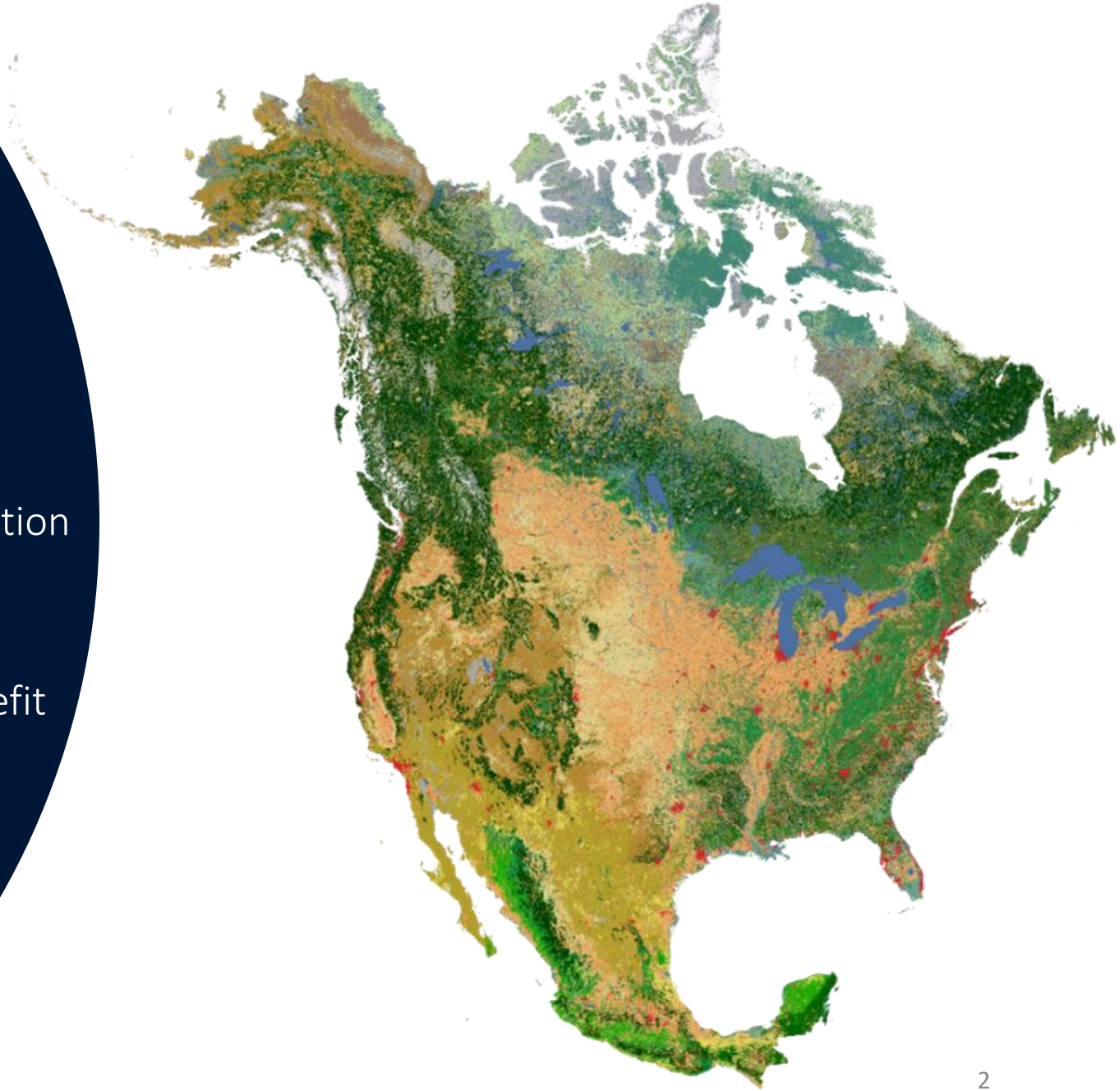
Overview of the Four New Guides on Nature-based Solutions to Address Flood Risks in Coastal Communities

CEC Mission

Facilitate cooperation and community participation for the conservation, protection and enhancement of the North American environment.

Support sustainable development in benefit of present and future generations.



Nature-based Solutions to Address Flooding in Coastal Cities

Project Objectives

1 – Provide a first opportunity for NBS practitioners, working across North America in a broad range of disciplines, to lay the foundation for a community of practice

2 – **Provide knowledge and tools for communities to support NBS implementation**

3 – Share practical experience on NBS

- Natural Resources Canada
- Housing, Infrastructure and Communities Canada
- National Research Council Canada
- Procuraduria Federal de Proteccion al Ambiente
- Secretaría de Medio Ambiente y Recursos Naturales
- National Oceanic and Atmospheric Administration
- United States Department of State

Nature-Based Solutions

Nature-based Solutions (NBS) serve to mitigate flood risks through the **informed use of natural systems and natural processes**, while simultaneously providing environmental, social, and economic co-benefits.

Activities


PHASE 1
PHASE 2
PHASE 3
Workshop Series
Guidance Development
Dissemination

Guides

Provide guidance and evidence to support decision makers in the broader implementation of NBS to address coastal flood risks.

Co-Benefits

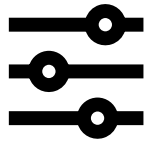
Retrofitting Existing Infrastructure

Monitoring Efficacy

Monitoring Efficacy: Proposed Methodology & Indicators

Objectives of the Guides

Develop a value proposition



Summarize opportunities and design options

Develop strategies and tools to support decision making

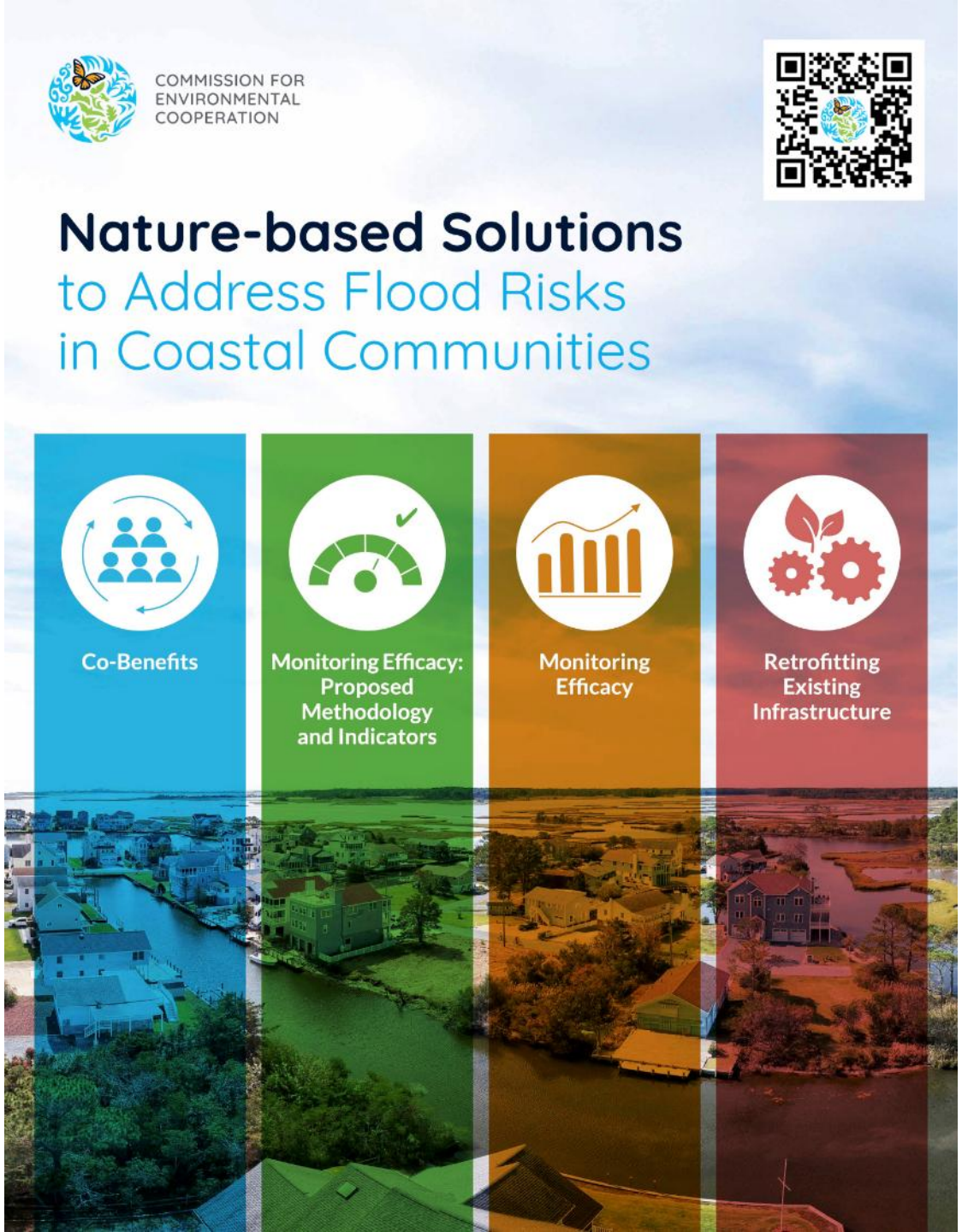
Summarize key constraints to implementation

