2025

Coastal Options Appraisal Guide

PUBLICLY AVAILABLE SPECIFICATION

DRAFT FOR PUBLIC REVIEW – OCTOBER 21, 2025

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Table of Contents

Note: This document outlines the proposed content of the publicly available specification.

Revisions have been incorporated based on feedback from the project Steering Group.

Annotations indicate sections where additional content will be added following public review.

Editing and further reworking will be undertaken based on Public Review. The references and glossary are included in this version for review but are currently being refined. The final version of the report will be professionally designed and translated into French.

Acknowledgements

This section will be completed in the final version of the report following the public review.

Executive Summary

This guide will help users identify and evaluate alternative management approaches for Canadian coastlines. It is intended to provide accessible and user-friendly support for a wide range of users, including coastal practitioners, decision-makers, planners, and other interested parties.

The guide outlines the overall process of coastal adaptation, together with a description of coastal hazards, regional considerations, and coastal management strategies in Canada.

A detailed description of option development and appraisal methods is provided, including common steps in option appraisal and how these are applied using four key appraisal methods:

1. Multi-Criteria Decision Analysis (MCDA)
2. Cost-Effectiveness Analysis (CEA)
3. Cost-Benefit Analysis (CBA)
4. Economic Impact Assessment (EIA)

For each type of option appraisal, the guide provides details of:

- Appraisal method
- Data requirements
- How ecosystem outcomes can be integrated
- How social outcomes can be integrated
- Strengths and limitations

A comparison of the four option appraisal methods is also provided, together with guidance on when and how to apply these methods in coastal management contexts.

The guide will be useful to several key groups of coastal actors. Suggestions of how different groups may be able to use the guide to support their work are outlined in Table 1.

Table 1: How different coastal actors can use the option appraisal guide

Audience	Who?	How can they use the guide?
Coastal community decision-makers and staff	Elected officials, local community staff (Indigenous and non-Indigenous), Rightsholders, project managers.	To develop options appraisal methods to support their coastal management decisions, that reflect their own community values. To help scope option appraisal work when coastal management approaches are being selected using external organizations. To understand the wider context of coastal management in Canada

Audience	Who?	How can they use the guide?
Coastal resilience funders	Federal, provincial, territorial and Indigenous governments, NGOs, and philanthropic foundations.	To obtain maximum benefit from investment of funds in coastal resilience. To provide funding that supports robust options appraisal prior to implementation. To embed reporting on options appraisal outcomes in funding application criteria.
Coastal interest groups	Community organizations, advocacy groups, Rightsholders, environmental nonprofits, and other interested parties.	To encourage their communities to adopt robust options appraisal as part of coastal management decision-making. To co-develop options appraisal approaches with their local community staff. To understand the wider context of coastal management in Canada
Technical practitioners	Scientists, engineers, Rightsholders and specialists in coastal management, environmental science, and related fields.	To embed options appraisal in work to support decision-making in coastal communities. To assist in suggesting appropriate options appraisal approaches, considering the methodologies available and community needs.

1 Introduction

1.1 Upgrading Coastal Option Appraisal in Canada

Coastal flooding and erosion are natural processes. However, in many places, communities have been developed in hazardous areas, placing housing, infrastructure and the wellbeing of Canadians at risk of flooding and erosion. These communities face increasing challenges from climate change impacts such as sea-level rise, coastal erosion, and extreme weather events.

As the impacts of climate change intensify, the urgency to manage coastal risks grows. Various coastal management approaches are possible. There is therefore a need for robust options appraisal methodologies to guide investment to the most appropriate approaches.

Options appraisal is the comparison of different options against set criteria to help decision makers select an approach that delivers the most desirable overall outcomes.

In the context of coastal management, options appraisal typically compares a range of different options against the “do nothing” option, which acts as a baseline for comparison.

Option appraisal is not always undertaken to consider coastal management options in Canada. Where option appraisal is undertaken, it is often not robust or transparent, and there is currently no standardized approach. Economic aspects of appraisal are frequently limited to the consideration of the avoided direct costs of damage to infrastructure.

Lack of adequate option appraisal can lead to short-term decision-making that does not appropriately weigh up the costs and benefits of action (or non-action). Key issues include undervaluation of long-term costs and benefits, bias towards “grey” infrastructure solutions that are more familiar to decision-makers, and failure to consider outcomes in the context of community values. Notably, critical services delivered by natural infrastructure, commonly referred to as “ecosystem services,” are currently not routinely considered in Canada.

Ecosystem services are “the contributions of ecosystems to the benefits that are used in economic and other human activity.”[1] They are typically considered in three categories [2]:

1. Provisioning services - products obtained from ecosystems, for example, food, wood, and fresh water.

2. Regulation and maintenance services - services that regulate ecosystem processes and support the production of other ecosystem services, including, for example climate regulation and water cycling.

3. Cultural services - spiritual, recreational, and cultural benefits that people obtain from nature, including for example, aesthetic enjoyment, and physical and mental health benefits.

Social outcomes associated with coastal management approaches are also currently under-represented in decision-making, including impacts on equity, displacement, physical and mental health and culture heritage.

1.2 Purpose of this Guide

This option appraisal guide aims to support communities across Canada in assessing and comparing coastal management approaches, considering a fuller range of outcomes and metrics. In a wider context, it may also support inclusion of ecological and social outcomes in options appraisal for all Canadian infrastructure projects.

The guide is not intended to provide detailed technical guidance for the design of coastal management solutions, which are provided in other resources highlighted for further reading.

1.3 Geographical Scope

The guide is applicable to Canada's marine coasts (East, West, North) and the Great Lakes, as illustrated in Figure 1 and detailed in Table 2.

Figure to be illustrated in a map, that might be featured in the section on regional considerations

Figure 1: Canada's coastlines, Provinces and Territories to which this guide applies.

Table 2: Provinces, Territories and Canada's Coastal Regions

Region	Provinces and Territories
East Coast	Newfoundland and Labrador, Nova Scotia, New Brunswick, Prince Edward Island, Québec (St. Lawrence Estuary)
Great Lakes	Ontario
West Coast	British Columbia
North Coast	Yukon Territory, Northwest Territories, Nunavut, Northern Québec (Nunavik), Northern Ontario, Northern Manitoba, Northern Newfoundland and Labrador (Nunatsiavut)

1.4 How Different Actors Can Use the Guide

The guide is intended to support a range of users involved in coastal management across Canada by providing an introductory guide to options appraisal methodologies.

Key audience groups are identified in Table 3, together with suggestions of how they may be able to use the guide to support their work.

Table 3: How different coastal actors can use the option appraisal guide

Audience	Who?	How can they use the guide?
Coastal community decision-makers and staff	Elected officials, local community staff (Indigenous and non-Indigenous), Rightsholders, project managers.	To develop options appraisal methods to support their coastal management decisions, that reflect their own community values. To help scope option appraisal work when coastal management approaches are being selected using external organizations. To understand the wider context of coastal management in Canada
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Technical practitioners	Scientists, engineers, Rightsholders and specialists in coastal management, environmental science, and related fields.	To embed options appraisal in work to support decision-making in coastal communities. To assist in suggesting appropriate options appraisal approaches, considering the methodologies available and community needs.

1.5 Navigating the Guide

The guide is divided into the following sections:

- **Section –** Coastal Management Context of Options Appraisal **- provides background to help the user understand the context of coastal options appraisal, including:**
    - Key principles
    - The coastal adaptation process
    - Overview of coastal hazards and regional characteristics
    - Coastal adaptation strategies

- **Section -** Options Development and Appraisal Methods**– describes methodologies that can be used to assess and compare different options, including:**
    - Developing a long list of options
    - Initial option screening
    - Four option appraisal methods - Multi-Criteria Decision Analysis (MCDA), Cost Effectiveness Analysis (CEA), Cost-Benefit Analysis (CBA), and Economic Impact Analysis (EIA)

- Guidance on selecting an appropriate appraisal methodology.

- **Section –Case Studies and Templates – provides details of Canadian and international examples of:**
    - Option appraisal approaches supporting community decision-making
    - Standardized option appraisal methodologies already being used

Within each section, further reading resources are identified and hyperlinked.

A Glossary is provided to help define important terms and those that may be less familiar to users.

2 The Coastal Management Context of Option Appraisal

2.1 Key Principles

Coastal management practices are currently evolving in Canada, incorporating lessons learned from other countries. The following principles were identified in the publication Nature-based infrastructure for coastal flood and erosion risk management: a Canadian design guide and are applicable to coastal adaptation in a wider sense.[3]

- **Adopt a Systems Approach** - Effective and sustainable flood and erosion management requires an understanding of both natural and human systems (e.g., tourism, housing). This sets current coastal conditions in the context of historic and future change – including inter-relationships between natural processes, human activities, and climate change.

- **Engage Communities, Partners, Regulators, and Multi-Disciplinary Teams** – Early, comprehensive, and continuing engagement and consensus-building with interested parties is key to coastal management that aligns with community context and values.

- **Embrace Indigenous Knowledge** – Indigenous worldviews and lived experience can enrich understanding of coastal systems. Indigenous-led and co-developed solutions are vital to uphold the inherent right of Indigenous Peoples to self-determination recognized in the United Nations Declaration on the Rights of Indigenous Peoples.[4]

- **Deploy Strategically** – Solutions should be grounded in a wider strategy that considers natural and human systems. Highly localized approaches that do not contribute to, or are not informed by, an overall strategy run the risk of failing to achieve the desired results.

- **Adaptively Manage Risk** – Phased deployment of solutions and adaptive management are essential for managing risk in an uncertain future, whether for conventional (hard) or nature-based infrastructure, or hybrid systems incorporating elements of both types

- **Match Solutions to Regional and Local Conditions** – Solutions should be selected and deployed based on their compatibility with regional and local conditions, including physical processes, availability of materials, interests of communities and Rights holders, local capacity, remoteness and logistics.

2.2 The Coastal Adaptation Process

Coastal adaptation is a continual process. An overview of the general coastal adaptation process is provided in Figure 2, highlighting the steps before and after option appraisal. This process draws on the international standard [ISO 14090 Adaptation to climate change – Principles, requirements and guidelines][5], and embraces an iterative, learning-based approach.

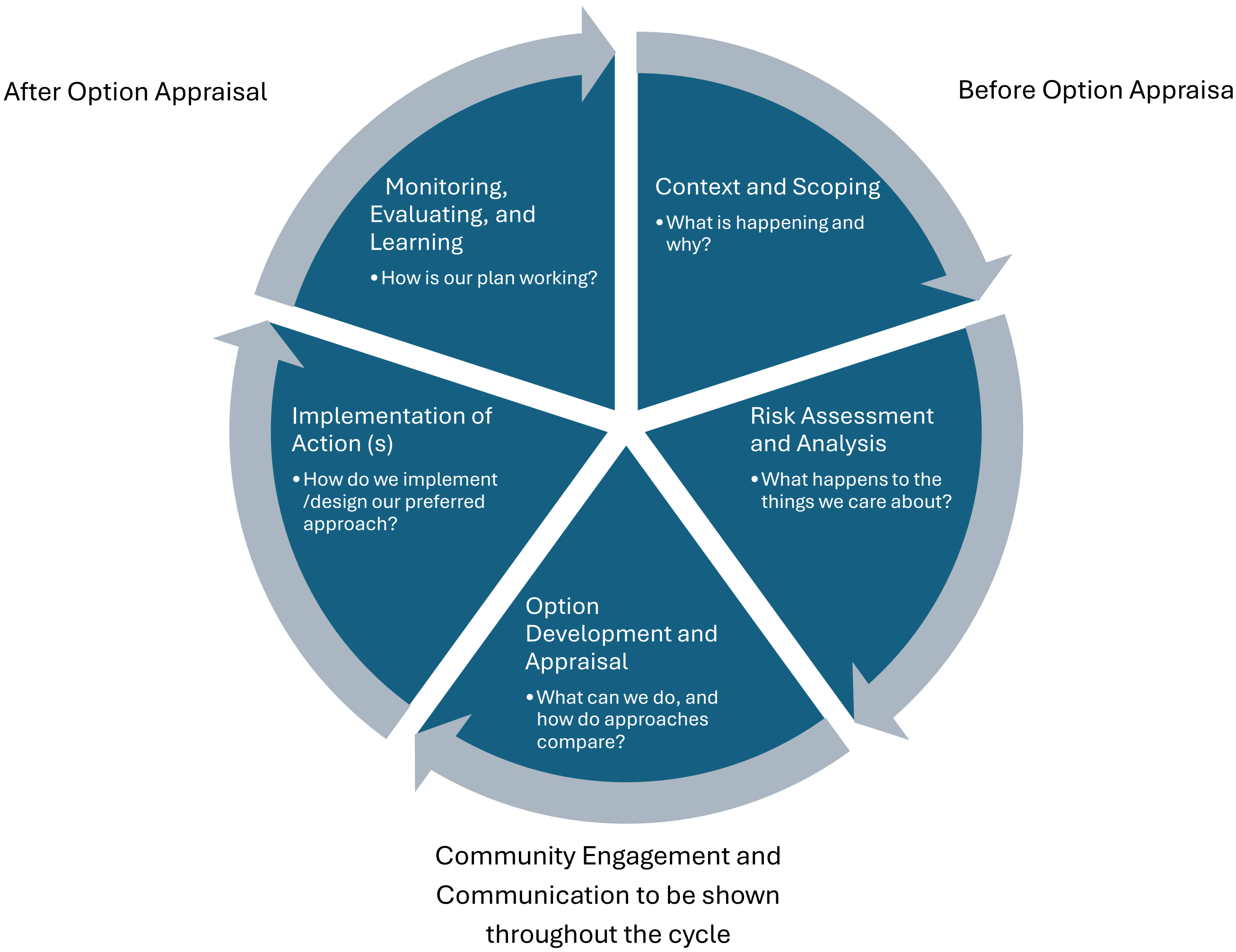

Figure 2: Approach to coastal adaptation (adapted from ISO 14090 Adaptation to climate change – Principles, requirements and guidelines)

2.2.1 Community and Partner Engagement

Community engagement and communication are not discrete steps in the coastal adaptation process, but continuous, cross-cutting elements. Different steps in the process should be informed by engagement and communication to support transparency and shared ownership. Meaningful participation of interested parties can help build trust and shape outcomes that fit community values.

A useful framework for considering the goal and level of public participation is the IAP2 Spectrum for Public Participation

Respectful inclusion of Indigenous knowledge systems and governance processes is essential. It is recommended to adopt a two-eyed seeing approach.

Two-Eyed Seeing / Etuaptmumk: "*learn[ing] to see from your one eye with the best or the strengths in the Indigenous knowledges and ways of knowing…and learn[ing] to see from your other eye with the best or the strengths in the mainstream (Western or Eurocentric) knowledges and ways of knowing…but most importantly, learn[ing] to see with both these eyes together, for the benefit of all.*" — Mi'kmaw Elder Albert Marshall (Institute for Integrative Science and Health, 2021).

