026%202021%20(2).pdf

Natural and Nature-Based Climate Change Adaptation Community of Practice [author: New Brunswick Environmental Network]. https://www.naturalinfrastructurenb.ca/

Nature-based solutions – Tools and Guidance

Managing Natural Assets to Increase Coastal Resilience: Guidance Document for Municipalities [author: David Suzuki Foundation, 2021]. https://davidsuzuki.org/wp-content/uploads/2021/12/Coastal-Assets-Guidance-Document-2021.pdf

Green Shores® – A Tool in the Shoreline Resilience Toolbox [author: D.G. Blair, 2021. The Stewardship Centre for British Columbia].
https://stewardshipcentrebc.ca/PDF_docs/greenshores/Resources/GS_CaseStudy_ShorelineResilience2021.pdf

International Guidelines on Natural and Nature-Based Features for Flood Risk Management [editors: Bridges, T. S., J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder, and R. K. Mohan, 2021. U.S. Army Engineer Research and Development Center]. https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/41946/3/NNBF-Guidelines-2021.pdf

Making room for movement: A Framework for Implementing Nature-based Coastal Adaptation Strategies in Nova Scotia [authors: van Proosdij, D., Manuel, P.; Sherren, K., Rapaport, E., McFadden, C., Rahman, T., & Reeves, Y., 2021. TransCoastal Adaptations Centre for Nature-based Solutions, Saint Mary's University].
https://static1.squarespace.com/static/5c83d5c63560c33561cc74de/t/61af943a0624555b127356c0/1638896708462/MakingRoomforMovement%5EDULFramework.pdf

https://www.transcoastaladaptations.com/making-room-for-movement

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