Provide tangible examples through case studies

Outline best practices

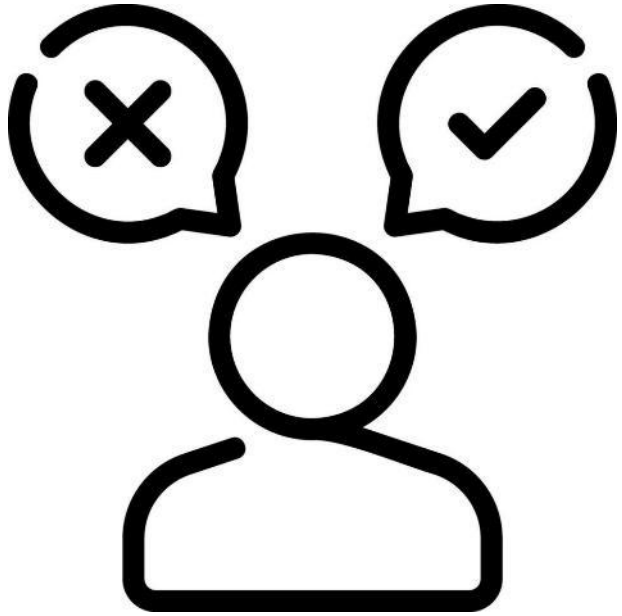
Overview

NBS Guides


COMMISSION FOR ENVIRONMENTAL COOPERATION
Nature-based Solutions
to Address Flood Risks
in Coastal Communities
Co-Benefits
Monitoring Efficacy: Proposed Methodology and Indicators
Monitoring Efficacy
Retrofitting Existing Infrastructure

NBS Guides

Who is the Intended Audience for the Guides?



NBS Guides

What is included in the Guides?

- ✓ Step by step decision-making frameworks
- ✓ Summaries of current best practices
- ✓ Summaries of options and key considerations in different contexts
- ✓ Case studies from Canada, Mexico and the United States
- ≠ **Technical guidance**

NBS Guides

Co-Benefits

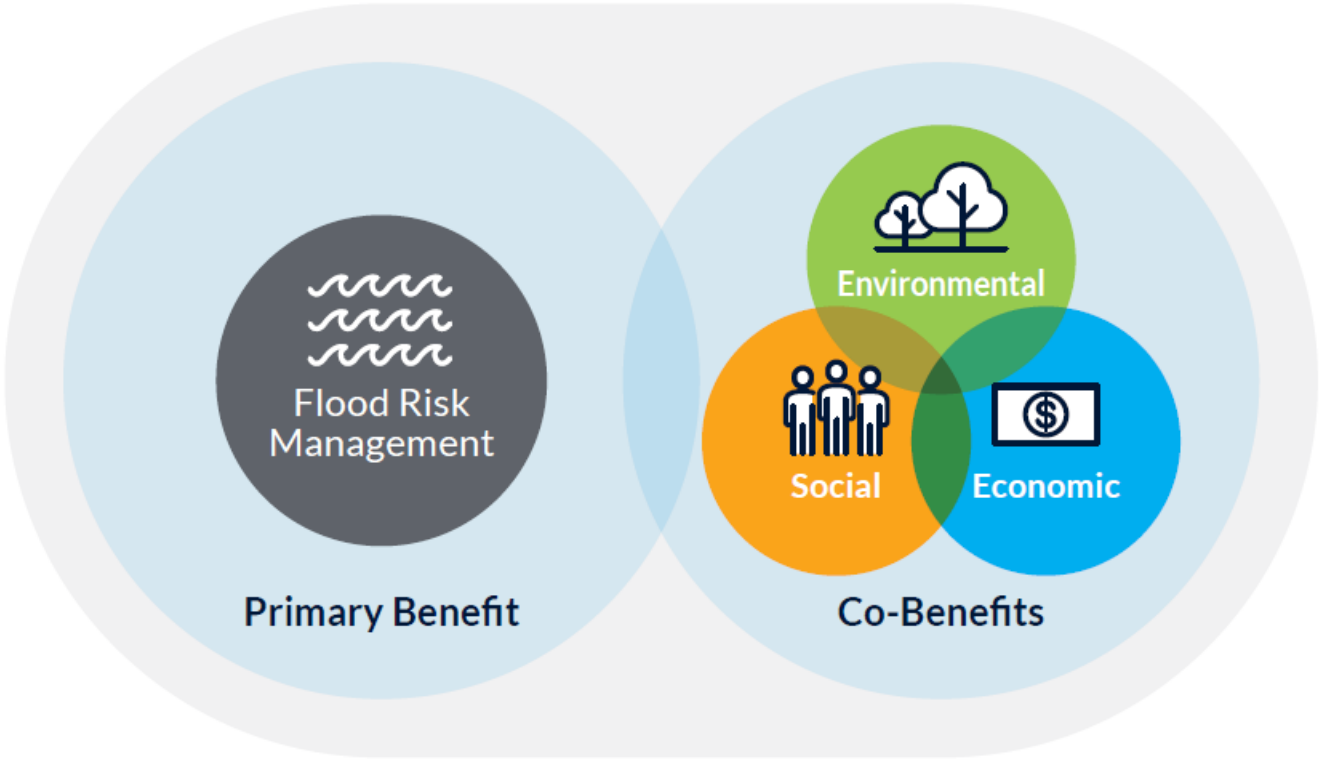
Retrofitting Existing Infrastructure

Monitoring Efficacy

Monitoring Efficacy: Proposed Methodology and Indicators

Co-Benefits

What are Co-Benefits?



- Additional benefits beyond flood risk reduction
- Environmental, social, and economic
- Examples: carbon sequestration, recreation, habitat creation

Co-Benefits

Why Analyze NBS Co-Benefits ?

- Holistically compare options
- Improve engagement and public buy-in
- Assess unintended impacts and improve accountability
- Anticipate trade-offs and set priorities
- Increase funding opportunities
- Inform adaptive management
- Share knowledge

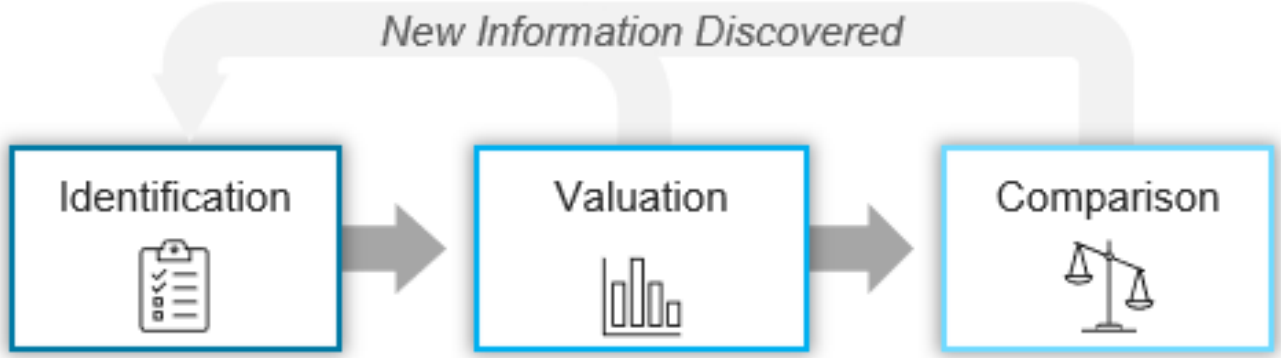
Co-Benefits

Barriers to Identify, Value, and Leverage Co-Benefits

- **Social/attitudinal** (e.g., perception that benefits are unrealistic or will not be realized)
- **Technical** (e.g., lack of technical guidance for co-benefit valuation)
- **Environmental** (e.g., seasonal or long-term variability of natural systems)
- **Institutional** (e.g., lack of funding and lack of government awareness)