Coastal management actors should include Indigenous knowledge using a code of ethical conduct, which includes principles related to:

- Free, prior and informed consent.
- Confidentiality and protection of Indigenous knowledge.
- Equitable sharing of the benefits that arise from using such knowledge.

The inclusion of Indigenous Peoples in coastal management *is* part of reconciliation at the local level.

2.2.2 Steps and Activities of the Coastal Adaptation Process

Typical activities undertaken at different steps in the coastal adaptation process are identified in Table 4. This provides an idea of the activities required prior to options appraisal, as well as those that are informed by options appraisal.

Table 4: Steps and Typical Activities of the Coastal Adaptation Process

Step	Typical Activities
Context and Scoping	• Identify interested parties and governance partners • Review relevant regulatory, administrative, and technical considerations • Collect initial baseline data and characterize natural processes • Identify assets (natural, built, cultural, and socio-economic) and community values • Determine scale of study, considering time (e.g. 100yrs) and the extent of natural system boundaries (coastal cells) • Identify desired objectives
Risk Assessment and Analysis	• Characterize coastal hazards, including climate change impacts • Determine exposed elements, vulnerabilities and risk • Consider cumulative impacts and existing pressures • Clarify needs, values, and potential trade-offs
Option Development and Appraisal (focus of this guide)	• Develop a long-list of potential options (supported by Section 4), including nature-based, structural, policy, and hybrid solutions. • Undertake initial option screening based on transparent, agreed-upon values and constraints to narrow down the list • Undertake options appraisal of short-listed options to consider the outcomes, costs, benefits, risks, and trade-offs of each option over the life-cycle of the approach.
Implementing Action	• Develop an implementation strategy (including detailed design where applicable), roles, timelines, and funding mechanisms. • Establish monitoring indicators and adaptive management triggers • Promote community capacity-building and stewardship
Monitoring, Evaluation and Learning	• Undertake monitoring, evaluation and learning according to identified indicators. • Use lessons learnt to adapt coastal adaptation approach.

2.3 Coastal Hazards in Canada

Coastal flooding and erosion are natural processes that shape Canada's coastal regions. Risks arise where coastal communities, infrastructure and other elements of social value are located in areas likely to flood or erode. Human activities have also directly modified coastal systems, which has made flooding and erosion worse in many places. Climate change is also causing changes in flood and erosion patterns.

The following sections provide an overview of coastal hazards and how they are anticipated to change in Canada. Further detail can be found in Canada's Changing Climate Report - Chapter 7: Changes in oceans surrounding Canada.[6]

2.3.1 Coastal Flooding

Coastal flooding occurs when high water levels and waves overtop natural shorelines or built defences, inundating low-lying coastal areas. It can result from the combined influence of tides, storm surge, waves, rainfall, and river flows, among other factors.

Many Canadian communities are located in areas of existing coastal flooding under present-day conditions. Climate change impacts will vary across regions in Canada, and the severity of hazards will be influenced by the adaptive pathways and emissions pathways taken.[7]

Generally, tides will remain predictable, but their interaction with sea level rise (SLR) increases flooding potential by allowing higher tides to reach further inland. In many areas across Canada, SLR is projected to exceed 1 m by 2100 under high-emission scenarios (AR6 SSP) such that coastal flooding will become more likely while also impacting larger areas. In the Great Lakes region, multi-year fluctuations in flooding will become more extreme with changing precipitation and evaporation patterns.

Storm surge interacts with higher baseline sea levels, such that a surge of the same magnitude today will cause greater inundation in the future when riding on elevated mean water levels. A storm that previously caused only minor flooding may, in the future, result in severe inundation under even slightly higher sea levels. Evidence also points to an increase in the intensity of storm events, with recent studies suggesting a higher frequency of extreme hurricanes and cyclones on the East Coast.

Estimating total water levels requires considering SLR-adjusted baselines, with tools like climatedata.ca in Canada, and Sea Level Projection Tool from NASA offering scenario-based guidance and interactive map viewers. More detail regarding the processes driving, and the influence of climate change, on coastal flooding in Canada is James et al. (2021).

2.3.2 Wave Effects

Wave action is a natural and ongoing hazard that shapes Canada's coasts, driving shoreline change, erosion, and flooding during storm events. Communities located in low-lying or exposed areas already face challenges from wave runup, overtopping, and infrastructure damage.

Climate change is modifying the nature of this hazard. Higher sea levels increase nearshore water depth, enabling larger wave heights to reach and impact the coast—resulting in greater runup, overtopping, increased erosion risks, and inland flooding. Communities may experience compound hazards, particularly in urbanized and low-lying areas. In more northern regions particularly in Arctic and Atlantic Canada, as well as the Great Lakes region, warming temperatures and the loss of sea ice will expose coastlines to winter storms that were previously buffered, increasing flood and erosion risk.

Climate change also affects wave regimes through changes in storm patterns On the East Coast, the rising frequency of intense Atlantic storms raises the urgency for adapting coastal defences. Meanwhile, wave-induced hazards in the Great Lakes region are also expected to intensify with more energetic local winds and fluctuating lake levels. Long wave oscillations (seiches), hurricanes, and tsunami risk in the Pacific region must now be considered within an evolving climate risk framework.

2.3.3 Coastal Erosion and Sediment Dynamics

Erosion and sediment transport are natural geomorphic processes that shape Canada's coastlines. Coastal communities have always experienced land loss, accretion, and shifting shorelines, particularly in areas of unconsolidated sediment.

Human activities such as shoreline hardening, dredging, and development have further disrupted these natural dynamics. Longshore and cross-shore sediment transport pathways are further disrupted by human interventions like armouring and hard infrastructure. Aeolian transport and natural dune-building processes are also threatened by changes in vegetation and human activity—further weakening natural coastal defences.

Sea level rise effectively shifts the shoreline inland, alters sediment transport dynamics, and can increase the frequency of erosive events. When combined with more energetic wave conditions and reduced recovery time between storms, this accelerates land loss. In areas where accelerating SLR is outpacing sedimentation rates, there can be shifts from accretion to erosional regimes (or drowning of coastal features like barrier islands, mudflats and salt marshes). Not only does this result in the loss of important ecosystems, but the protection these features provide from coastal hazards will also be lost, resulting in greater exposure and vulnerability of communities in these areas.

In Arctic regions, melting permafrost is also contributing to more rapid shoreline retreat.

2.3.4 Climate Uncertainty

Climate change introduces significant uncertainty when developing coastal management options. While SLR projections are well-documented, they come with error bounds and confidence intervals that interested parties must interpret when selecting design elevations or planning infrastructure. For example, designing for a high-end scenario may drastically increase project cost but lower future risk.

2.3.5 Compounding and Cascading Hazards

Coastal hazards must be considered in combination with other processes and risks, in order to develop a **systems approach** to coastal management. For example, compound flooding that is influenced by rainfall and fluvial flooding, as well as coastal processes should be considered. Other risks that impact on community wellbeing include saltwater intrusion and extreme heat.

2.3.6 Regional Considerations

A diversity of coastal habitats, processes and communities exist along Canada's coastlines. Understanding these regional differences, the processes that drive them, and the communities that live with them is key to the development, appraisal, and selection of options for coastal management. Select regional considerations are highlighted in Table 5.

Table 5: Select key regional considerations for coastal management.

Region	Northern Coast	West Coast	Great Lakes	East Coast
Provinces and Territories	Yukon Northwest Territories Nunavut Manitoba Ontario Quebec (Nunavik) Labrador (Nunatsiavut)	British Columbia	Ontario	Newfoundland Nova Scotia Prince Edward Island New Brunswick Quebec – St Lawrence River
Coastal Development	Remote, small and Indigenous coastal communities. Access to materials is difficult/ expensive	Large, highly developed areas (e.g. Vancouver, Richmond) contrast with remote and Indigenous communities (e.g. Vancouver Island)	Large, highly developed areas, as well as smaller communities. Significant hardening of shorelines.	Many small, rural and Indigenous communities. Coastal tourism is significant.
No of dwellings 1km from the coast (2021)[8]	12,613	472,632	Not measured in 2021 Census data	463,982
Coastal Flooding	Coastal flooding is dominated by extratropical storms that pass over the Beaufort Sea and significant storm surges.	Large low-lying areas and complex systems of, fjords, inlets, and islands. Compound impacts include major estuaries, and tsunami.	Lake water levels are regulated but control is limited. Short-term events such as seiches and storm surges heighten flooding.	Hurricanes and post-tropical storms can bring extreme storm surges and waves, causing flooding and erosion.
Wave Effects	Sea ice is important in limiting wave	Highly localized micro-climates and	Lake depth impacts waves - shallow	Sea ice is important in limiting wave

Region	Northern Coast	West Coast	Great Lakes	East Coast
	impacts on shorelines and is reducing with climate change.	storm systems must be considered on a per-site basis.	lakes (Erie) vs deep/large lakes (Huron, Superior, and Michigan.)	impacts on shorelines, and reducing with climate change.
Coastal Erosion and Sediment Dynamics	Permafrost thaw is increasing erosion rates.	Complex and varying coastlines. Cobble and gravel beaches along hardened shorelines can see significant change.	Glacial till bluffs are susceptible to coastal erosion. Warmer winters with less ice can increase erosion.	Varied shoreline types. Sand dominated systems are particularly susceptible to erosion (e.g. PEI).
Climate Change and Uncertainty	Climate is warming faster in the North than elsewhere in Canada. Lack of data makes predicting change and coastal management challenging.	Highly variable local conditions, and uncertain change in drivers such as the El Niño–Southern Oscillation (ENSO) make predicting change challenging.	Water level variability is anticipated to increase with more extreme highs and lows, rather than a uniform trend.[9] Algae blooms and water quality are key concerns (Erie, Huron and Ontario)	Reduction in ice will result in more winter storms reaching the coast Some research suggests there will be more storms that develop into hurricanes[10]

Read more about regional considerations in the publication Nature-based infrastructure for coastal flood and erosion risk management: a Canadian design guide[11] Chapter 6, which particularly highlights considerations for nature-based infrastructure.

2.4 Coastal Adaptation Strategies

Canada does not yet have a strategic planning framework or standard classification of strategic approaches for coastal risk management. This section presents three frameworks that have been developed and applied in Canada.

- The Protect, Accommodate, Retreat, Avoid (PARA) Framework
- Sea2City Design Challenge: New Approach to Coastal Adaptation
- 5Rs: Reimagine, Reserve, Relocate, Restore, Reinforce

2.4.1 The Protect, Accommodate, Retreat, Avoid (PARA) Framework

The "Protect, Accommodate, Retreat and Avoid" (PARA) framework[12] is the most commonly used framework in Canada to categorize adaptation and disaster risk reduction approaches to coastal hazards and inland flood risks.[13]

The framework outlines four key strategies for managing coastal risks:

- *Protect*: Strategies include actions that alter the environment to protect existing activities, property, and infrastructure from a hazard, while that which is being protected remains largely unchanged.
- *Accommodate*: Strategies involve actions that alter the property, infrastructure or activity that is at risk to better live with the risk.
- *Retreat:* Strategies reduce risk by removing the people, property, and infrastructure away from a hazardous area. Retreat strategies can be proactive, or implemented as part of a disaster response
- *Avoid:* Strategies prevent future development in hazard zones.

This classification reflects three of the six types of coastal management responses identified by the IPCC in 2019, and includes "avoid" as distinct category. The IPPC also identified "No Response", "Advance", and "Ecosystem-based adaptation" as separate responses. [14]

Practically these strategies are often used in combination to build long-term coastal resilience and may be applied in sequence as part of an adaptation pathway. Nature-based solutions can also play a role in both coastal protection and retreat, as reflected in the modified PARA framework presented Eyquem, 2021 (Figure 3).

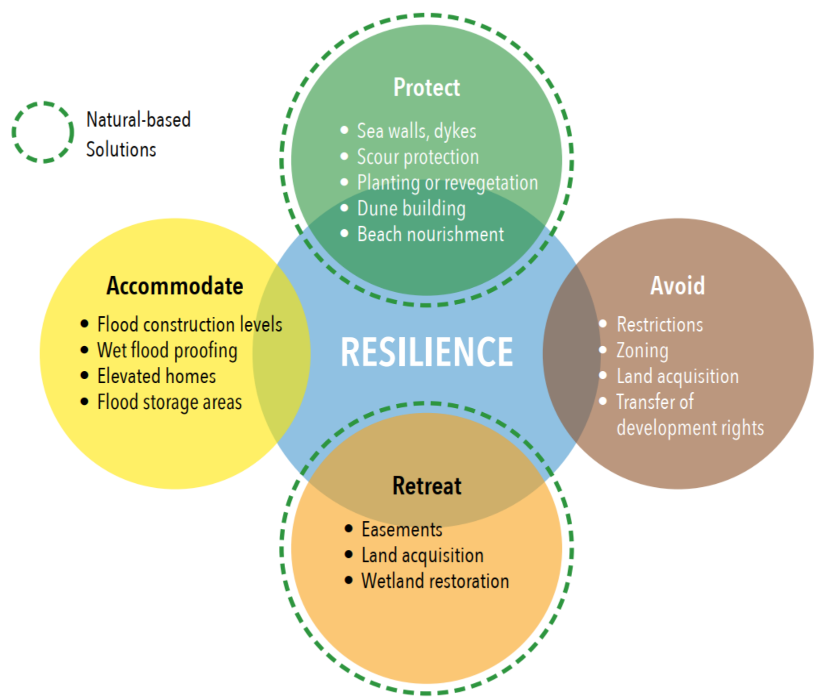

Figure 3: The PARA framework (Eyquem 2021, adapted from Doberstein et al 2018)

2.4.2 Sea2City Design Challenge: New Approach to Coastal Adaptation

A new approach was developed as part of the Sea2City Design Challenge for False Creek in Vancouver, British Columbia. The approach challenges the colonial framing of adaptation terms like "resist," "retreat," and "accommodate," which position nature as an adversary. Instead, adaptation is reframed with new language that encourages a more respectful and reciprocal relationship with natural systems and Indigenous values: (see Figure 4).

- **Acknowledge**: spaces are retrofitted or relocated over time to improve their resilience and better care for and steward natural systems.
- **Host**: a dynamic place where water, nature, and culture are welcomed and stewarded. Human uses are flexible, adaptable, and leave a light-touch. Infrastructure works with nature to enhance resilience.
- **Restore**: a revitalized and rehabilitated shoreline that restores natural functions, features, and ecosystems and includes improved flood protection for upland communities.

The approaches were envisioned as not mutually exclusive, to be interwoven with a foundation of Host Nation values embedded in them.

