Financiado por
la Unión Europea

EUCDs COL01: Soluciones basadas en la naturaleza para la adaptación al cambio climático en ciudades costeras y sistemas insulares en Colombia

NbS on the Global Agenda and the Normative Framework

Iñigo J. Losada

CEMarin
ZMT LEIBNIZ-ZENTRUM für Marine Tropenforschung
IH cantabria INSTITUTO DE HIDRÁULICA AMBIENTAL UNIVERSIDAD DE CANTABRIA

AGENDA

1. NbS: THE CONCEPT
2. GOVERNMENT, POLICY SUPPORT AND INTEGRATION
3. FINANCING
4. NbS LIFE CYCLE: CHALLENGES
5. RECOMMENDATIONS

1

NBS: THE CONCEPT

The term "Nature-based Solutions" (NbS) first emerged with the World Bank portfolio for Biodiversity, Climate Change, and Adaptation (World Bank, 2008), where it was used in the context of finding new solutions to mitigate and to adapt to climate change effects whilst simultaneously protecting biodiversity and improving sustainable livelihoods

"If human societies work with nature, rather than against it, we can develop and implement solutions that create a more resilient, resource-efficient and green economy"

"Nature-based Solutions" (NbS) -> RELATIVELY NEW CONCEPT STILL UNDER CONSTRUCTION

YEAR	ORGANISATION	DEFINITION	REFERENCE
2015	European Commission	Nature-based solutions aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions inspired by, supported by or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions. (…) They have tremendous potential to be energy and resource-efficient and resilient to change, but to be successful they must be adapted to local conditions.	European Commission, 2015
2016	IUCN	Actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits.	IUCN, 2016
2020	WWF	Ecosystem conservation, management and/or restoration interventions intentionally planned to deliver measurable positive climate adaptation and/or mitigation benefits that have human development and biodiversity co-benefits managing anticipated climate risks to nature that can undermine their long-term effectiveness.	WWF, 2020
2021	European Environment Agency	Solutions to societal challenges that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. Nature-based solutions must benefit biodiversity and support the delivery of a range of ecosystem services.	European Environment Agency, 2021
2022	United Nations Environment Assembly of the United Nations Environment Programme	Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits.	**UNEP, 2022**

NbS intends to embrace other concepts such as:

- ecosystem-based approaches (EbAp),
- ecosystem-based adaptation (EbA),
- ecosystem-based disaster risk reduction (Eco-DRR)
- green infrastructure (GI)
- blue-green infrastructure (BGI),
- ecological engineering (EE),
- ecological restoration (ER),
- sustainable management (SM),
- ecosystem-based management (EbM),
- sustainable forest management (SFM),
- integrated watershed management (IWM)
- … or even

- hybrid solutions (combined green/grey)

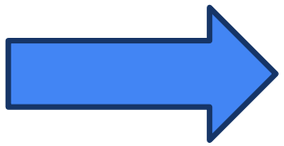
Source: i-SANA GROUP, IHCANTABRIA (2023)

IUCN (2020) came up with a set of principles in order to move towards an operational framework that can guide applications of the NbS concept

1. Embrace nature conservation norms (and principles);
2. Implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions);
3. Determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
4. Produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation;
5. Maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
6. Applied at a landscape scale;
7. Recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystems services;
8. Constitute an integral part of the overall design of policies, and measures or actions, to address a specific challenge.

Other normative principles

- WWF principles (WWF, 2020)
- World Bank principles on nature-based flood protection (World Bank, 2017)
- IUCN principles (Cohen-Shacham *et al.*, 2019)
- FEBA (Friends of Ecosystem-based Adaptation) framework for EbA criteria and standards (FEBA, 2017)
- International principles and standards for the practice of ecological restoration (Gann *et al.*, 2019)



IUCN Global Standard for NbS (2020)

Aiming to provide an opportunity to create a global user community that helps guide implementation on the ground, accelerate policy development, and create conservation science on NbS

Consists of 8 Criteria and 28 Indicators, interconnected and intended as a "user-friendly framework for the verification, design and scaling up of Nature-based Solutions

The Engineering perspective

What is EWN?