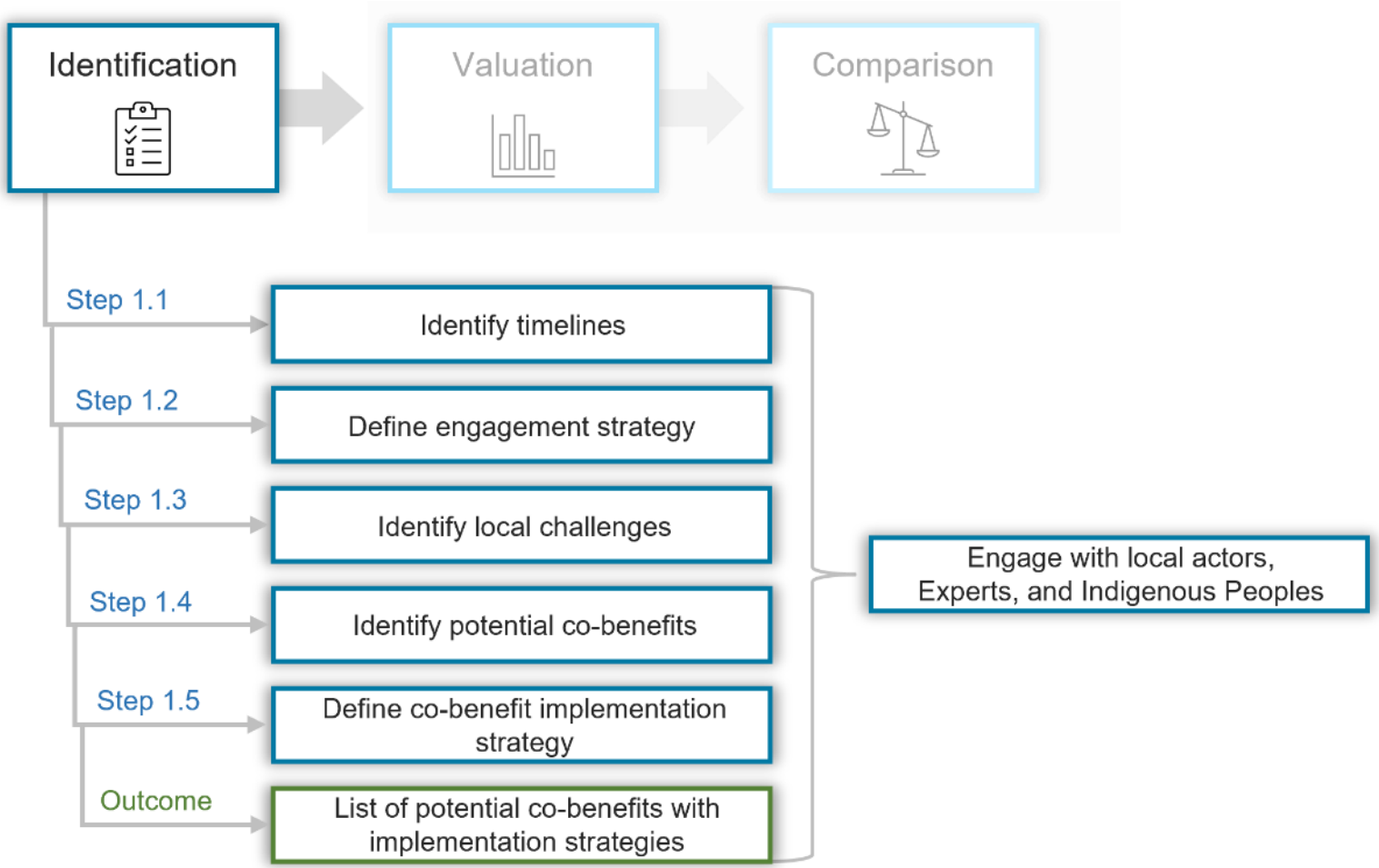
Co-Benefits

Co-Benefits Assessment Process



Co-Benefits

Co-Benefits Assessment Process



Co-Benefits

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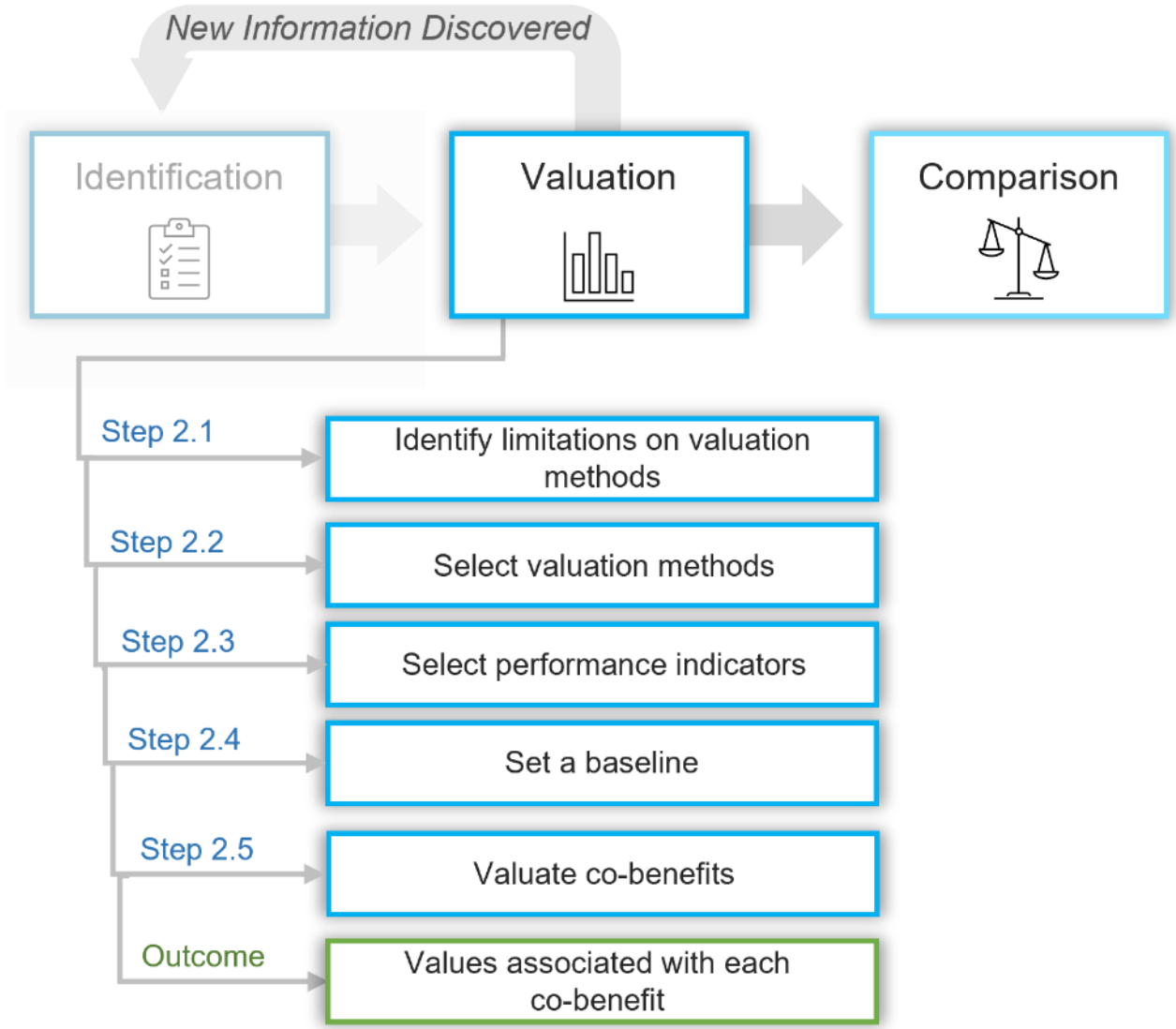
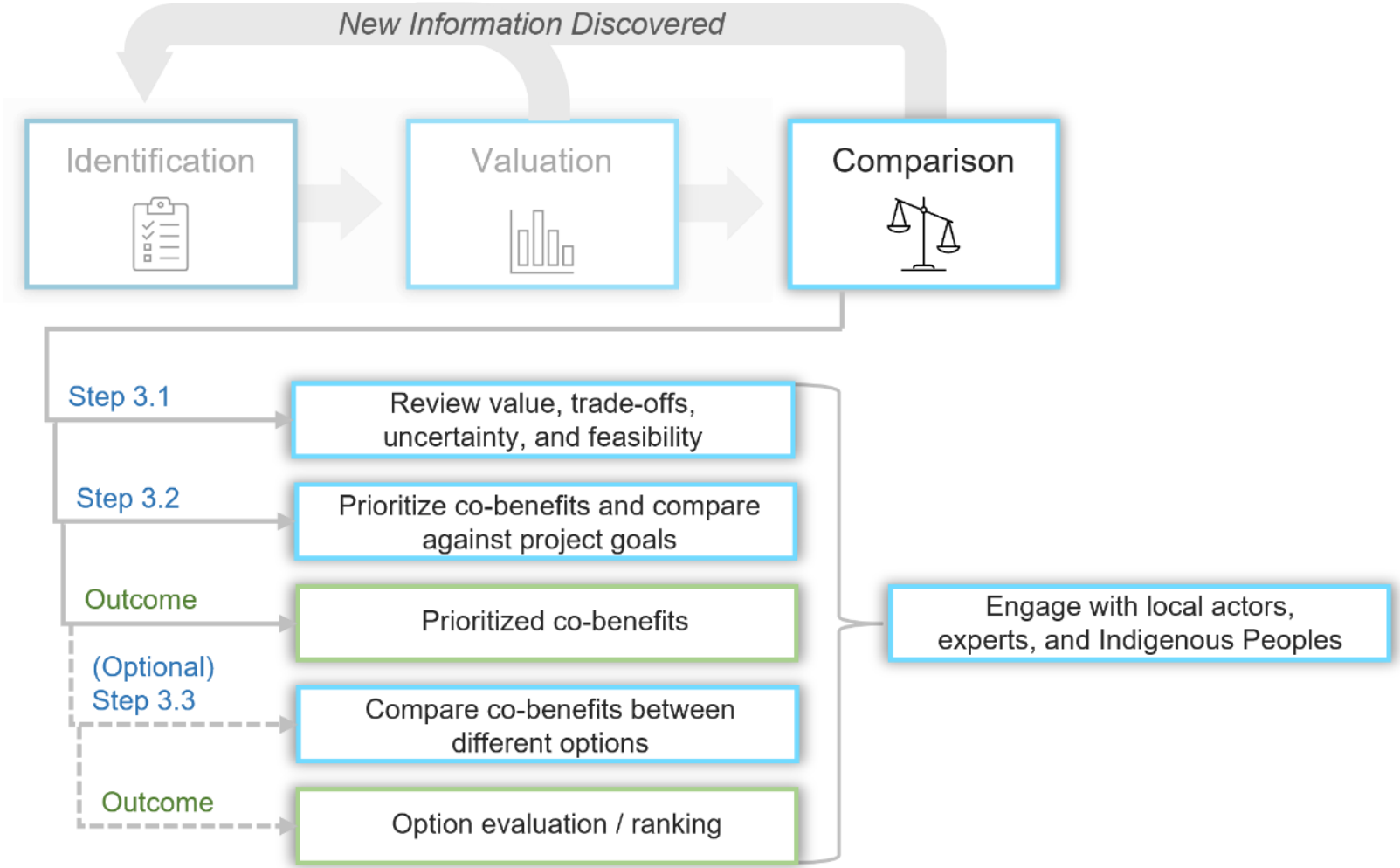