Figure 4: Sea2City's New Approach to Coastal Adaptation (adapted from City of Vancouver, 2022)

2.4.3 5Rs: Reimagine, Reserve, Relocate, Restore, Reinforce

On the Atlantic coast, a new framework has been developed for Nature-based Coastal Adaptation (NBCA).[15] Co-created with Indigenous Peoples in Atlantic Canada, the approach introduces five interconnected strategies:

- **Reimagine** coastal living by shifting away from controlling nature.
- **Reserve** space for natural systems through protective land-use policies.
- **Relocate** infrastructure or communities at risk, guided by public engagement.
- **Restore** degraded ecosystems as part of adaptation.
- **Reinforce** only when necessary, using protection measures designed to work with nature.

Together, these "5Rs" offer a more inclusive and ecological approach to coastal resilience. The The new framework is gaining attention - the Green Shores Program of Stewardship Centre for BC has already been viewed through the lens of the 5Rs and promotes activities that align with these concepts.[16]

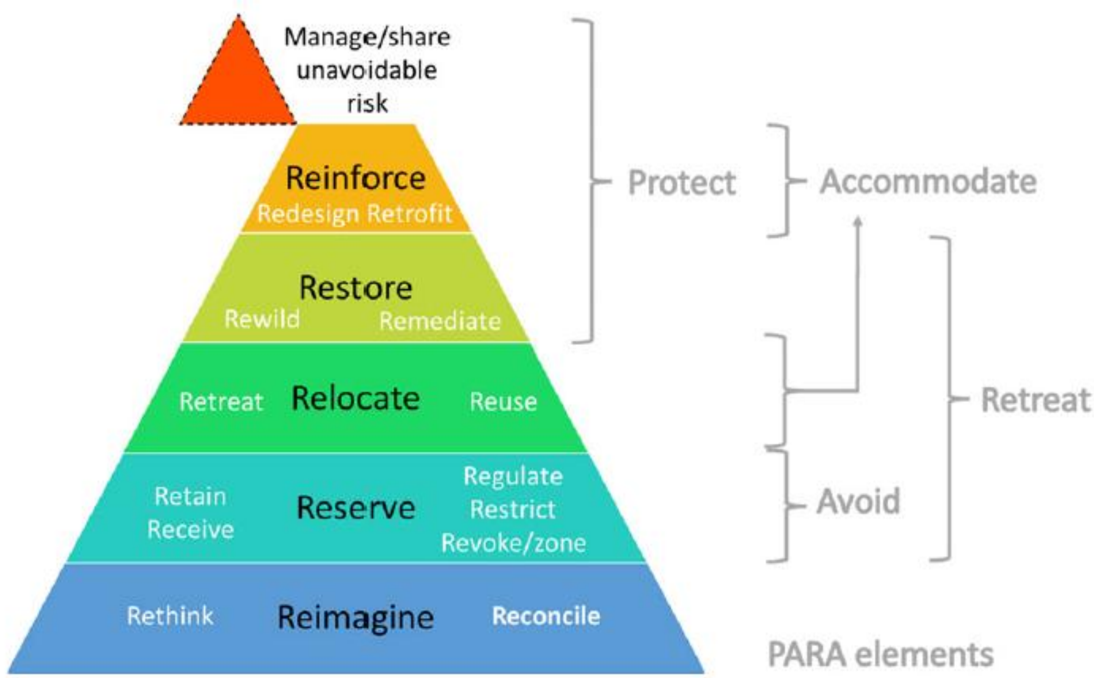

Figure 5: 5Rs approach to nature-based coastal adaptation (Sherron et al. 2024)

3 Options Development and Appraisal Methods

3.1 Developing a Long List of Options

Options development starts with developing a long list of potential options, including non-intervention, policy or regulatory change, and / or physical intervention on the ground. Option development should include community and partner engagement.

An overview of common coastal management options is described below and does not always involve physical intervention. Often different options are combined and implemented in tandem to obtain the best outcomes for the community. Further detail on factors to consider during options development are provided in Appendix A.

3.1.1 "Do Nothing" / Non-Intervention

When assessing potential coastal management options, the inclusion of a baseline 'do-nothing' or 'non-intervention' option is used to help assess the added-value of intervention.

The baseline scenario should consider future changes that are likely to occur within the timeframe of appraisal when no action is taken, including:

- Changes in coastal hazards and risks, incorporating climate change impacts
- Ongoing development trends and socio-economic factors

3.1.2 "Do minimum" / Business as Usual

Alongside the "do nothing" scenario, project teams may also wish to define a "Do minimum" or "Business as Usual" option in which ongoing operations, maintenance, policy or legislation that has been previously established is continued, but no additional action is taken.

3.1.3 Policy or Regulatory Change

Coastal management options do not always involve the development of new built or natural infrastructure or active enhancement / restoration. Options may include changes to policies or regulation, like land use planning, zoning, or permitting. This can particularly be effective in avoiding placing new housing and infrastructure at risk. Education can also be used as a coastal management option, for example to reduce activities that make risk worse.

Environmental management policies or conservation designations, like Marine Protected Areas, can contribute to coastal management to limit human activities that accelerate coastal flooding or erosion. These designations may also support recovery of coastal habitats, like sand dunes, that can help reduce coastal flood and erosion risk.

3.1.4 Additional Physical Intervention

Additional physical intervention may include nature-based, grey and hybrid infrastructure solutions. Options range from active restoration of natural coastal habitats to protection, reinforcement, or retrofitting using grey or nature-based infrastructure. Options are also frequently combined to form hybrid approaches (Figure 6). Additionally, physical intervention may also include proactively relocating or retreating housing and infrastructure at risk to areas less at risk.

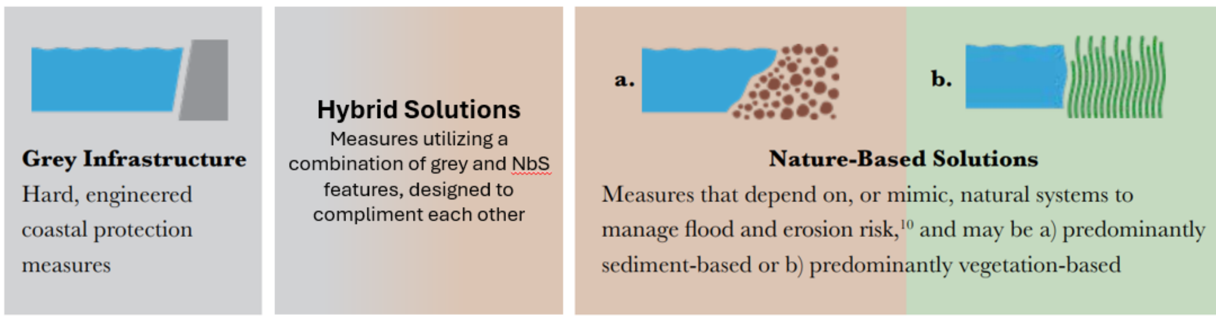

Figure 6: Overview of Grey, Hybrid and Nature-Based Solutions (Modified from Eyquem, 2021)[17]

Nature-based Solutions (NbS) leverage natural processes, and assets simultaneously reducing coastal risks while providing environmental, social, and economic co-benefits to communities. Grey infrastructure approaches, such as sea walls and rock revetments, have traditionally been used for coastal management mitigation, offering protection in extreme environments. However, they often work against natural processes and may lead to ecological degradation and unintended socio-economic effects over time. In reality, most coastal adaptation approaches combine these approaches. In some cases, coastal processes have already been so highly modified that natural processes are not self-sustaining (e.g. sediment supply no longer sufficient to maintain a beach).

Additional information regarding a range of nature-based, grey and hybrid coastal protection options, together with their advantages and their disadvantages, can be found in Rising Tides and Shifting Sands: Combining Natural and Grey Infrastructure to Protect Canada's Coastal Communities.[18]

Specific design guidance for consideration of nature-based infrastructure options can be found in Nature-based infrastructure for coastal flood and erosion risk management: a Canadian design guide

The Green Shores Program, supported by the Stewardship Centre for BC and their funding partners, also provides science-based tools and best practices to minimize the impacts of new developments and restore shoreline ecosystem function of previously developed sites. Various elements of the program, including Green Shores for Shoreline Development, Green Shores for Local Government, Green Shores for Homes, and associated certification schemes may be useful in developing a list of potential options.

-Table 6 Overview of nature-based, grey and hybrid infrastructure coastal adaptation options

	Coastal Management Option	**Description**	**Hazard Applicability**				
			Coastal Flooding	**Erosion**	**Wave Effects**	**Climate Uncertainty**	**Compound Hazards**
Nature-based Solutions	Existing coastal ecosystems	Conservation of existing coastal ecosystems.					
	Terrestrial and intertidal vegetation	Planting of native vegetation.					
	Marine vegetation (including kelp and eelgrass beds)	Planting or encouraging vegetation to help stabilize sediments and reduce wave energy					
	Wetland restoration / expansion	Restoration/expansion of coastal wetlands					
	Shell (clam) gardens	Enhancing clam habitat and productivity in the intertidal zone to provide coastal stabilization					
	Brushwood / sediment fencing	Use of natural materials to trap blowing sand and encourage accretion and dune growth.					
Hybrid Solutions	Dynamic revetments	Coarse material reshaped by wave action to mimic natural beaches and support sediment processes and ecological functions.					
	Habitat Islands	Artificial or restored islands to provide coastal protection and shelter.					
	Beach nourishment	Addition of material to beach system. Includes sand, gravel, and cobble beaches.					
	Dune nourishment	Addition of material to dune systems to encourage/maintain healthy dunes when faced with loss of sediment.					

Coastal Management Option		Description	Hazard Applicability				
			Coastal Flooding	Erosion	Wave Effects	Climate Uncertainty	Compound Hazards
	Dikes (including living and conventional)	Embankments built to prevent coastal flooding.					
	Emergent breakwaters (including headlands)	Detached structures to reduce wave energy reaching the shore.					
	Submergent breakwaters and reefs	Underwater structures to encourage wave breaking and dissipate energy before reaching the shore.					
Grey Infrastructure	Groynes and sills	Shore-oblique or -perpendicular structures designed to manage sediment.					
Grey Infrastructure	Seawalls (including living and conventional)	Shore-parallel, often vertical structures to protect shorelines from wave action.					
Grey Infrastructure	Surge barriers and sea dams	Large, often moveable, structures designed to close off estuaries to prevent extreme flooding.					
Grey Infrastructure	Relocation/Raising of infrastructure	Moving existing buildings or infrastructure to a new location to avoid coastal hazards.					
Grey Infrastructure	Revetments (including conventional, terraced, and vegetated)	Shore-parallel, sloped structures designed to protect from coastal erosion.					

3.2 Initial Options Screening

Options screening aims to identify a shortlist of most appropriate coastal adaptation options for further, more detailed, option appraisal.

Based on the initial long list of approaches, initial option screening considers key factors such as technical feasibility, cost, regulatory requirements, social acceptability, and impacts on different groups. Options are screened out when a “red flag” issue, that would make the implementation of the option inappropriate or unfeasible, is identified.

Option screening should be transparent and involve interested parties (see Section 2.2.1) to enhance the credibility of screening decisions. Potential screening criteria are presented in Table 7, with more detail provided in Appendix A.

Table 6: Coastal Option Screening Factors and Potential Screening Criteria

Option Screening Factors	Potential Screening Criteria
Technical Feasibility	• If the option is a built or natural infrastructure intervention, is it physically feasible considering local coastal processes and initial understanding of materials required? • Is the option likely to negatively impact neighbouring coastlines, people, or existing structures? • Is the option appropriate in both present and future potential climate change conditions, given a range of uncertainties?
Cost	• Can this option be realistically funded in the short- and long-term? • Is maintenance likely required, and if so, will future funding be available for it?
Regulatory Requirements	• Does the option meet legal requirements within federal, provincial, local and Indigenous law?
Social Acceptability	• Is the option likely to reduce coastal risks to acceptable levels? • Does the option reflect local values? • Is the option likely to be acceptable to key interest groups, including community leaders, shoreline users and decision-makers? • Does the option meet political, cultural and social objectives?
Impacts on Different Groups	• Is the option unfair, or exacerbate existing equity issues? • Does the option address the needs of vulnerable or underrepresented groups?

3.3 Options Appraisal Methods

Options appraisal is the comparison of different options against set criteria to help decision makers select an approach that delivers the most desirable overall outcomes.

Options appraisal is typically applied to a shortlist of coastal management options following option screening. Comparison to a baseline scenario of "do nothing" or "non-intervention", is included to understand how an adaptation option compares.

A variety of option appraisal methods can be applied. This chapter describes four key methods:

5. Multi-Criteria Decision Analysis (MCDA)
6. Cost-Effectiveness Analysis (CEA)
7. Cost-Benefit Analysis (CBA)
8. Economic Impact Assessment (EIA)

Certain steps in option appraisal are common to each of these methods and are described in the first section of the chapter:

However, the four option appraisal methods also vary significantly in approach and complexity, and bring different strengths and limitations. For each type of option appraisal, the subsequent sections provide details of:

- Appraisal method
- Data requirements
- How ecosystem outcomes can be integrated
- How social outcomes can be integrated
- Strengths and limitations

The chapter concludes with a comparison of the four option appraisal methodologies and guidance on when and how to apply each in coastal management contexts.

3.3.1 Common Steps in Option Appraisal

Each option appraisal approach presented in this chapter includes seven common steps. A brief description of each of these steps is presented in Figure 7.