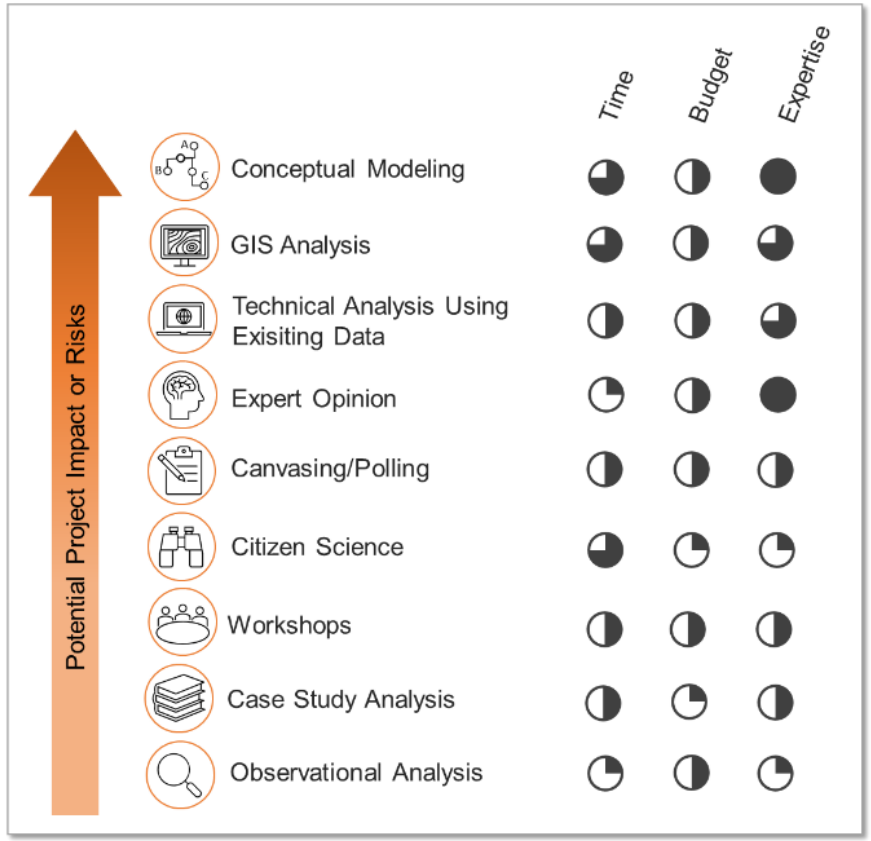
Co-Benefits

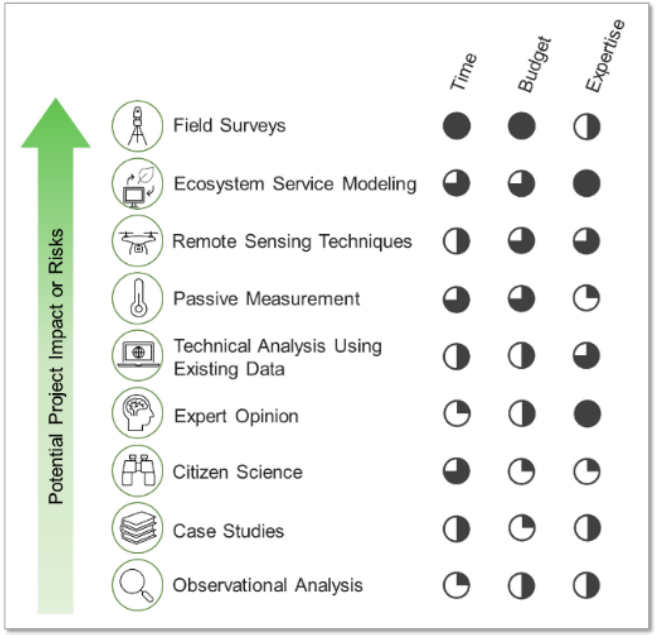
Co-Benefits Assessment Process

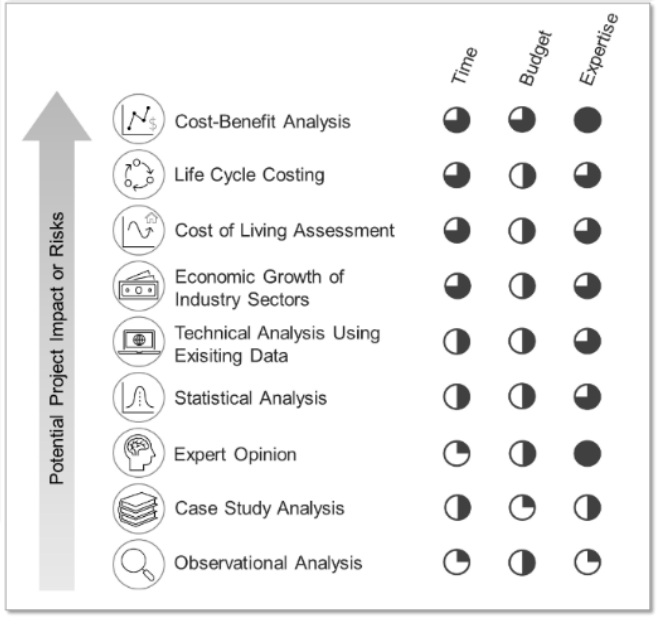


Co-Benefits

Co-Benefits Valuation Methods







Co-Benefits

Case Study

Qualicum Beach waterfront evaluation frameworks:
Evaluating co-benefits, comparing options, and improving designs

Qualicum Beach, British Columbia, Canada

In 2016, the Town of Qualicum Beach published a *Waterfront Master Plan* (Town of Qualicum Beach, 2016). It aimed to guide future development along the waterfront in a sustainable manner, while responding to climate change related effects and aligning with community values and goals.

As part of the *Waterfront Master Plan,* two evaluation frameworks (which use MCA) were developed to help assess proposed waterfront developments in a systematic and transparent matter, and inform decision making related to their approval (Town of Qualicum Beach, 2016, 4):

- Engineering and Environmental Framework
- Community Values Framework

The Engineering and Environmental Framework included 11 criteria, which aimed to assess compatibility with coastal processes, foreshore ecological services, and technical feasibility/longevity (SNC Lavalin, 2016, 3). The Community Values Framework included seven (7) criteria, which were informed by extensive community engagement (Town of Qualicum Beach, 2016, 39). Each criterion was scored between +2 and -2, with weightings ranging between 1–12 percent (SNC Lavalin, 2016; Town of Qualicum Beach, 2016). Extensive guidance was also provided for each criterion to help instruct valuations.

Wilson et al., (2018) describe an application of the Engineering and Environmental Framework to a proposed shoreline protection project. In this example, the proposed solution (an armour rock revetment) was evaluated and compared against a 'do nothing' approach. The assessment resulted in a negative valuation for the proposed solution in comparison to the 'do nothing' approach (Figure 13). As a consequence, the design was amended (resulting in a beach nourishment) such that the project provided additional co-benefits which better aligned with the Town's priorities.

Figure 13. Example valuation for a proposed rock armour revetment against a 'do nothing' approach, which resulted in a negative evaluation

No.	Criteria Name	Score		Weighted Score	
		Armour Rock Revetment	'Do Nothing'	Armour Rock Revetment	'Do Nothing'
1a	Compatibility with Expected Sea Level Rise	-2	-2	-20	-20
1b	Flood Adaptation Effectiveness	-2	-2	-24	-24
1c	Compatibility with Coastal Processes	-1	+2	-12	+24
			Sub-Total	-36	-20
2a	Effect on Marine Riparian Vegetation	-1	0	-8	0
2b	Foreshore Habitat Supply	-1	0	-8	0
2c	Foreshore Habitat Diversity	-1	0	-8	0
2d	Marine Pollutants	0	0	0	0
2e	Cumulative Effects to the Foreshore Environment	-1	0	-5	0
			Sub-Total	-29	0
3a	Compatibility with Existing Infrastructure and Adjacent Properties	+1	-1	+11	-11
3b	Stability and Maintenance	+1	-1	+10	-10
3c	Technical Feasibility and Innovation	-1	0	-11	0
			Sub-Total	+10	-21
			Total	**-55**	**-41**

Source: Wilson et al., 2018

Co-Benefits

Key Takeaways

- Engagement is key
- Multi-disciplinary teams are needed
- Resource limitations must be considered
- Multi-criteria analysis

Retrofitting Existing Infrastructure

What is Retrofitting?

Replacing, modifying, or enhancing existing gray infrastructure with natural or nature-based features and processes






Retrofitting Existing Infrastructure

Objectives

- Value proposition
- Outline incentives
- Summary of retrofitting options
- Cost-comparisons
- Identify and compare retrofitting opportunities and options

Retrofitting Existing Infrastructure

Benefits of Retrofitting?

- **Improved Flood or Erosion Risk Management**
- **Reinforce or Repair Existing Aging Infrastructure**
- **Improved Residual Performance** (i.e., resilience)
- **Enhanced Climate Change Adaptation**
- **Compliance with Project Requirements** (e.g., funding requirements)
- **Opportunity for Indigenous and Community Partnerships**
- **Advance and Apply New Knowledge** (e.g., research and guidance development)
- **Improved Public Buy-In**
- **Environmental Co-Benefits** (e.g., habitat restoration)
- **Social Co-Benefits** (e.g., improved access to green space)
- **Economic Co-Benefits** (e.g., decreased life cycle costs)
- **Location Specific Solutions**

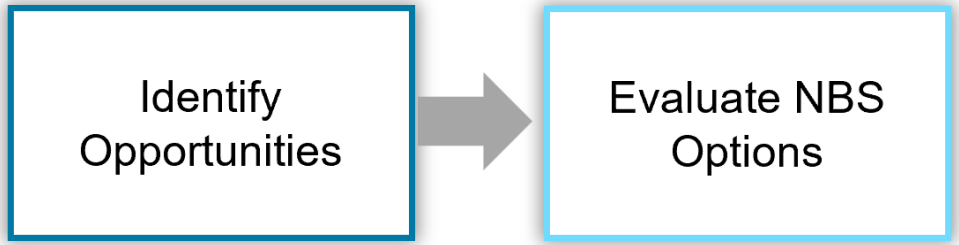
Retrofitting Existing Infrastructure

Existing Data Gaps and Barriers to Retrofitting

- **Social/attitudinal** (e.g., perception that NBS do not provide the same level of protection and performance as gray structural approaches)
- **Technical** (e.g., lack of technical guidance, trained professionals, or pilot/demonstration projects in diverse settings)
- **Environmental** (e.g., seasonal and long-term variability of natural systems, and resilience to disturbances)
- **Institutional** (e.g., lack of funding, regulatory issues)
- **Lack of data** (e.g., on performance and co-benefits in varied regions, particularly in comparison to conventional, gray approaches)

Retrofitting Existing Infrastructure

Process for scoping retrofitting opportunities and options



Retrofitting Existing Infrastructure

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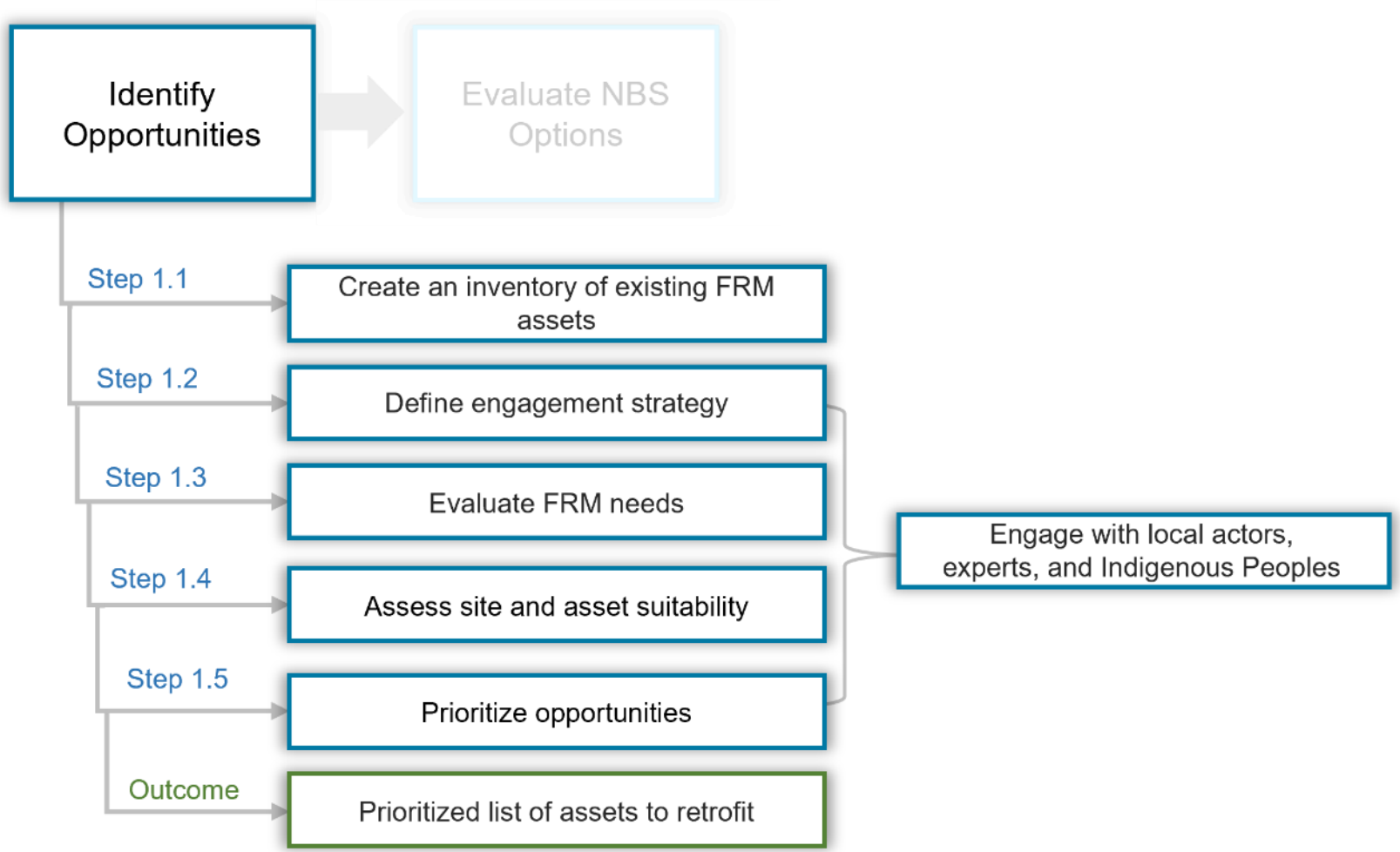