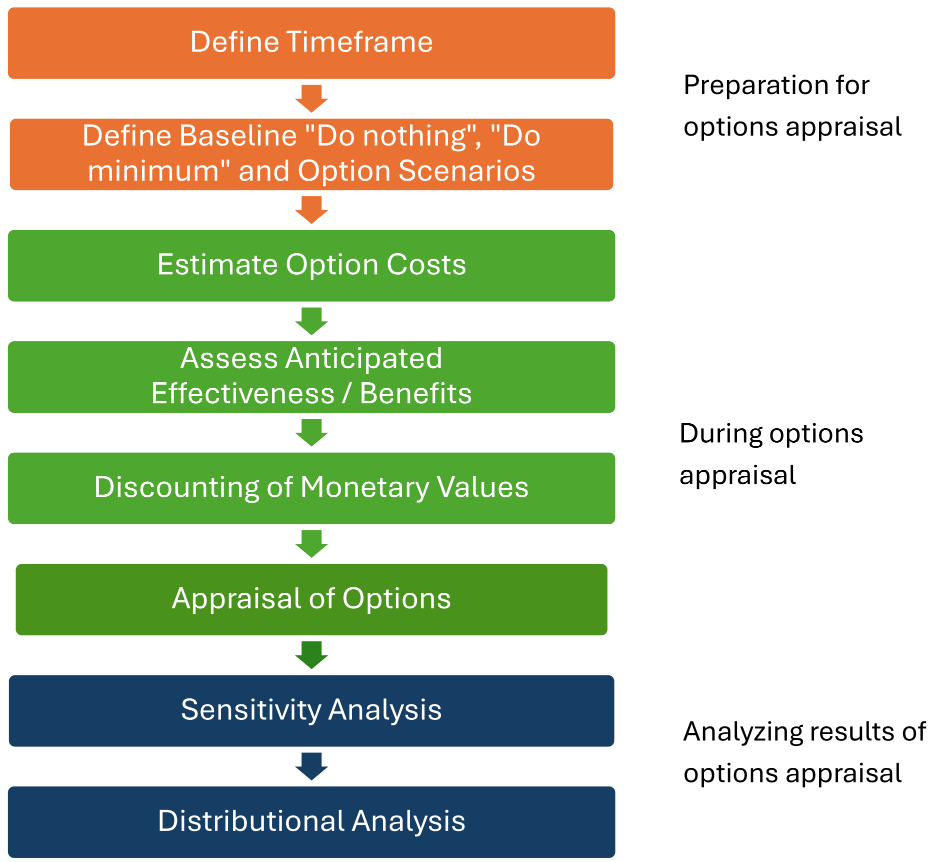

Figure 7: Common Steps in Options Appraisal

3.3.1.1 Define Timeframe

Options appraisal should be undertaken over a defined timeframe. The timeframe should be selected to reflect the coastal hazards being considered, expected service life of interventions, and the need for long-term coastal resilience. Clear justification should be provided for the chosen period. As an example, options appraisal is undertaken over a standard period of 100 years in England and Wales (see Section 4.4) . Within Indigenous world views an outlook spanning seven generations is often referenced.[19]

It should be noted that, within the overall timeframe of appraisal, different coastal management options may be considered to be implemented at different times, as part of a sequenced or adaptation pathway approach.

3.3.1.2 Define the Baseline "Do Nothing", "Do Minimum" and Option Scenarios

A "do nothing" scenario (described in Section 3.1.1) provides a baseline that all other coastal management options can be compared with.

The way in which the “do nothing” scenario is assessed will depend on the option appraisal methodology being applied. Assumptions made, together with supporting data or basis for them, should be clearly documented along with associated uncertainties.

A "do minimum" scenario may also be defined (see Section 3.1.2) in which ongoing maintenance, policy or legislation that has been previously established is continued under a “business as usual” approach, but no additional action is taken.

Alongside these baseline options, the shortlisted options should also be defined, including the timing of different types of intervention.

3.3.1.3 Estimate Option Costs

An estimate of the cost of each option is required as an input for each option appraisal method. Costs that can be considered are detailed in Table 8. The detail required in costing may vary according to the appraisal method selected and the stage of the project.

Costs should be estimated over the full timeframe of the appraisal. This includes upfront capital expenditures (where options include additional physical intervention), as well as ongoing costs of operation, maintenance, monitoring, and decommissioning.

Many costs relate to elements that are traded and therefore have market values, such as the cost of labour and materials. However, to account for ecological or social costs, negative externalities also need to be estimated, such as degradation of ecosystem services or loss of access to cultural areas, which are often neglected in traditional option cost estimates.

Incorporation of these option costs typically involves estimating non-market values. Methods that can be used to estimate non-market values are described in Appendix B. Negative changes in non-market values can be considered as option costs. Classifications and valuation tools that can be specifically useful in valuing changes in ecosystem services are identified in Appendix C.

Table 7: Costs to consider in Option Cost Estimation

Cost Category	Costs to Consider
Planning & Implementation	• Feasibility, baseline studies, analysis and assessments, that may be required for design, permitting and funding applications. • Conceptual and detailed design development (where option is physical intervention) • Capital costs • Equipment and labour • Community engagement • Planning permissions • Permits • Surveys • Transitional costs

Cost Category	Costs to Consider
	• Legal advice
Operations	• Project management • Administrative costs • Equipment and labour • Energy • Input costs • Enforcement • Monitoring
Maintenance	• Inspection costs • Corrective repair and maintenance* • Regular maintenance activities
Renewal	• Replacement costs
Decommissioning	• Removal and disposal cost • Restoration costs resulting from decommissioning
Negative externalities	• If natural assets are impaired - reduction in the value of ecosystem services provided (may include non-market values) • If cultural or built heritage assets are impaired – cost of degradation or loss of access (may include non-market values) • Foregone revenue from trade-offs (e.g., foregone tourism revenue, or income from reduction in fish productivity) • Residual damage costs
Indirect costs	• Declines in other markets

*Corrective maintenance includes activities to help the asset become self-sustaining and in the case of natural assets, provide ecosystem services.

3.3.1.4 Assess Anticipated Effectiveness / Benefits

Assessing the anticipated effectiveness and benefits of a coastal adaptation option is undertaken according to outcome indicators and performance metrics. The approach to measurement varies with different option appraisal methods.

Cost-Effectiveness Analysis measures performance against a single outcome measure that must be fulfilled by all options. Other option appraisal methods additionally involve consideration of a range of additional benefits (frequently termed co-benefits) and associated performance metrics. Metrics used to assess effectiveness should be selected based on the hazards, goals, and objectives established at the start of the coastal adaptation process.

Examples of effectiveness / benefit performance metrics for coastal option appraisal are presented in 9. Data availability and the intent of the appraisal will need to be considered in selection of effectiveness / benefit performance metrics.

For additional guidance relating to NbS co-benefits see Co-Benefits. Nature-Based Solutions to Address Flood Risks in Coastal Communities (CEC, 2025)[20].

Table 8: Examples of effectiveness / benefit performance metrics for coastal option appraisal.

Outcome	Potential Performance Metrics
Coastal flooding and/or wave impacts	Reduced coastal hazard (flood depth, wave effects etc.)
	Decreased hazard frequency
	Avoided damage to property and infrastructure
	Reduction in operation and maintenance costs
	Number of people displaced per year
	Decreased number of closures of facilities/roads
Coastal erosion and sediment management	Average annual rate of coastal change (historic vs. projected)
	Avoided damage to property and infrastructure
	Reduction in operation and maintenance costs (e.g. dredging)
	Number of people displaced
	Coverage of coastal vegetation such as dune grasses
Nature and biodiversity	Improved fish productivity
	Species presence for biodiversity
	Landscape habitat diversity
	Landscape connectivity
	Habitat intactness
Social wellbeing	Avoided heath care costs related to stress and anxiety
	Quality-adjusted life year (QALY) index
Local economy	Increase in property values
	Increase in business revenues (e.g. from tourism)
Climate change mitigation	Amount of carbon sequestered from the atmosphere per year (tC/ha/yr)
	Above ground carbon (ton C/ha)
Cascading and Compounding Hazards	Runoff volumes
	Coastal water quality (including algae blooms)
	Saltwater intrusion and well water quality

As part of option appraisal, non-market valuation methods may be used to incorporate the estimated value (in $) of anticipated beneficial changes in ecosystem services or social wellbeing (as well as negative changes that may input to option costs – see Section 3.3.1.3.).

Methods that can be used to estimate non-market values are described in Appendix B. Positive changes in non-market values can be considered as option benefits. Classifications and valuation tools that can be specifically useful in valuing changes in ecosystem services are identified in Appendix C.

Benefits will also need to be appropriately estimated over time. For example, nature-based infrastructure may experience moderate upfront costs with minor benefits at implementation, but its influence of coastal processes will increase over time as the ecosystem grows and thrives; leading to significant benefits that are not realized for years or decades after implementation. In comparison, hard engineered structures or grey infrastructure might require high upfront costs that result in immediate benefits, but performance can often degrade towards the end of the designed service life.

3.3.1.5 Discounting of Monetary Values

Discounting is an economic process to convert future values, including costs and benefits, into present-day dollar values (Net Present Value – NPV). It reflects the rate at which society is willing to trade off current and near-term prosperity with future prosperity.

A dollar is worth more today than in the future because (1) it has a greater capacity to earn interest, (2) inflation devalues the purchasing power of a dollar over time, and (3) the future is uncertain. Because of this, future values are discounted to determine how much they are worth today.21

Discounting allows a comparison of benefits and costs across projects in dollar values that are comparable. This is important, since a large share of costs in coastal management may be incurred at the beginning of a project, whereas benefits tend to accrue over time.

Discounting is applied as a rate (%) each year over the timeframe of appraisal and the costs/benefits are summed to calculate Present Value.

Present Value (PV) is calculated according to the following calculation:

$$Present\ Value = \frac{Net\ Cash\ Flow_t}{(1 + Discount\ Rate)^t}$$

Where t is the time of the cash flow

In Canada, a standard discount rate of 8 % is used for the evaluation of regulatory interventions.[22] However, a lower discount rate (often referred to as a social discount rate) may be appropriate where intergenerational and environmental considerations are important.

For example, the federal government uses a 2% discount rate in any cost-benefit analysis (CBA) or analysis in which social cost of greenhouse gas values are applied to multiple future years.[23] For a coastal cost-benefit analysis study conducted by Ouranos (see Section 4.3), the discount rate chosen was 4%, as recommended in the organization's economic analysis guide.[24]

The influence of discount rate on calculations of net present value can be significant (and sensitivity analysis with a range of discount rates is recommended (see Section 3.3.1.6).

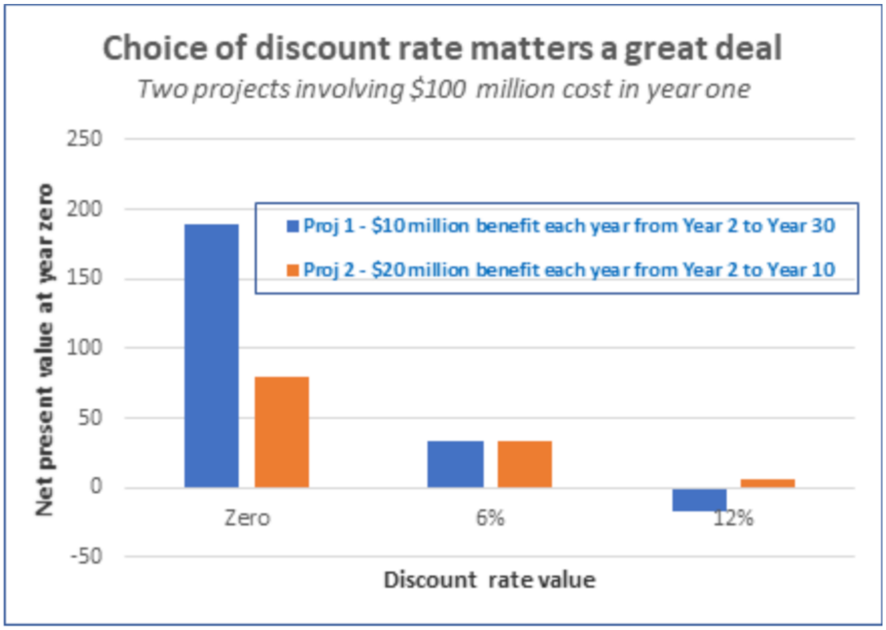

Figure 8: Influence of choice of discount rate on net present value of two projects (adapted from Brumby and Cloutier, 2022)[25]

3.3.1.6 Sensitivity Analysis

Sensitivity analysis is used to determine how different key variables or sources of uncertainty impact the outcome of options appraisal.

For example, effects of climate change carry a degree of uncertainty, and assumptions related to how coastal assets will deteriorate over time need to be made to assess future impacts and performance. Sensitivity analysis can help identify how thresholds for action, or 'tipping points' that can be considered within the options appraisal process.

Given the level of uncertainty surrounding the effects of climate change and coastal hazards that coastal communities face, sensitivity analysis for long-term adaptation may be expanded to include the use of multiple baseline scenarios. Uncertainties surrounding future socio-economic conditions may also benefit from multiple baseline scenarios for long-term options appraisal.

Sensitivity analysis may be used to explore the impact on option appraisal outcomes of:

- Different coastal hazard scenarios incorporating different future climate projections
- Change in estimated input costs such as land prices or construction materials
- Assumptions relating to repair and maintenance requirements
- Change in natural assets and priority ecosystem services
- Use of different discount rates

3.3.1.7 Distributional Analysis

Distributional analysis helps to identify how coastal adaptation options affect different population groups in different ways, especially those who have fewer resources or are at greater risk (OECD 2019).

The way benefits or losses are shared can significantly influence equity and social acceptability, which in turn affects the success of the approaches. Distributional analysis helps identify the impacts on different groups, such as low-income individuals or older members of a community. Many coastal adaptation options will seek to specifically support vulnerable groups. If these groups are negatively impacted, their increased vulnerability could increase risk.

Several authoritative guidelines endorse distributional analysis. These include Canada's Treasury Board Secretariat (2022) Cost-Benefit Analysis Guide for Regulatory Proposals, the United States Environmental Protection Agency (2024) Guidelines for Preparing Economic Analysis, and Canada's Impact Assessment Agency (2025) Practitioner's Guide to Federal Impact Assessments. Under Canada's Impact Assessment Act, gender-based analysis plus (GBA+) is required to evaluate how impacts are distributed among diverse population groups.

3.3.2 Multi-Criteria Decision Analysis (MCDA)

3.3.2.1 Appraisal Method

Multi-Criteria Decision Analysis (MCDA) assesses options against several performance metrics linked to specific criteria. Criteria can be quantitative or qualitative, and commonly include cost, effectiveness, achievement of co-benefits, regulatory requirements, social acceptability, and impacts on different groups. Each criterion is given a weighting to arrive at an overall score for each option and options are compared based on this score. A simple version of MCDA is often used for initial option screening.

Criteria selection and weighting is typically informed by a group of interested parties. MCDA therefore involves engaging with interested parties, including community representatives. Community and partner engagement should begin at the start of the coastal adaptation process, well before the option appraisal stage (see Section 2.2.1).

Key considerations and specific tasks for undertaking MCDA are identified in Table 10, framed within the common appraisal steps outlined in **Error! Reference source not found.**7. Specific tasks are indicated in *italics*.

Table 9: Key considerations and specific tasks for Multi-Criteria Decision Analysis (MCDA)

Step	Key Considerations and Specific Tasks
Estimate option costs	• Option costs do not necessarily need to be fully quantified in monetary terms if there is insufficient data, but should still be estimated over the full timeframe of appraisal.

Step	Key Considerations and Specific Tasks
	• Ranges of costs may be used for different stages of implementation. • *Interested parties should be engaged in selection and weighting of cost criteria.*
Assess Anticipated Effectiveness / Benefits	• *Anticipated effectiveness and benefits are assessed using performance criteria and weighting.* • *Interested parties should be engaged in selection and weighting of effectiveness and benefit criteria to reflect community values.*
Discounting of Monetary Values	• Where the monetary value of costs and benefits is estimated in detail (on a yearly basis), discounting should be applied to enable more robust option comparison.
Appraisal	• *A manageable set of criteria, associated performance metrics and weightings should be agreed on in a transparent manner (see Section 3.3.1.4 for guidance on potential performance metrics).* • *Interested parties should input to scoring against the criteria.* • *Options (including "do nothing") are compared based on their overall score, which combines performance against the different criteria.*

3.3.2.2 Data Requirements

Data requirements for MCDA can be grouped into three categories

- Options data - including estimated costs and anticipated effectiveness and benefits over the timeframe of appraisal, in monetary, quantitative or qualitative terms.
- Criteria data - to define appropriate performance metrics
- Scoring data – to assess performance of each option against each criterion

Data in each of these three categories may be quantitative (e.g., cost/m^2) or qualitative (e.g., high, medium or low). MCDA is therefore a flexible approach that can be applied even where detailed data is not available. A low-resource approach, such as the use of expert opinion, may rely on qualitative data and metrics, whereas a high-resource approach, such as modelling coastal hazards and ecosystem function, can use quantitative metrics.

3.3.2.3 Integrating Ecosystem and Social Outcomes

Ecosystem outcomes can be fully integrated into MCDA by identifying specific criteria and performance metrics related to changes in ecosystem services (e.g. increased filtration and water quality) or social wellbeing (e.g. physical and mental health, equity, culture and heritage, education). As for other criteria, selection of ecosystem or social outcome-related criteria should be made with input from interested parties, considering the data is available.

The ecosystem and social outcomes integrated in MCDA may be desirable / positive (benefits) or undesirable / negative (costs). Depending on the data available, criteria may also be qualitative or quantitative and performance metrics can include non-market valuation of changes in dollars. Methods that can be used to estimate non-market values are described in Appendix B. Classifications and valuation tools that can be specifically useful in valuing changes in ecosystem services are identified in Appendix C.

Care will be required to avoid double-counting benefits – for example the ecosystem services provided by vegetation in reducing wave impacts could also be accounted for in effectiveness criteria.

3.3.2.4 Strengths and Limitations

Strengths	Limitations
• Flexible approach to account for a wide array of data and information. • Can be applied where detailed data is not available, important benefits are difficult to quantify and multiple outcomes are important (as is the case for most coastal management approaches). • Performance metrics can include monetary costs and benefits, as well as non-market values. • Facilitates interested parties and title and Rightsholder engagement • Highly transparent by clearly documenting objectives, appraisal criteria, data & sources and weights and scores.	• No widely accepted authoritative guidance • Criteria selection and weighting is subjective and the result is influenced by the selection of interested parties to be involved. A different group of interested parties may reach a different preferred option. • Assessment of highly complex problems can be challenging and time-consuming.

3.3.2.5 Furthering Reading

Source	Description	Jurisdiction
Belton, V, and Stewart, TJ (2002). *Multiple Criteria Decision Analysis: An Integrated Approach*, Kluwer: Boston.	Text book addressing range of tools and approaches to MCDA.	US
Dean, M. A Practical Guide to Multi-Criteria Analysis. University College London. Jan 2022.	Guidance for students, academics and practitioners on the key aspects of MCDA and instruction for completing an assessment.	UK

Source	Description	Jurisdiction
Esmail, B., A. & Geneletti, D. Multi-criteria decision analysis for nature conservation: A review of 20 years of applications. Methods in Ecology and Evaluation. 2018: 9:42-53. DOI: 10.1111/2041-210X.12899	Review of literature on MCDA, highlighting key steps, elements, criteria, methods and communicating results.	UK
Multiple Criteria Decision Making – International Society on MCDM". *www.mcdmsociety.org*	International Society to advance research, applications of MCDA, encourage collaboration and knowledge-sharing,	International
Use of Multi-Criteria Decision Analysis in options appraisal of economic cases: Guidance. Government of United Kingdom. (2024).	Guidance for completing MCDA for options appraisal.	UK

3.3.3 Cost-Effectiveness Analysis

3.3.3.1 Appraisal Method

Cost-Effectiveness Analysis (CEA) evaluates the relative efficiency of different options or interventions by comparing their estimated costs to achievement of a desirable outcome.

CEA can only identify the most cost-effective option using a single outcome measure. When outcomes (and costs) of different options differ, CEA cannot be used to identify the most efficient option.

Key considerations and specific tasks for undertaking CEA are identified in Table 1011, framed within the common appraisal steps outline in Figure 7. Specific tasks are indicated in *italics*.

Table 10: Key considerations and specific tasks for Cost-Effectiveness Analysis (CEA)

Step	Key Considerations and Specific Tasks
Estimate option costs	• Costs should be estimated over the entire timeframe of appraisal and can include negative externalities using non-market values.
Assess Anticipated Effectiveness / Benefits	• *A single outcome measure must be defined as a basis to assess all options. For example, reduction in annual damages caused by coastal flooding.*
Discounting of Monetary Values	• Monetary value of costs should be estimated on a yearly basis and appropriate discounting should be applied to enable more robust option comparison.
Appraisal	• *A Cost-Effectiveness Ratio (CER) can be calculated for each option by dividing the option cost by its forecast effectiveness*

Step	Key Considerations and Specific Tasks
	$$CER = \frac{Total\ Cost}{Effectiveness\ Outcome}$$ • *Options are compared based on their Cost-Effectiveness Ratio (CER)*

A higher Cost-Effectiveness Ratio (CER) indicates an intervention with higher cost relative to its effectiveness while a lower CER indicates an intervention with lower cost relative to its effectiveness. If the outcome is the same for all options, the CER can be used to identify the most efficient intervention; however, if outcomes are not the same then the CER represents the trade-off between cost and outcome but does not reveal the most efficient intervention.

3.3.3.2 Data Requirements

Data requirements for CEA include:

- Monetary estimates of option costs distributed over the timeframe of appraisal (see Section 3.3.1.3.) and discounted.
- Measurement of effectiveness according to the performance metric selected.

3.3.3.3 Integrating Ecosystem and Social Outcomes

CEA can incorporate costs associated within adverse ecosystem or social outcomes (e.g. reduction in ecosystem services, loss of cultural assets). However, unless the performance metric selected to indicate effectiveness relates to ecosystem or social outcomes, these benefits are not included.

This limits the usefulness for robustly assessing and comparing nature-based, hybrid, and grey infrastructure solutions, where co-benefits are significantly different and potentially important to the community.

3.3.3.4 Strengths and Limitations

Strengths	**Limitations**
• Helps identify the least costly option for achieving a specified desired outcome • Requires less time compared to a Cost-Benefit Analysis since benefits are not monetized.	• Does not provide information on whether the benefits of an option outweigh its costs • Likely to significantly underrepresent the benefits of many coastal management options, particularly where co-benefits are important (e.g. for nature-based infrastructure) • Comparing options remains difficult where they have very different co-benefits

Strengths	Limitations
	• Does not encourage coastal managers to seek options that achieve multiple objectives.

3.3.3.5 Furthering Reading

Source	Description	Jurisdiction
Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2018). *Cost-Benefit Analysis: Concepts and Practice* (5th ed.). Cambridge: Cambridge University Press.	Covers protocols for completing CBA, with illustrative examples and case studies.	UK
[NOAA] National Oceanic and Atmospheric Administration (2021). Methodology Guide: Cost-Effectiveness Analysis. Accessed on June 13, 2025 from: https://coast.noaa.gov/data/digitalcoast/pdf/econguide-cost-effectiveness.pdf	A guide to completing CEA, including suitable uses, strengths and limitations, interpreting results and further resources.	US
[TBCS] Treasury Board of Canada Secretariat (2022). Canada's Cost-Benefit Analysis Guide for Regulatory Proposals. Accessed on June 13, 2025 from: https://publications.gc.ca/collections/collection_2022/sct-tbs/BT58-5-2022-eng.pdf	Guidance to assist departments and agencies in complying with Federal Policy on Cost-Benefit Analysis.	Canada
[USEPA] United States Environmental Protection Agency (2024). Guidelines for Preparing Economic Analyses (3rd edition). Report number EPA-240-R-24-001. Washington, DC. Accessed on June 13, 2025 from: https://www.epa.gov/system/files/documents/2024-12/guidelines-for-preparing-economic-analyses_final_508-compliant_compressed.pdf	Guide of best practices for economic analysis, including economic theory, steps for completion and presentation of results.	US
Watkiss, P. and Hunt, A. (2013). Decision Support Methods for Climate Change Adaptation: Cost-Effectiveness Analysis. Briefing Note Series: Summary of Methods and Case Study Examples from the MEDIATION Project. Funded by the EC's 7FWP. Accessed on June 13, 2025 from: https://www.sei.org/publications/decision-support-	Technical Policy Briefing Note that provides a summary of CEA for assessing projects and	EU

Source	Description	Jurisdiction
methods-for-climate-change-adaptation-cost-effectiveness-analysis/	policies to address climate change adaptation.	

3.3.4 Cost-Benefit Analysis (CBA)

3.3.4.1 Appraisal Method

Cost-Benefit Analysis (CBA) identifies and compares the economic, ecosystem and social costs and benefits of an option. Total expected benefits are compared to total expected costs in present monetary terms, to assess whether benefits outweigh costs, and identify the option that generates the greatest net benefits to society.

The cost and benefits considered can include estimates of market and non-market values. Both costs and benefits are discounted based on the timing of their occurrence within the timeframe of appraisal in order to present them in a common, present-day values (see Section 3.3.1.5). Recommendations are generally based upon:

- Net-Present Value (NPV) - the difference between the present value of benefits and the present value of costs.
- Benefit: Cost Ratio (BCR) - the ratio of the present value of benefits to the present value of costs, used to assess the economic efficiency of an option.

The basic formula for calculating NPV is:

NPV = (Cash Flow / (1 + Discount Rate)^Number of Periods) - Initial Investment

Key considerations and specific tasks for undertaking CBA are identified in Table 12, framed within the common appraisal steps outline in Figure 7. Specific tasks are indicated in *italics*.

Table 11: Key considerations and specific tasks for Cost-Benefit Analysis (CBA)

Step	Key Considerations and Specific Tasks
Estimate option costs	• *Option costs should be estimated over the entire timeframe of appraisal and discounted to present day values. Cost estimates can include non-market values.*
Assess Anticipated Effectiveness / Benefits	• *Option benefits should be estimated over the entire timeframe of appraisal and discounted to present day values. Benefit estimates can include non-market values.*
Discounting of Monetary Values	• Monetary value of costs and benefits should be estimated on a yearly basis and appropriate discounting should be applied to enable more robust option comparison.

Step	Key Considerations and Specific Tasks
Appraisal	• *Calculation of Net Present Value (NPV) for each option (including "do nothing"), which is calculated based on the formula:* *NPV = ∑ PV (Benefits) - ∑ PV (Costs)* *Holding all else constant, actions with a positive NPV are worth undertaking, while those with a negative NPV are not.* *Options are compared based on their NPV.* • *Calculation of Benefit: Cost Ratio (BCR) for each option, which is calculated based on the formula:* *BCR = Discounted Value of Benefits / Discounted Value of Costs* *Options are compared based on their BCR.* *Certain methods involve calculation of the incremental increase in BCR between different options.*

3.3.4.2 Data Requirements

Sufficient data is required in order to define the shortlisted options, and quantify anticipated changes, to a level that can be used to estimate monetary costs and benefits. Obtaining this data for coastal management option CBA typically involves modelling of coastal hazards, exposures and vulnerabilities, including for the influence of both built and natural infrastructure.

Data may not always be available to enable sufficiently robust estimation for certain costs and benefits. The assumptions made should be documented and transparent.

3.3.4.3 Integrating Ecosystem and Social Outcomes

CBA can incorporate both costs and benefits associated with ecosystem and social outcomes, and presents them in the same terms as more traditional economic benefits.

Methods that can be used to estimate non-market values are described in Appendix B. Classifications and valuation tools that can be specifically useful in valuing changes in ecosystem services are identified in Appendix C.

Qualitative costs and benefits cannot be included, and sufficient data may not always be available. Care is also required to avoid double-counting benefits – for example the ecosystem services provided by vegetation in reducing damage from flooding is likely already accounted for in anticipated change in annual flood damages.

3.3.4.4 *Strengths and Limitations*

Strengths	Limitations
• Accepted and well tested approach – there are several standardized methodologies. • Can be used to account for ecological and social costs and benefits in an integrated manner. • Results are easily understood by a non-technical audience.	• Potential for bias, by overestimating benefits and/or underestimating costs • Certain ecological and social outcomes are more difficult to value in monetary terms, particularly cultural or ethical considerations. • Qualitative data is difficult to incorporate

3.3.4.5 *Furthering Reading*

Source	Description	Jurisdiction
Canada's Cost-Benefit Analysis Guide: Regulatory Proposals. 2019. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwiki.gccollab.ca%2Fimages%2F8%2F8e%2FCBA_Guide-EN.doc&wdOrigin=BROWSELINK.	*Under development*	Canada
European Commission. Guide to Cost Benefit Analysis of Investment Projects. 2014. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://ec.europa.eu/regional_policy/sources/studies/cba_guide.pdf.	*Under development*	EU
United States of America. Challenge Corporation: Cost Benefit Analysis Guidelines. https://www.mcc.gov/resources/doc/cost-benefit-analysis-guidelines/.	*Under development*	US

3.3.5 Economic Impact Assessment (EIA)

3.3.5.1 Appraisal Method

Economic impact assessment (EIA) is a tool used to evaluate the broader economic implications of options, often focusing on employment, income, and output impacts across sectors and regions.

Economic impact assessments are not focused on social welfare or efficiency, rather on a project's economic impacts and their distribution, and as such they may be complementary tools to the other methods discussed in this guide (MDCA, CEA and CBA).

Key considerations and specific tasks for undertaking EIA are identified in Table 13, framed within the common appraisal steps outline in Figure 7. Specific tasks are indicated in *italics*.

Table 13: Key considerations and specific tasks for Economic Impact Assessment (EIA)

Step	Key Considerations and Specific Tasks
Estimate option costs	• Costs should be estimated over the entire timeframe of appraisal and can include negative externalities using non-market values.
Assess Anticipated Effectiveness / Benefits	• *Identification of most important economic impacts - may include direct impacts like job creation, indirect impacts on suppliers, or induced impacts like household consumption changes. Effects may be monetized, such as a change in income, or unmonetized, such as a change in employment.* • *Metric selection and data collection - to represent how an intervention influences economic inputs, outputs, and outcomes. These metrics may also include measures of environmental or health effects.*
Discounting of Monetary Values	• Monetary values are derived from economic modelling.
Appraisal	• *Estimate metrics using economic models - to assess how an intervention influences the selected metrics and quantify its costs and benefits over time. The forecast impacts can be compared with "do nothing" baseline allowing an estimate of its incremental impacts.*

Appropriate modeling tools for Economic impact assessment (EIA) depend on several factors including scope and complexity. Common economic models include:

- Input-output models (I-O),

- Partial equilibrium models, and
- Computable General Equilibrium (CGE) models.