Retrofitting Existing Infrastructure

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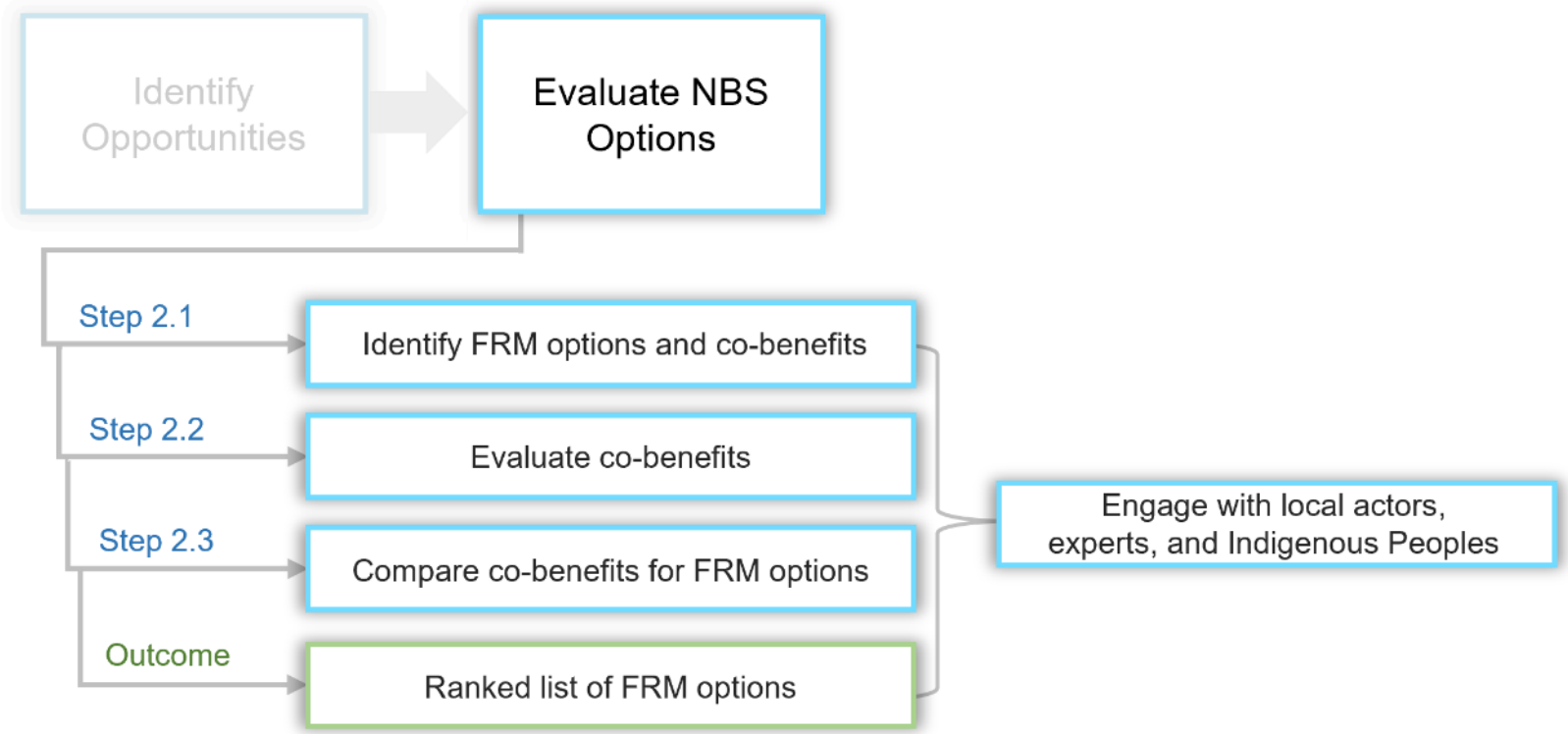


Retrofitting Existing Infrastructure

Examples of site conditions, constraints, and opportunities

Appropriate Location	• Is there sufficient space available for all types of NBS? • Do existing land-uses conflict with some NBS? • Will regulations restrict the project footprint? • Will some NBS require the purchase or lease of new land?
Coastal Hazard Exposure	• Does the site host a large tidal range? • Is the site exposed to regular or severe waves or storm surges? • Are there regular or strong winds?
Existing Sediment Supply	• Has the naturally occurring sediment supply to the system been altered by either natural or anthropogenic influence (i.e., currently in a sediment deficit)? • Is the system dominated by longshore or cross-shore sediment transport? • What are the off-site sources of sediment?
Access Constraints	• How will access be gained during construction? • Will construction require underwater or offshore work? • Will there be access available for long-term monitoring and adaptive management? • Could regular maintenance cause negative impacts to systems?
Existing Natural Features & Ecosystems	• Are there existing natural features (such as sand dunes or wetlands) which could be restored or enhanced? • Are there existing natural features or habitats which may be negatively impacted by new construction activities?
Community Support	• Is there community support for NBS at this site? • Have community members been negatively impacted by past FrM projects in this area? • Is there potential for significant co-benefits to the community?

Retrofitting Existing Infrastructure

Wetlands

Box 5. Examples of typical co-benefits provided by NBS involving wetlands

Environmental	Social	Economic
Aquatic habitat availability and quality	Broader recreation and gathering spaces	Increased tourism
Abundance and diversity of native plant and animal species	Improved esthetics	Reduced costs to adjacent infrastructure (flood losses)
Water storage and quality		Ecotourism opportunities
Carbon sequestration		

Box 6. Key takeaways for NBS involving wetlands

- Coastal wetlands include salt, brackish and freshwater marshes, sand and mud tidal flats and mangroves. They offer protection from erosion and flooding, and provide new habitat and improved recreation and tourism benefits, although scale is important in reducing flood risks and to ensure a functioning system.
- Wetland restoration is achieved by promoting natural inundation of land (often through dike and levee breaching) or by raising existing low-lying lands to suitable elevations, sediment deposition, native vegetation planting, and removal of invasive species.
- Salinity, hydrology (e.g., drainage), sediment transport and soil type will all be key factors to consider for successful vegetation establishment.
- Salt marshes generally form in shallow temperate intertidal zones, that are low energy, wave protected and have a continuous sediment supply. Mangroves inhabit salty and brackish water in the tropics and subtropics.
- It is important to understand local coastal dynamics to allow for sediment accumulation and vegetation growth. Adaptive management should be expected.