I-O models are more appropriate for assessing detailed sectoral impacts over shorter time periods at smaller scales (e.g., regional, provincial, or local) while partial and general equilibrium models are suitable for longer periods and larger scales. Partial equilibrium models are focused on specific sectors while CGE models are applicable to modelling the wider economy. Models may integrate environmental data, such as CO_2 emissions, as in the case of environmentally extended I-O models.[26]

3.3.5.2 Data Requirements

Economic impact analysis relies on various types of data, including demographic and socioeconomic characteristics, business operations, labour market trends, government and nonprofit financial data, trade, and industry-specific expenditures.

Data requirements vary by approach, for instance:

- Input-output analysis focuses on employee wages, workforce numbers, industry classifications, and non-labor expenditures (e.g., property, equipment, and operations) within a specific geographic region. These inputs feed into a model using multipliers to estimate economic effects under different scenarios, such as coastal adaptation (NOAA 2021) (NOAA, 2021).
- Computable general equilibrium (CGE) models are calibrated using input-output data but also require additional information like elasticities, unemployment rates, labor supply, etc. (Hosoe et al. 2010). If the CGE model already exists then this data may not be required. Data on economic disruptions, such as those stemming from storm surge flooding, as well as any mitigative coastal adaptation can be used to shock the model under different scenarios.
- For assessing climate-induced storm surges and coastal adaptation in Canadian provinces, Withey et al. (2016) incorporated forecast biophysical impacts, direct damage costs to dwellings, agricultural and forest land, and costs of coastal protection to develop shocks for different scenarios in a CGE model.

3.3.5.3 Integrating Ecosystem and Social Outcomes

Ecosystem outcomes can be incorporated into certain models used for economic impact analysis. For example, environmentally-extended input-output (EEIO) models are enhanced using satellite accounts that track physical environmental flows such as water use, greenhouse gas emissions, or land use (Ingwersen et al. 2024). EEIO are often used for life-cycle assessment, carbon foot-printing, or ecosystem services accounting. CGE models are similarly capable in that they can directly incorporate environmental stocks, flows, and feedback as variables, commodities, or constraints (e.g., Qu et al. 2023).

Social outcomes can also be incorporated into economic impact analysis. These analyses can directly assess certain outcomes such as sectoral changes in employment — a key outcome of input-output models – but are also capable of assessing the distribution of impacts across different population groups (USEPA 2024). For example, CGE models can disaggregate households by factors such as income, region, or other characteristics enabling an analysis of how these different groups are affected (Hosoe et al. 2010).

3.3.5.4 *Strengths and Limitations*

Strengths	Limitations
• Useful for showing how a coastal adaptation options may influence the local economy • Useful for regional planning • Strong theoretical foundation	• Focus on economic impacts may omit co-benefits that are not valued in traditional economic systems. • Data intensive and requires understanding of economic models • Can lack participation from interested parties • Models may not disaggregate impacts to show their distribution • Outputs, such as growth in GDP, can be misinterpreted as benefits

3.3.5.5 *Furthering Reading*

Source	Description	Jurisdiction
Gunton, T., Gunton, C., Joseph, C., and Pope, M. (2020). Evaluating Methods for Analyzing Economic Impacts in Environmental Assessment. Knowledge Synthesis Report prepared for Social Science and Humanities Research Council of Canada. Accessed on June 13, 2025 from: https://rem-main.rem.sfu.ca/papers/gunton/sshrc_cea_Report_Final_March_31_2020.pdf	Research paper exploring methodological guidelines and identifying best practices for analyzing socio-economic impacts of projects.	Canada
Hosoe, N., Gasawa, K., & Hashimoto, H. (2010). Textbook of computable general equilibrium modeling: programming and simulations. Springer.	Guidance for completing computable general equilibrium models.	UK

Source	Description	Jurisdiction
[NOAA] National Oceanic and Atmospheric Administration (2021). Methodology Guide: Input-Output Analysis. Accessed on June 13, 2025 from: https://coast.noaa.gov/data/digitalcoast/pdf/econguide-input-output.pdf	Guide to completing input-output modelling to estimate industry-level economic impacts of a project or policy.	US
[USEPA] United States Environmental Protection Agency (2024). Guidelines for Preparing Economic Analyses (3rd edition). Report number EPA-240-R-24-001. Washington, DC. Accessed on June 13, 2025 from: https://www.epa.gov/system/files/documents/2024-12/guidelines-for-preparing-economic-analyses_final_508-compliant_compressed.pdf	Guidelines and best practices for economic analysis.	US

3.3.6 Comparing and Selecting an Options Appraisal Approach

3.3.6.1 Comparison of Option Appraisal Methods

All of the option appraisal methods considered in this guide are valuable tools for decision-making. They serve different purposes and have different strengths and limitations. Key features of each of the methods are summarized in Table 14.

Table 14: Comparison of Option Appraisal Methods

Feature	Multi-Criteria Decision Analysis	Cost-Effectiveness Analysis	Cost-Benefit Analysis	Economic Impact Assessment
Purpose in a nutshell	Weighing up options using economic, environmental, and social criteria	Comparing costs against one measure of effectiveness	Quantifying net benefits using monetized values of costs and benefits	Understanding wider economic impacts
Primary Metrics	Criteria scoring and weighting	Cost per unit of effectiveness (e.g., $/cm flood reduction)	Net Present Value Benefit: Cost Ratio	Traditional economic indicators (e.g., GDP, employment, income)
Data Requirements	Flexible - can include quantitative and qualitative data	Requires data to monetize costs and assess effectiveness, but does not monetize benefits	Requires data sufficient to monetize costs and benefits	Requires significant economic data and modeling
Benefit Valuation	Monetizes benefits where indicators can be assessed	Does not monetize all benefits; uses physical effectiveness metrics	Does not monetize all non-market benefits	Monetizes benefits where possible, focuses on economic performance
Key Strengths	Includes a range of objectives that can be identified with interested parties.	Objective way of identifying the most cost-effective approach for a given outcome.	Integrates and compares economic, ecosystem and social costs and benefits on the same footing in $.	
Key Limitations	Often subjective and depends on who sets criteria and weighting	Does not address co-benefits	Difficult to incorporate non-monetary costs and benefits	Methodologically complex and can omit benefits that are not valued in traditional economic systems.

3.3.6.2 Considerations in Selecting an Options Appraisal Method

Selection of an appropriate optional appraisal method to assess short-listed options will depend on the specific objectives and context of the appraisal. The chosen approach will balance the degree of detail required by decision makers with practical considerations, such as budget, data availability, and the strengths and limitations of the different approaches.

Key considerations to take into account in choosing an optional appraisal method are outlined in Tabel 15.

Table 125: Considerations in Choosing an Option Appraisal Method

Consideration	Description
Funding Criteria	Funding may be available for option appraisal studies themselves and may indicate the methods that should be used in line with associated policy. Funding will also likely be required to implement coastal management options that involve additional physical intervention. Funding criteria or application requirements may set out what option appraisal or indicators are required in order to justify why the preferred option has been selected. This may include how option costs, effectiveness and benefits should be presented. Selection of an option appraisal method may also aim to enhance the likelihood of funding being obtained from multiple funding sources.
Community decision-making drivers	Options appraisal should seek to reflect community decision-making drivers, identified through early and ongoing engagement with interested parties. Economic efficiency may a key driver. However, other site-specific community values, such as improving equity, preservation of landscape aesthetics, and protection of cultural sites, may also be important.
Data Availability	The type, volume, and quality of data available may dictate whether approaches that monetize costs and benefits can be applied, or if a mix of quantitative and qualitative is appropriate. This relates also to the stage of planning and design, since more data typically becomes available as investigation and assessment of options progresses.
Stage of Planning and Design	Certain option appraisal methods that require less quantitative data, like MCDA, can be used earlier in the process during initial option screening. Other methods will require detailed studies to document baseline conditions and define different option scenarios, in order to provide the data necessary to complete the option appraisal.
Resource Availability	Availability of resources for option appraisal, including time, budget, available internal or external expertise and technology (e.g. modelling or GIS systems), will need to be considered.

A simplified decision tree for the selection of an options appraisal approach, based on the key drivers for the appraisal and the degree to which data can be quantified is presented in Figure 9.

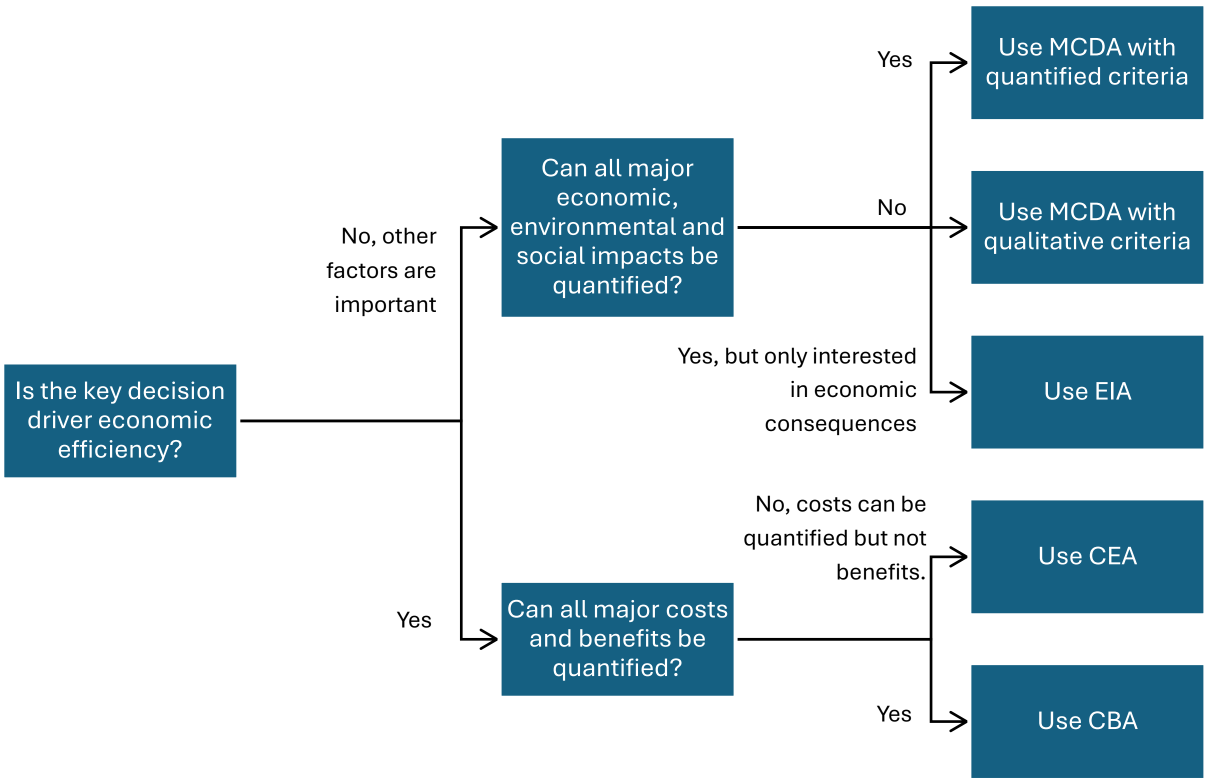

Figure 9: Simple decision tree for selecting an options appraisal method

4 Case Studies and Templates

Still being developed and refined

4.1 Tsleil-Waututh Nation, BC – Multi-Criteria Decision Analysis

Project Name	Tsleil-Waututh Nation Shoreline Adaptation and Restoration Project (SARP)
Location and Lead Organization(s)	*Photo and map to be included* Location: Burrard Inlet, North Vancouver, British Columbia Lead Organization(s): Tsleil-Waututh Nation (TWN), with technical and design support from Westmar Advisors Ltd., Hatfield, PWL, DHI Water & Environment Inc.
Timeline	2023–2026 (Under construction; completion expected in 2026)
Overview	The Tsleil-Waututh Nation Shoreline Adaptation and Restoration Project (SARP) is a landmark Indigenous-led initiative to restore the health and resilience of Burrard Inlet's shoreline. Combining traditional ecological knowledge, advanced coastal engineering, and nature-based design, the project re-establishes natural processes, enhances habitat, and protects community spaces from climate-driven flooding and erosion. SARP exemplifies how cultural values and modern science can work together to heal coastal ecosystems and strengthen community resilience.
Project Objective & Scope	The project aims to: • Rehabilitate and protect TWN's shoreline through ecosystem-based and nature-based restoration approaches. • Adapt to climate change by reducing flood and erosion risks associated with sea level rise and storm activity. • Support cultural revitalization by restoring shoreline access and traditional use areas. • Demonstrate leadership in Indigenous-led coastal resilience and serve as a model for collaborative adaptation across Burrard Inlet. The project spans approximately 2 km of reserve shoreline and includes beaches, intertidal zones, and nearshore marine areas, connecting ecological restoration with cultural renewal
Methodology	**e.g., Cost-Benefit Analysis, Multi-Criteria Analysis, Scenario Planning. Note the criteria used and how options were shortlisted.** The methodology combined community-driven design, technical modeling, and experimental validation, guided by Tsleil-Waututh Nation's stewardship principles: • Extensive community consultation: Multiple workshops, shoreline walks, and design charrettes engaged Elders, youth, and community members in defining priorities, cultural values, and design concepts. • Community-led design process: TWN members worked alongside landscape architects, engineers, and ecologists to co-develop shoreline typologies and restoration layouts that reflected both function and culture.

	• Field monitoring: Physical monitoring of waves, boat wake, and shoreline conditions informed the understanding of local energy dynamics and sediment behavior. • Numerical modeling: DHI conducted high-resolution MIKE 21 hydrodynamic and spectral wave modeling to evaluate coastal processes, storm events, and sea-level-rise impacts under future climate scenarios. • Engineering and landscape integration: Designs blended ecological restoration with engineered resilience, balancing performance, habitat, and community access. • Physical modeling: Scaled laboratory testing at the National Research Council's Ocean, Coastal and River Engineering (OCRE) facility validated design performance, stability, and habitat response under simulated wave and wake conditions. • Multi-criteria and co-benefit assessment: The final shoreline design alternatives were evaluated through a multi-criteria analysis combining technical performance, ecological enhancement, cultural value, constructability, and cost. A co-benefits assessment quantified ecosystem, social, and cultural outcomes, ensuring community priorities and stewardship goals guided final option selection. • Final design development: Results from modeling, assessments, and community input were synthesized into detailed construction drawings and adaptive management plans. This iterative and inclusive process ensured that the final design was technically robust, ecologically effective, and culturally meaningful, reflecting both scientific rigor and community vision.
Social & Environmental Outcomes	**How these were factored into the analysis (qualitative, non-market, etc.). Include IDEA principles or local/traditional knowledge.** SARP delivers wide-ranging social and environmental benefits: • Creation of new intertidal habitat for salmon, shellfish, and eelgrass. • Stabilization of eroding areas using natural materials and vegetation. • Cultural reconnection through shoreline access, traditional harvesting areas, and youth engagement in restoration. • Strengthened local capacity for Indigenous-led coastal management and long-term monitoring. Indigenous knowledge and stewardship principles were central to all decisions, ensuring that both ecological and cultural values were treated as essential project outcomes.
Community & Stakeholder Engagement	**Describe engagement approaches and insights. Were Indigenous, underrepresented, or equity-seeking groups involved?** The project was led by the Tsleil-Waututh Nation Treaty, Lands and Resources Department, supported by extensive engagement with Elders, youth, and community members. Collaborative workshops and shoreline walks helped identify culturally significant areas and traditional ecological indicators. External partners, including the Vancouver Fraser Port Authority, District of

	North Vancouver, and Metro Vancouver, participated through advisory and permitting coordination to ensure regional alignment
Selected Option(s)	*Name and describe the preferred adaptation option or actions.* Implemented shoreline adaptation measures include: • Living beaches with cobble, native salt-marsh vegetation, and driftwood structures. • Engineered habitat islands to attenuate wave energy and support eelgrass recovery. • Clam gardens and log features to promote sediment retention and biodiversity. • Community access zones integrating cultural use, education, and stewardship programming. These integrated designs create a dynamic, self-sustaining shoreline that balances protection, restoration, and cultural connection
Status / Implementation	*Complete / In progress / Awaiting funding / Further assessment required.* Status: Under construction (2024–2026). Design, modeling, and permitting were completed in 2024, with construction beginning in 2025. The project is progressing successfully and is recognized as a leading example of Indigenous-led shoreline restoration and adaptation in Canada.
Key Takeaways	*One lesson learned, one success or innovation, one challenge or recommendation.* Lesson learned: Co-designing with the community from the outset builds shared ownership and lasting impact. Success / innovation: Combined physical and numerical modeling validated nature-based designs at unprecedented detail for a community-led project. Challenge / recommendation: Permitting pathways for Indigenous-led NbS projects need greater flexibility to match innovation and timelines.
Supporting Materials & Acknowledgements	*Link to final report, map/photo if available, and acknowledgements.* Tsleil-Waututh Nation

4.2 Pointe-du-Chene, NB – Cost Effectiveness Analysis

Case study under development

4.3 L'Anse du Sud, Percé, QC - Cost Benefit Analysis

Project Name	**Cost Benefit Analysis of Coastal Adaptation Options in Perce**
Location and Lead Organization(s)	*Photo and map to be included* *Perce, Quebec* Led by Ouranos and the Laboratoire de dynamique et de gestion intégrée des zones côtières (LDGIZC) at UQAR
Timeline	2015
Overview	The City of Perce shoreline faced risks from erosion and sea-level rise, leaving infrastructure and coastal communities at risk. Key tourism and business assets had been repeatedly damaged. The study aimed to find the most cost-effective ways to protect vulnerable coastal segments.
Project Objective & Scope	The project focused on four coastal segments in Percé: Côte Surprise, Anse du Sud, Mont-Joli Sud, and Anse du Nord. It assessed erosion risk and analyzed the costs and benefits of various adaptation options over a 50-year period (2015–2064).
Methodology	**Cost-Benefit Analysis (CBA)** was used to compare each adaptation option to a non-intervention scenario. Options were assessed using net present value (NPV) and benefit-cost ratios, with a 4% discount rate. Tourism, heritage, and environmental values were considered.
Social & Environmental Outcomes	Social and tourism benefits (e.g., avoided losses from fewer tourists) were key drivers of positive outcomes. Cultural and heritage values were acknowledged, especially for the Frederick-James Villa.
Community & Stakeholder Engagement	A province-wide online survey of 2,000 Quebecers was used to estimate changes in tourism behaviour under different scenarios.
Selected Option(s)	Beach replenishment with pebbles was identified as the most economically beneficial option for Anse du Sud and Anse du Nord. Planned retreat was the only technically appropriate option for cliffside areas like Côte Surprise and Mont-Joli Sud.
Status / Implementation	Study completed; implementation varies by segment. Some adaptation work has begun in Percé, including coastal protection near the boardwalk.
Key Takeaways	**Lesson:** Including tourism losses in economic models can highlight the high cost of inaction. **Success:** Beach replenishment showed an extremely high benefit-cost ratio. **Challenge:** Planned retreat, even when cost-effective, remains politically and socially difficult to implement.
Supporting Materials & Acknowledgements	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ouranos.ca/sites/default/files/2022-07/proj-201419-emart-circe-rapportreg04_en.pdf

4.4 Disaster Mitigation and Adaptation Fund, Canada – Multi-Criteria Decision Analysis

Case study under development

4.5 FEMA Benefit-Cost Toolkit – Cost-Benefit Analysis

Case study under development

4.6 FCERM Project Appraisal Guidance, England and Wales, UK – Cost-Benefit Analysis

Case study under development

5 Next Steps

This section will be developed once the main content has been reviewed. It will include:

- *A summary of key points*
- *Guidance on adoption and implementation (collaboration, adaptive mgt, importance of data)*
- *Next steps and call to action*

Appendix A: Option Development Considerations

Option development should include community and partner engagement. This appendix identifies certain resourcing, regulatory, policy, jurisdiction and technical considerations that will also need to be taken into account.

Resources

- Availability of funding for option investigations and appraisal - Funding may be required and available to do the option development and appraisal work itself, including engagement and partnerships. Potential sources of funding (public and private) should be considered, together with their eligibility requirements.

- Availability of funding for implementation and long-term operations - Long-term funding is likely to be necessary to implement many coastal management options, in particular those involving additional physical interventions. Potential sources of funding (public and private) should be considered, together with their eligibility requirements.

Governance, Governments and Jurisdictional Considerations

In Canada, coastal areas are managed by a combination of Indigenous, federal, provincial, municipal, and international jurisdictions. The political and jurisdictional context for coastal planning and management activities are unique to each local context.

Read more about regional considerations in the publication Nature-based infrastructure for coastal flood and erosion risk management: a Canadian design guide[27] Chapter 4 - Governance, which particularly highlights considerations for nature-based infrastructure.[1]

Indigenous Governance

Indigenous Peoples have special rights under Canadian law because their ancestors had distinct legal traditions and rights before Europeans began to colonize the land referred to as Canada (McIvor, 2022). Respect of these rights was written into treaties signed with the Crown in many areas and they were later protected in Section 35 (1) of the Constitution Act 1982 (Government of Canada, 1982). Upholding and recognizing Indigenous rights across Canada is critical to

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[1] Eyquem, J. L., Lueck, V., & Thurston, E. (2024). "Chapter 4 – Governance." In Murphy, E., Cornett, A., van Proosdij, D., & Mulligan, R. P. (Eds.) Nature-Based Infrastructure for Coastal Flood and Erosion Risk Management – A Canadian Design Guide. ISBN 978-0-660-71886-6. https://nrc-publications.canada.ca/eng/view/ft/?id=58396f73-fa9e-42ec-8f77-9524df841921

supporting the Truth and Reconciliation Commission's Calls to Action and relationships between Indigenous and non-Indigenous Peoples.

Governmental Jurisdictions

All levels of government in Canada—Indigenous, federal, provincial, local—have some jurisdiction in coastal areas with different associated legislation and roles that influence coastal governance. No single body or level of government is responsible or accountable for coastal flood and erosion management, which contributes to a fragmented and inconsistent approach to both coastal governance and implementation of management solutions. A review of flood risk management governance in Canada by Golnaraghi et al. (2020) identified the following key roles:

- Federal government: convenes, coordinates, and provides resources.
- Provincial / territorial government: has authority over flood and erosion risk management, preparedness, mitigation, response, and recovery.
- Local government: implements and enforces flood and erosion risk management legislation and manages pluvial flood risk.

Generally speaking:

- The **federal government** has jurisdiction over the seabed and subsoil of the Exclusive Economic Zone (EEZ); marine protected areas (MPAs), the water column for shipping, navigation and fisheries; DFO is responsible for managing Canada's oceans and fisheries; Canada's Coast Guard (CCG) is responsible for search and rescue, marine safety, and environmental protection in marine waters.

- The **provincial / territorial government** has jurisdiction over the foreshore, lands adjacent to the coast, coastal waters and international waters. It is often the case that provinces have coastal management plans and policies.

- **Rightsholders** have treaty rights, title and rights to lands and resources stemming from historical practices and historical use and occupation, including those in coastal areas. Some Indigenous Peoples have self-governance agreements that provide jurisdiction for certain aspects of coastal management.

- **Local government** jurisdiction is granted by the province / territory. Municipalities have jurisdiction over land use through planning strategies, zoning by-laws, subdivision control, site-planning and expropriation powers.

Regulatory and Policy Considerations

Jurisdiction		Regulation
Federal		Fisheries Act Migratory Birds Convention Act Canada Wildlife Act Canadian Navigable Waters Act Impact Assessment Act Canadian Environmental Protection Act Species at Risk Act Oceans Act Canadian National Marine Conservation Areas Act Canada Shipping Act Canada National Parks Act Oil Tanker Moratorium Act Fishery (General) Regulations
Provincial and Territorial	Newfoundland and Labrador	Environmental Protection Act Canada–Newfoundland and Labrador Atlantic Accord Implementation Act Water Resources Act
	Nova Scotia	Beaches Act Environmental Act Fisheries and Coastal Resources Act
	New Brunswick	Coastal Areas Protection Policy Coastal Land Use
	Prince Edward Island	Environmental Protection Act Recreation Development Act Planning Act
	Quebec	Watercourses Act Quebec Water Strategy Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains
	Ontario	Environmental Protection Act Conservation Authorities Act Planning Act (see Provincial Planning Statement 2024)
	Manitoba	Water Protection Act The Environment Act

Jurisdiction		Regulation
		Aquatic Invasive Species Regulation
	British Columbia	Fish Protection Act Wildlife Act Land Act Local Government Act Ecological Reserves Act Environmental and Land Use Act Heritage Conservation Act Park Act Forest and Range Practices Act
	Yukon	Yukon Territory Fishing Regulations Contaminated Sites and Spills Regulations Parks and Land Certainty Act
	Northwest Territories	The Waters Act Environmental Rights Act Territorial Parks Act Mackenzie Valley Resource Management Act
	Nunavut	Commissioner's Land Act Environmental Protection Act Nunavut Planning and Project Assessment Act Nunavut Land Claims Agreement

Physical Intervention Considerations

The following is a set of considerations to inform technical design and appraisal of short-listed options that involve physical intervention (adapted from *[CEC Monitoring Document, not yet published]*; Federal Highway Administration 2018; IDB 2020; Suedel et al. 2021; Vouk et al. 2021; World Wildlife Fund 2016):

Spatial and Temporal Scale

- Does the physical scale correspond to the scale of coastal processes?
- Does the physical scale impact navigation or infringe on neighbouring lands?
- Does the design account for both acute and chronic processes?
- Does the design consider lag-time required to reach full performance?
- What is the design life of structural, grey components?

- What is the uncertainty in future conditions at the site? (i.e., high uncertainty may make NBS more desirable)

Design

- How will sediment supplies be maintained, if not self-sustaining?
- Have changes to the cross-shore profile, crest elevation, and roughness been considered, in response to varying morphological conditions or changes in vegetation or biological growth?
- Have geotechnical and hydrogeological processes been considered?
- How will living components (i.e., vegetation and biological actors) contribute to flood and erosion risk management performance?
- Does the design have the potential to negatively impact existing grey and natural infrastructure?
- Will the design perform in both present and future potential climate change conditions, given a range of uncertainties?
- Does the design incorporate sufficient redundancy or residual flood and erosion risk management performance considering known processes, uncertainties, and lag-time?
- Are there risks that remain?

Construction & Maintenance

- When and where will materials be sourced to facilitate implementation?
- How will management and maintenance of existing grey and natural infrastructure be impacted?
- Has 'closure' at the end of the design life been considered?

Appendix B: Non-Market Valuation Methods

Key Categories and Methods

Economists have developed several techniques for estimating non-market values, which can be applied to estimating costs and benefits relating to ecosystem services and social / cultural services. These can be grouped into three broad categories:

- **Direct market valuation methods** derive estimates from related market data
- **Revealed preference methods** estimate economic values based the market prices of goods or services that people actually use to benefit from a connected non-market good or service.
- **Stated preference methods** obtain economic values by asking people to make trade-offs among sets of services or characteristics

A description of key valuation methods within these broad categories is provided in Table B1, together with the associated welfare measure.

Table B1: Accepted valuation methods used to estimate non-market values

Valuation Method	Description	Welfare Measure
DIRECT MARKET VALUATION APPROACHES		
Market prices	Assigns value equal to the total market revenue of goods /services.	Total revenue
Replacement cost	Services can be replaced with man-made systems; for example waste treatment provided by wetlands can be replaced with costly built treatment systems.	Value larger than the current cost of supply
Avoided cost	Services allow society to avoid costs that would have been incurred in the absence of those services; for example storm protection provided by barrier islands avoids property damages along the coast.	Value larger than the current cost of supply
Production approaches	Services provide for the enhancement of incomes; for example water quality improvements increase commercial fisheries catch and therefore fishing incomes.	Consumer surplus, producer surplus,
REVEALED PREFERENCE APPROACHES		
Opportunity cost	Value of the next best alternative use of resources; for example, travel time is an opportunity cost of travel because this time cannot be spent on other pursuits.	Consumer surplus,

		producer surplus, or total revenue for next best alternative
Travel cost	Service demand may require travel, which have costs that can reflect the implied value of the service; recreation areas can be valued at least by what visitors are willing to pay to travel to it, including the imputed value of their time.	Consumer surplus
Hedonic pricing	Service demand may be reflected in the prices people will pay for associated goods; for example housing prices along the coastline tend to exceed the prices of inland homes.	Consumer surplus
STATED PREFERENCE APPROACHES		
Contingent valuation	Service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; for instance, people generally state that they are willing to pay for increased preservation of beaches and shorelines.	Compensating or equivalent surplus

Use of Benefit Transfer

Ideally, a non-market valuation should involve site-specific studies (often termed primary studies). Unfortunately, undertaking such studies is expensive and time consuming. The benefit transfer approach can be used to indicate an order-of-magnitude values for a range of services.

There are two types of benefit transfer approaches:

- **Unit value transfers** refer to the transfer of a single number or set of numbers from pre-existing primary study. The numbers can be transferred "as is" or adjusted to account for variations in the receiving environment (e.g. for differences in income or purchasing power, or ecosystem integrity). This approach assumes asset value experienced at one site is the same as the value experienced at another site.