Retrofitting Existing Infrastructure

Flood-risk management benefits provided by retrofitting options

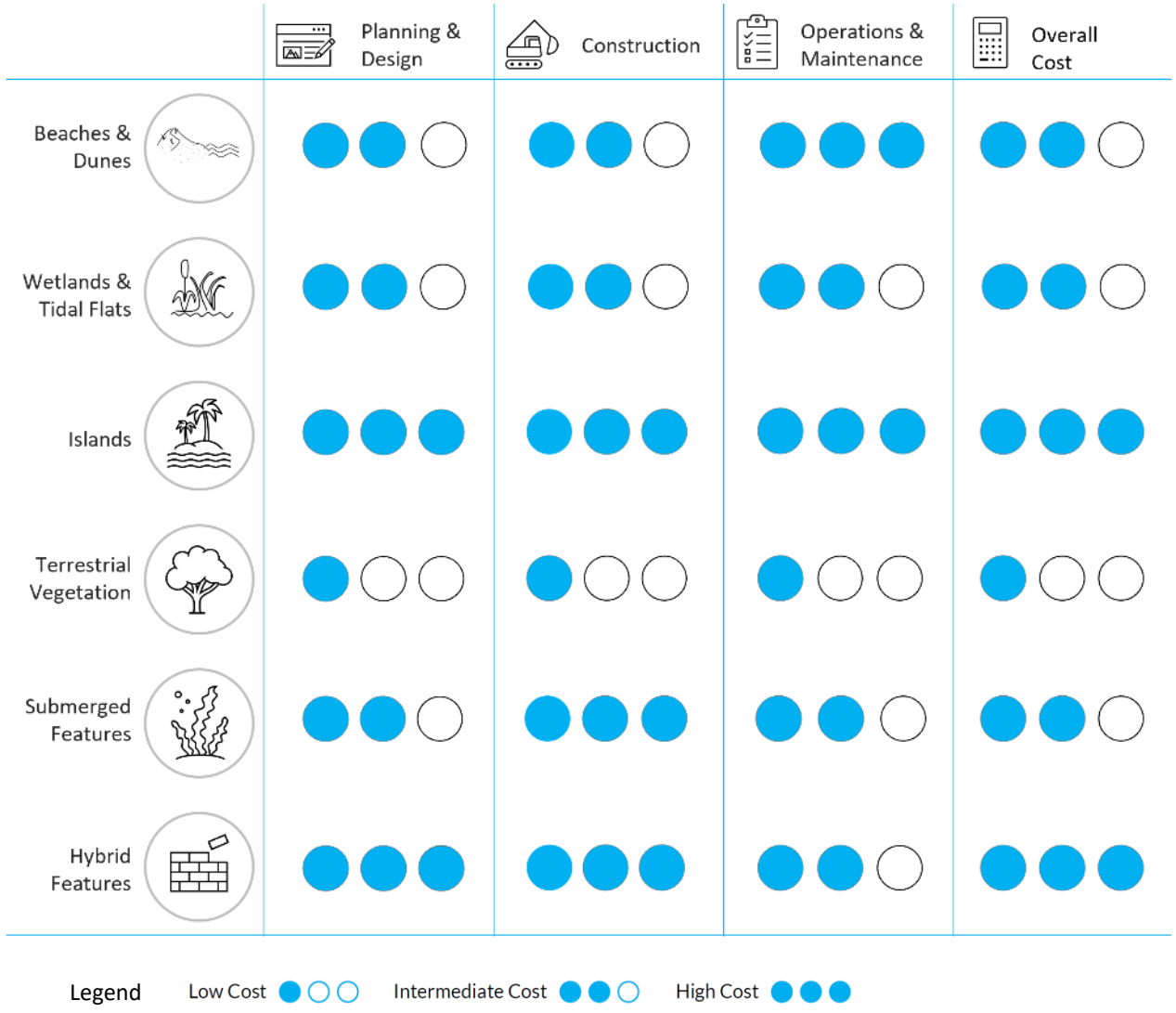
LEGEND

- ○ Benefit not provided
- ? Benefit sometimes provided, depending on design specifics
- ✓ Benefit provided

	Beaches & Dunes	Wetlands & Tidal Flats	Islands	Terrestrial Vegetation	Submerged Features	Hybrid Features
Reduced maximum still water flood levels	○	?	?	○	○	?
Reduced wave effects (i.e., overtopping)	✓	✓	✓	✓	?	?
Reduced or diverted flood water velocities	?	?	?	?	?	?
Shorter flood duration	?	?	○	?	○	?
Residual performance following flood events	✓	✓	✓	✓	✓	✓
Resilience or contingencies for failure of FRM defenses	?	✓	✓	✓	✓	?
Erosion protection	✓	✓	✓	✓	?	?
Improved sediment supply or retention	✓	✓	✓	✓	?	?

Retrofitting Existing Infrastructure

Relative Costs for NBS by Project Development Stage



Retrofitting Existing Infrastructure

Case Study - Wetland Restoration Project (Oregon, United States)

- **Issue**: repetitive seasonal flooding damaging properties, farmlands, highways, and rail lines
- **Damages**: Between 1996 – 2000, Flood-related losses in Tillamook are estimated to have totaled more than USD 60 million
- **Who**: Collaborative effort between 24 communities, local, state and federal agencies
- **Solution**: Wetland restoration, 8 km of levees removed and 15 tide gates replaced further from the sea, 18 tidal channels reconnected
- **Results**: Estimated savings of $9.2 million from flood damages over the next 50 years, creation of 108 jobs, reduced dredging, increasing water quality and storage of 25,000 tons of blue carbon

Retrofitting Existing Infrastructure

Key Takeaways

- Enhance the natural system function or reduce negative impact
- Multi-criteria analysis
- Incentives

Monitoring

Monitoring Efficacy

- ✓ Overview of monitoring process
- ✓ Administrative considerations
- ✓ Technical considerations
- ✓ Impact of site characteristics and climate change on monitoring results

Monitoring Efficacy: Proposed Methodology and Indicators

- ✓ Monitoring program design
- ✓ Performance metrics
- ✓ Performance indicators
- ✓ Monitoring methodologies

Monitoring Efficacy

Why Monitor NBS Projects?

- **Assess FrM Performance**
- **Assess Co-Benefits**
- **Assess Unintended Impacts**
- **Inform Adaptive Management**
- **Comply with Project Requirements** (e.g., funding requirements)
- **Knowledge-Sharing** (e.g., research and guidance development)
- **Improve Accountability and Public Buy-In**
- **Enable the Comparison of FrM Solutions** (e.g., compare NBS against conventional structural methods)
- **Capacity Building and Job Creation**

Monitoring Efficacy

NBS Monitoring Barriers

- **Social/attitudinal** (e.g., perception of monitoring as an unnecessary cost)
- **Technical** (e.g., lack of trained professionals or poor data distribution)
- **Environmental** (e.g., long-term variability of natural systems)
- **Institutional** (e.g., lack of funding or regulatory hurdles)

Monitoring Efficacy

Focus & Structure

- Overall NBS monitoring process
- Administrative and Technical considerations for developing monitoring plans
- Impact of site setting and climate change on monitoring
- Comparison of the differences between monitoring conventional (gray) infrastructure and NBS

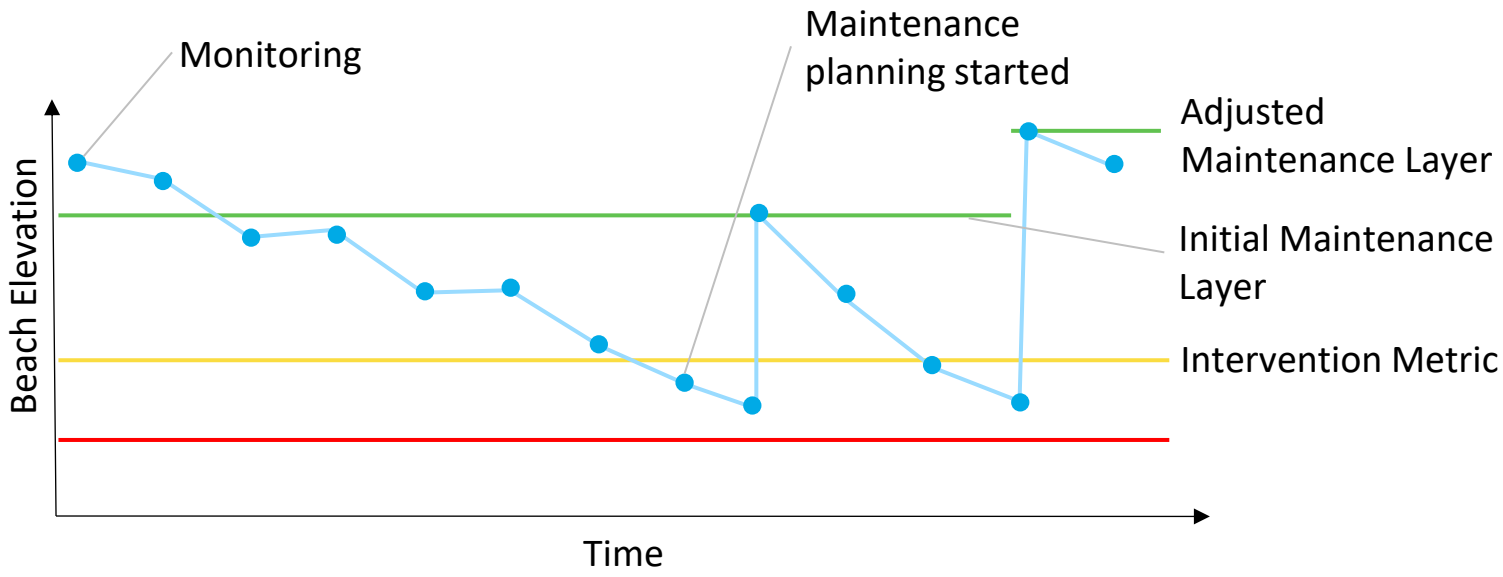
Monitoring Efficacy

Variables Impacting Monitoring Results

- Site characteristics (e.g., limited tidal windows or daylight hours, excess vegetation growth or coverage, ice coverage, debris accumulation, storm damage, vandalism of equipment, limited proximity to resources, and overall site access)
- Climate Change (e.g., impacts to the functioning of monitoring equipment and techniques, shifts in baseline conditions and performance indicator targets)