- **Benefit function transfers** use parametric functions from a primary study to relate the value of services to variables such as income, environmental quality, demographics, or other relevant factors. The function is then applied to the new site by inputting local data for those variables to generate an estimated value that reflects local conditions. This approach takes more information into account in the transfer of value but requires time and data.

Recommended Valuation Approaches for Different Services

Table B2: Recommended Valuation Approaches for Different Services (adapted from Farber, et al., 2006).[28]

Ecosystem Service	Recommended Approach	Transferability
Aesthetic, Cultural & Recreational	TC, CV, H, OC	Low
Disturbance Regulation	AC, RC, H	Medium
Gas and Climate Regulation	CV, AC, RC	High
Habitat Refugium and Nursery	CV, P, AC, H, OC	-
Raw Materials	M, P	High
Soil Erosion Control	AC, RC, H	Medium
Waste Processing	AC, RC, CV	Medium - High
Water Regulation	M, AC, RC, H, P, CV	Medium
Water Supply	AC, RC, M, TC, CV, OC	Medium
Food Provisioning	M, P	High

Legend: AC = avoided cost; CV = contingent valuation; H = hedonic pricing; M = market pricing; P = production approach; RC = replacement cost; TC = travel cost; OC = opportunity cost.

Appendix C: Ecosystem Service Classification and Valuation Tools

Ecosystem Service Classification

Ecosystem services provided by natural assets are of value to human wellbeing. This is outlined in the Cascade Model, which demonstrates the linkage between biophysical or structural process, function, ecosystem service provision and the benefits and value provided to people (Figure C1). Different ecosystem services provide different benefits. Reductions in these benefits can be treated as costs.

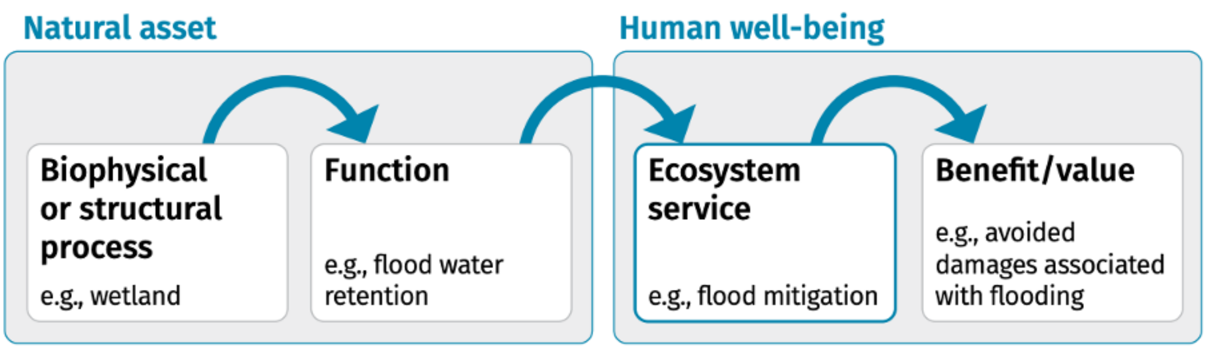

Figure C1: Illustration of the linkage between a natural asset, the ecosystem services provided and the benefits and values that flow to end users. (CSA Group, 2023, adapted from Potschin and Haines-Young, 2011)

High profile examples of modern ecosystem services classification protocols, include:

1. Common International Classification of Ecosystem Services (CICES) - developed by the European Environmental Agency to support including ecosystem services into national accounts.[2]
2. Final Ecosystem Goods and Services Classification System (FEGS-CS) - developed by the U.S. Environmental Protection Agency.[3]
3. National Ecosystem Services Classification (NESCS) - developed by the U.S. Environmental Protection Agency.[4]

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[2] http://cices.eu
[3] http://www.epa.gov/eco-research/final-ecosystem-goods-and-services-classification-system
[4] http://www.epa.gov/eco-research/national-ecosystem-services-classification-system-framework-design-and-policy

Ecosystem Service Valuation Tools

A selection of tools that may be useful in estimating costs and benefits related to changes in the value of ecosystem services are presented in Table C1.

Table C1: Selection of ecosystem service valuation tools

Tool	Brief Description
ARIES (Artificial Intelligence for Environment & Sustainability)	A digital software for rapid ecosystem service assessment and valuation. The tool considers ecosystem service supply, demand and flow in order to quantify actual service provision and use by society.
B£ST (Benefits Estimation Tool)	An Excel spreadsheet tool which supports one to assess monetary benefits of Blue-Green Infrastructure and Natural Flood Management (NFM), based on the performance of the whole system rather than individual components.
Co$ting Nature	Web based policy-support tool for natural capital accounting and analysis of the ecosystem services provided by natural environments.
Ecosystem Services Toolkit	Canadian technical guide to ecosystem services assessment and analysis that offers practical, step-by-step guidance for governments at all levels, as well as for consultants and researchers.
Ecosystem Service Values Database (ESVD)	The Ecosystem Services Valuation Database (ESVD) provides robust and easily accessible information on the economic benefits of ecosystems and biodiversity, and the costs of their loss, to support decision making.
Environmental Reference Library (EVRI)	The Environmental Valuation Reference Inventory is a searchable storehouse of empirical studies on the economic value of environmental assets and human health effects. It was developed and is housed by Environment and Climate Change Canada.
Green Infrastructure Valuation Toolkit (GI-Val)	The Green Infrastructure Valuation toolkit contains a set of calculator tools to assess the value of a natural asset or a proposed green investment. Where possible, benefits are given an economic value. Other quantitative contributions (e.g. number of jobs) and qualitative contributions (e.g. case studies or research) can also be provided to give a more comprehensive value of an asset.

i_Tree Eco	i-Tree Eco is a modelling tool designed for urban forest assessment. It uses field data from complete inventories or sample plots, along with local monitoring data. It quantifies the structure and environmental effects of urban forests and calculates their value to communities.
InVEST (Integrated Valuation of Ecosystem Services and Trade-Offs)	InVEST is a suite of open-source software models for mapping and valuing the ecosystem services provided by land and seascapes. It utilizes environmental data to explore how changes in ecosystems are likely to affect the flow of benefits to people.
TESSA (Toolkit for Ecosystem Service Site based Assessment	The TESSA toolkit is a workbook that leads the user through steps to assess the ecosystem services provided at an identified site. It compare base case and future state analysis, e.g. before and after restoration or conversion, and support a high level of engagement.
Tools for Coastal Climate Adaptation Planning A Guide for Selecting Tools to Assist with Ecosystem-Based Climate Planning	The Tools for Coastal Climate Adaptation Planning provides guidance for coastal natural resource managers and community planners to identify appropriate tools for spatially explicit solutions for climate-related planning

Glossary

Still being refined

5Rs Framework	Atlantic Canada framework developed with Indigenous Peoples, expanding PARA by emphasizing stewardship, resilience, and cultural values. The 5Rs are Reimagine, Reserve, Relocate, Restore, Reinforce.
Adaptation Pathways	A planning method that maps sequences of possible adaptation actions over time, allowing flexible responses as conditions change. Often visualized as decision “roadmaps” with branches depending on thresholds being exceeded.
Adaptive Management	Iterative management that monitors performance, learns from outcomes, and adjusts strategies accordingly. Especially relevant for NbS projects and long-term flood risk management.
Aeolian Transport	Wind-driven movement of sediment, particularly shaping coastal dunes and sandy beaches. A key process for natural shoreline evolution.
Appraisal	The systematic process of identifying, assessing, and comparing a range of options to manage coastal risks, considering factors such as technical feasibility, economic efficiency, environmental impact, and social value
Beach Nourishment	Placement of sand or sediment onto beaches to offset erosion, increase width, or maintain recreational and protective functions. Requires periodic renourishment.
Benefit–Cost Ratio (BCR)	Ratio of discounted benefits to discounted costs. If >1, benefits outweigh costs and project is considered beneficial. Often reported alongside Net Present Value.
Breakwaters	Offshore or shoreline-parallel engineered structures that reduce wave energy reaching the coast, creating calmer waters for harbors and reducing erosion.
Co-benefits	Secondary or ancillary benefits from adaptation actions, such as biodiversity gains, carbon storage, or recreation, beyond the primary hazard reduction objective.
Cost-Benefit Analysis (CBA)	Formal evaluation comparing monetized benefits and costs of options over time using NPV and BCR. Widely applied in coastal decision-making.
Cost-Effectiveness Analysis (CEA)	Compares cost per unit of a fixed outcome (e.g., cost per hectare protected or depth of flooding reduced). Useful where outcomes are predefined.

Discount Rate (in Coastal Appraisal)	A factor converting future costs and benefits into present values. Reflects trade-offs between current and future prosperity. Social vs. financial rates may differ.
Distributional Analysis	Examines how adaptation costs, benefits, and risks are distributed across regions, socioeconomic groups, or vulnerable populations. Highlights issues of fairness.
Do Nothing / Non-Intervention	Baseline comparator in option appraisal where no action is taken. Hazards continue unchecked, providing a reference point for benefits of alternatives.
Economic Impact Assessment (EIA)	Analysis of wider economic implications of adaptation, such as effects on employment, income, productivity, and sectors (tourism, fisheries).
Ecosystem goods and services	Ecosystem goods and services, often shortened to ecosystem services, are the benefits that humans derive from ecosystems. These services are broadly categorized into provisioning services (like food and water), regulating services (like climate or disease regulation), cultural services (like recreation and spiritual values), and supporting services (like nutrient cycling and soil formation). Essentially, they are the positive contributions ecosystems make to human well-being. The term depicts a one-way flow of services from ecosystems to people, which lacks recognition of the roles of humans in actively cultivating, improving and positively contributing to ES. Reciprocal relationships between humans and ecosystems are often (but not exclusively) evidenced in indigenous worldviews.
Elasticities	Elasticity is an economics concept that measures responsiveness of one variable to changes in another variable. For example, how much will the consumption of shoreline recreation decline if an entry fee is charged on a beach?
ENSO	ENSO stands for El Niño–Southern Oscillation. It's a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean, along with shifts in atmospheric pressure across the Pacific.
Etuaptmumk	learn[ing] to see from your one eye with the best or the strengths in the Indigenous knowledges and ways of knowing...and learn[ing] to see from your other eye with the best or the strengths in the mainstream (Western or Eurocentric) knowledges and ways of knowing...but most importantly, learn[ing] to see with both these eyes together, for the benefit of all."
Green Shores®	Canadian NbS framework that rewards designs maintaining coastal processes, reducing pollutants, enhancing habitat, and considering cumulative effects. Includes a credit/rating system. Along the Pacific coast of Canada, ENSO affects

	weather patterns by influencing ocean temperatures and storm activity: El Niño tends to bring warmer, drier winters and reduced snowpack, which can impact water supply and ecosystems. La Niña usually leads to cooler, wetter winters, with more storms and snowfall, especially in coastal and mountainous areas.
Groynes	Hard, shore-perpendicular structures designed to trap sediment transported by longshore drift, stabilizing beaches but often causing downdrift erosion.
Hybrid Solutions	Adaptation measures that combine NbS with grey infrastructure, such as marsh restoration fronting a seawall. Aim to maximize resilience and co-benefits.
IAP2 Spectrum (Public Participation Spectrum)	Framework that categorizes engagement approaches: inform, consult, involve, collaborate, empower. Guides how stakeholders are included in coastal planning.
Intergenerational Equity	Ethical principle ensuring fairness between present and future generations, central in climate adaptation where benefits accrue long-term.
Managed Retreat	Strategy of deliberately moving defences inland to create intertidal habitat and restore natural processes, while reducing flood risk elsewhere.
Multi-Criteria Decision Analysis (MCDA)	Structured decision-support tool that compares options across multiple weighted criteria (economic, environmental, social). Transparent but subjective.
Nature-based Solutions	Nature-based Solutions are actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits
Net Present Value (NPV)	Present-day value of future net benefits (benefits – costs) after discounting. Positive NPV signals worthwhile project.
Non-monetary valuation	The value attributable to an item or a service without relation to any acceptable cash price and for which a fixed or determinable amount of currency is absent (e.g. many ecosystem services, interpersonal good-will, health, etc.).
Options Appraisal	A structured process used to identify, assess, and compare different project alternatives — including the "do nothing" baseline — to determine the preferred course of action. It supports transparent, evidence-based decision-making by

	evaluating trade-offs across ecological, economic, cultural, and technical criteria.
PARA Framework (Protect, Accommodate, Retreat, Avoid)	Widely used framework outlining four broad coastal adaptation strategies.
Quality-Adjusted Life Year (QALY)	Composite measure of health benefit combining life expectancy and quality of life. Used in appraisal of avoided health impacts of flooding.
Resilience	The capacity of a system, community, or ecosystem to absorb disturbance, adapt, and recover while maintaining essential functions.
Retreat	Adaptation strategy involving relocation of assets, infrastructure, or communities away from high-risk areas.
Rock Revetments	Sloped rock structures placed along shorelines to absorb wave energy and prevent erosion.
Sea2City Framework (Acknowledge, Host, Restore)	Vancouver/BC-developed approach reframing adaptation in terms of reconciliation, cultural hosting, and ecological restoration.
Sea-Level Rise (SLR)	The increase in mean sea level due to climate change (thermal expansion, glacial melt), driving coastal flooding and erosion.
Seawalls	Vertical or near-vertical hard structures built to protect land from wave attack and flooding. Often lead to beach narrowing and scouring.
Seiches	Standing wave oscillations in enclosed or semi-enclosed water bodies (e.g., lakes, fjords, harbors). Can amplify flood risk.
Sensitivity Analysis	Testing robustness of results by varying assumptions (e.g., discount rate, sea-level projections, cost estimates). Identifies critical tipping points.

SMART Criteria	The SMART criteria are a widely used framework to guide the selection of effective goals, performance metrics, or indicators. It stands for: Specific – Clearly defined and focused, answering what will be achieved and why it matters. Measurable – Quantifiable or otherwise observable, so progress and outcomes can be tracked over time. Attributable (sometimes written as Achievable) – Directly linked to the intervention or action, so changes can reasonably be attributed to it. Realistic – Feasible to achieve with the available resources, data, and capacity, while considering local context. Timely (or Time-bound) – Defined within a timeframe that allows for assessment of progress and success.
Thresholds	Critical points where small changes in conditions result in abrupt shifts in system state (e.g., dune collapse).
Two-Eyed Seeing (Etuaptmumk)	Mi'kmaw guiding principle of seeing from both Indigenous and Western perspectives for mutual benefit.
Uncertainty Analysis	Systematic examination of uncertainties in models, climate scenarios, socio-economic trends, and data, to inform robust decision-making.

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