Monitoring Efficacy

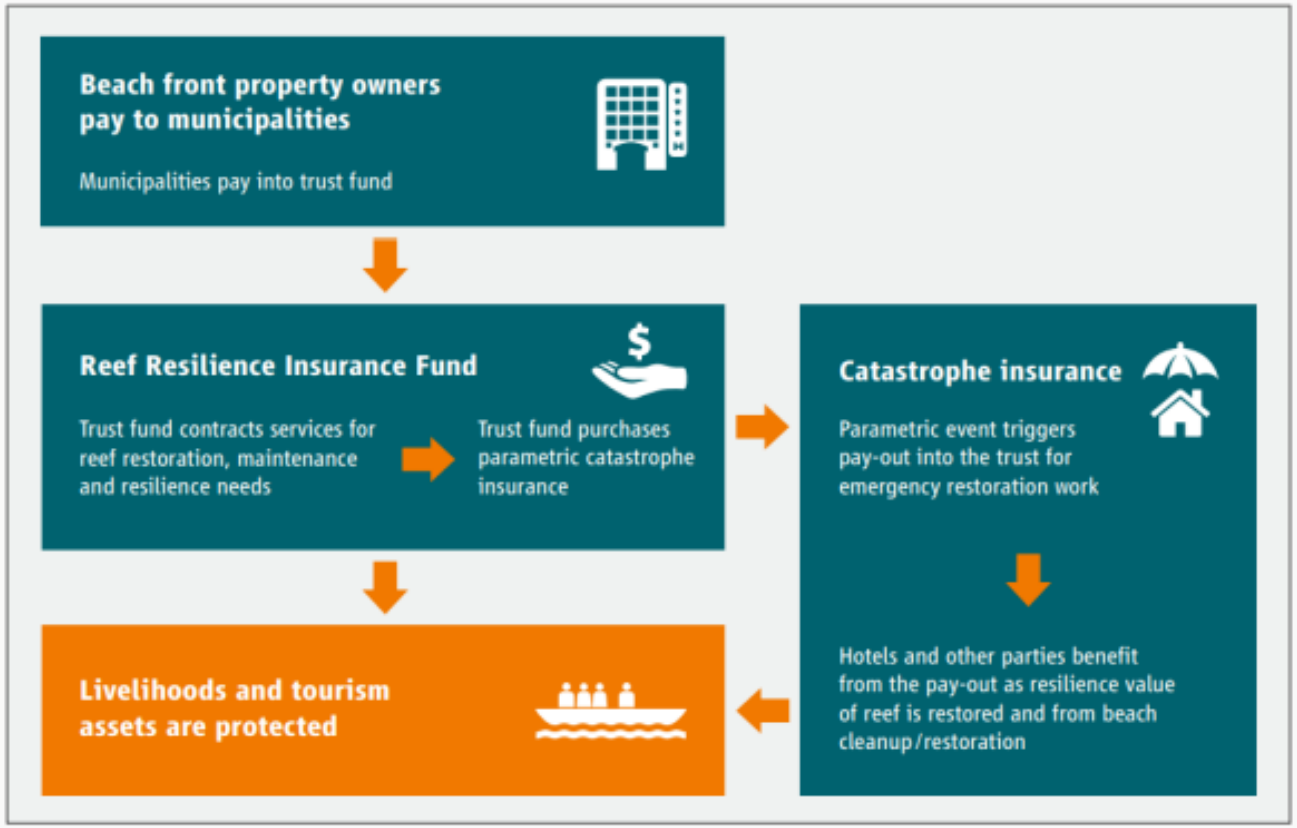
Monitoring and Adaptive Management



Monitoring Efficacy

Case Study - Mesoamerican Reef: Securing Long - Term Funding through Insurance (Quintana Roo, Mexico)

Figure 10. Structure of the insurance trust scheme



Source: Beck et al. 2019

Monitoring Efficacy: Proposed Methodology and Indicators

Focus & Structure

- Monitoring methodology
- Performance indicators
- Monitoring techniques
- Special considerations for different ecosystems and NBS type

Monitoring Efficacy: Proposed Methodology and Indicators

Performance Indicators Across Ecosystem Types

- **Wetlands & tidal flats**: marsh elevation, salinity, pH, oxygen, species abundance
- **Beaches & dunes**: dune morphology, vegetation cover, wave energy, change in high-water marks
- **Hybrid features**: combining gray and green elements, with customized indicators per structure
- **Submerged features**: monitoring of water chemistry, biomass, colonization, structural integrity

Monitoring Efficacy: Proposed Methodology and Indicators

Performance Metrics & Indicator Categories

LEGEND
- Core
- Additional
- Not applicable

Performance Metric	Submerged Features	Wetlands & Tidal Flats	Coastal Forests & Woody Areas	Beaches & Dunes	Islands	Hybrid Features
Reduced flood hazard area for a given event	–	✓	✓	✓	✓	✓
Reduced flood hazard exposure for a given event	–	✓	✓	✓	✓	✓
Reduced wave effects for a target area	✓	✓	✓	✓	✓	✓
Increased habitat connectivity to adjacent habitats	?	?	?	?	?	?

Monitoring Efficacy: Proposed Methodology and Indicators

Example of monitoring techniques

- Hydrological monitoring (water-level loggers)
- Biological surveys (benthic communities, vegetation)
- Remote sensing (drone or satellite imagery)
- Socio-economic surveys, interviews, community-based monitoring, social media, etc.

Monitoring Efficacy: Proposed Methodology and Indicators

Data Management & Sharing

FAIR principles for data:

- Findable
- Accessible
- Interoperable
- Reusable

Monitoring

Key Takeaways

- Collaboration and communication are key
- Need to expand data access and dissemination
- Multi-disciplinary teams are needed
- Conventional (gray) and NBS monitoring differences

Cross-Cutting Themes

1. **Engagement is foundational** — co-benefits, design, and monitoring all require multi-sector/actor collaboration.
2. **Uncertainty is expected, but manageable** — through monitoring and adaptive management.
3. **Data matters** — both for valuation and monitoring. The guides emphasize baseline data, reference conditions, and long-term monitoring.
4. **Capacity building & funding alignment** — many of the barriers identified (technical, institutional, financial) can be addressed through strategic investments and partnerships.

Example of how the guides can be used

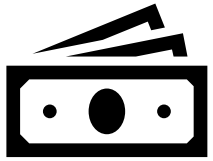
- **A coastal city planner** is assessing whether to retrofit a seawall or restore a marsh; they can use the retrofitting guide + co-benefits framework to assess trade-offs.
- **An NGO designing a dune restoration project** can use the monitoring methodology guide to set up an effective community-based monitoring plan.
- **Funders evaluating proposals** can use the co-benefits and monitoring frameworks to assess the robustness and long-term viability of NBS proposals.

Opportunities to Advance NBS

67 **Opportunities Identified in the Guides**

Resolve conflict between jurisdictional and agency regulations.

Require project teams to commit to data distribution (including failures).



Develop funding streams to support long-term monitoring, adaptive management, co-benefits evaluation, and retrofitting.

Upcoming Publications

www.cec.org/publications/

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  - Porfirio Álvarez, Consorcio de Instituciones del Golfo de México y Caribe (CIGOM)
  - Horacio Limón, Consultant (Environmental economics)
  - Phil Osborne, NHC
  - Pete Zuzek, Zuzek Inc
  - Michelle Molnar, Municipal Natural Assets Initiative
  - Colleen Mercer Clarke, Interdisciplinary Scientist, Landscape Architecture/Coastal Adaptation
  - Joanna Eyquem, Intact Centre on Climate Adaptation, University of Waterloo
  - Cole Delisle, Kahnawake Environment Protection Office
  - Candice D. Piercy ,U.S. Army Engineer Research and Development Center
  - Bhaskaran Subramanian, NOAA Climate Program Office, Office of Oceanic and Atmospheric Research
  - Marguerite Pelletier, U.S. Environmental Protection Agency
  - Dale Werkema Jr., U.S. Environmental Protection Agency
  - Mads Christensen, DHI
  - Alexandra Forsythe, University of Ottawa and Baird & Associates

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Thank you!

¡Gracias!

Merci!

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