Engineering With Nature

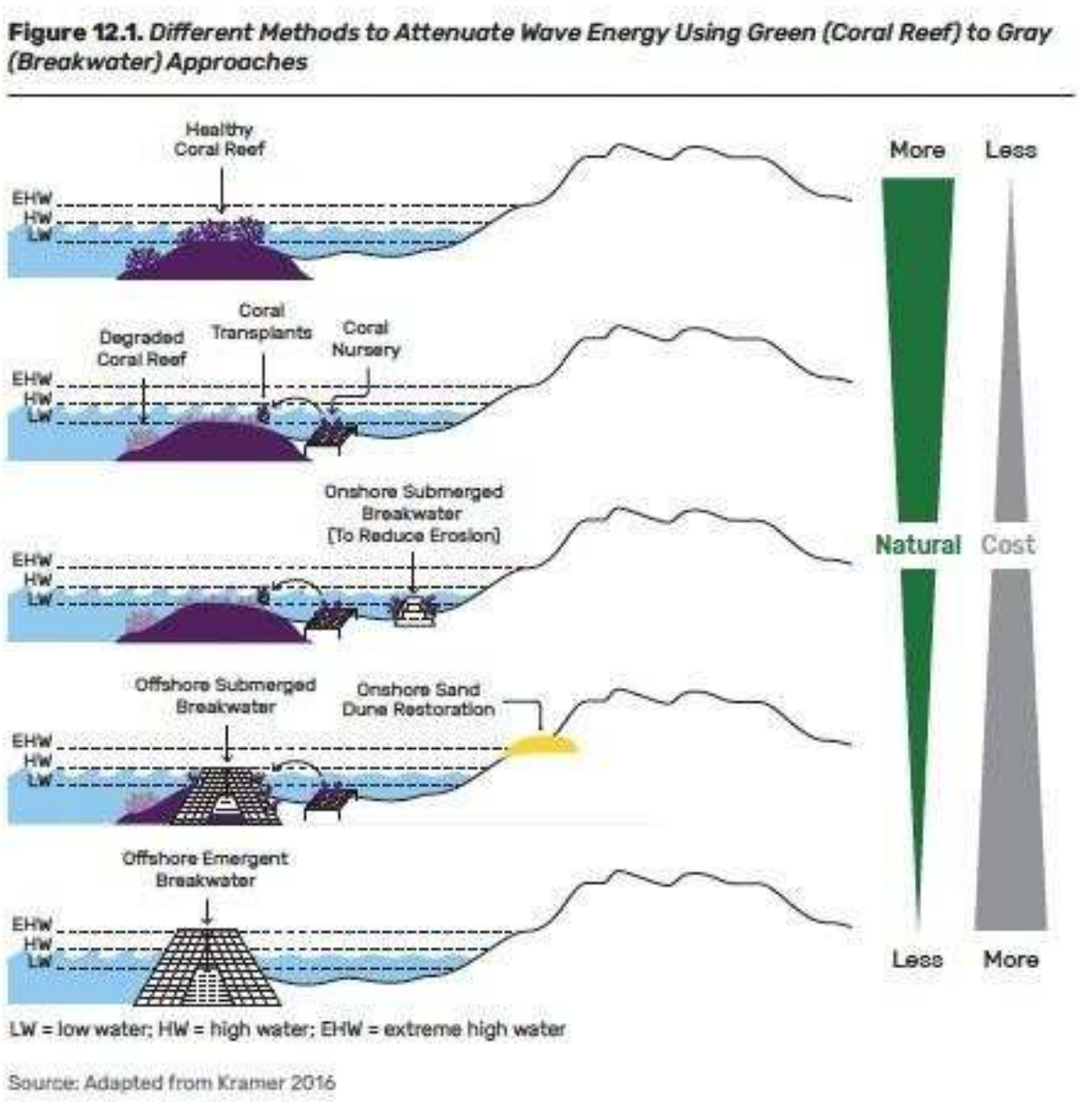
We define Engineering With Nature as the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes

What are NBFs?

Nature-based Features (NBF) are those that may mimic characteristics of natural features but are created by human design, engineering, and construction to provide specific services such as coastal risk reduction.

US Army Corps of Engineers®

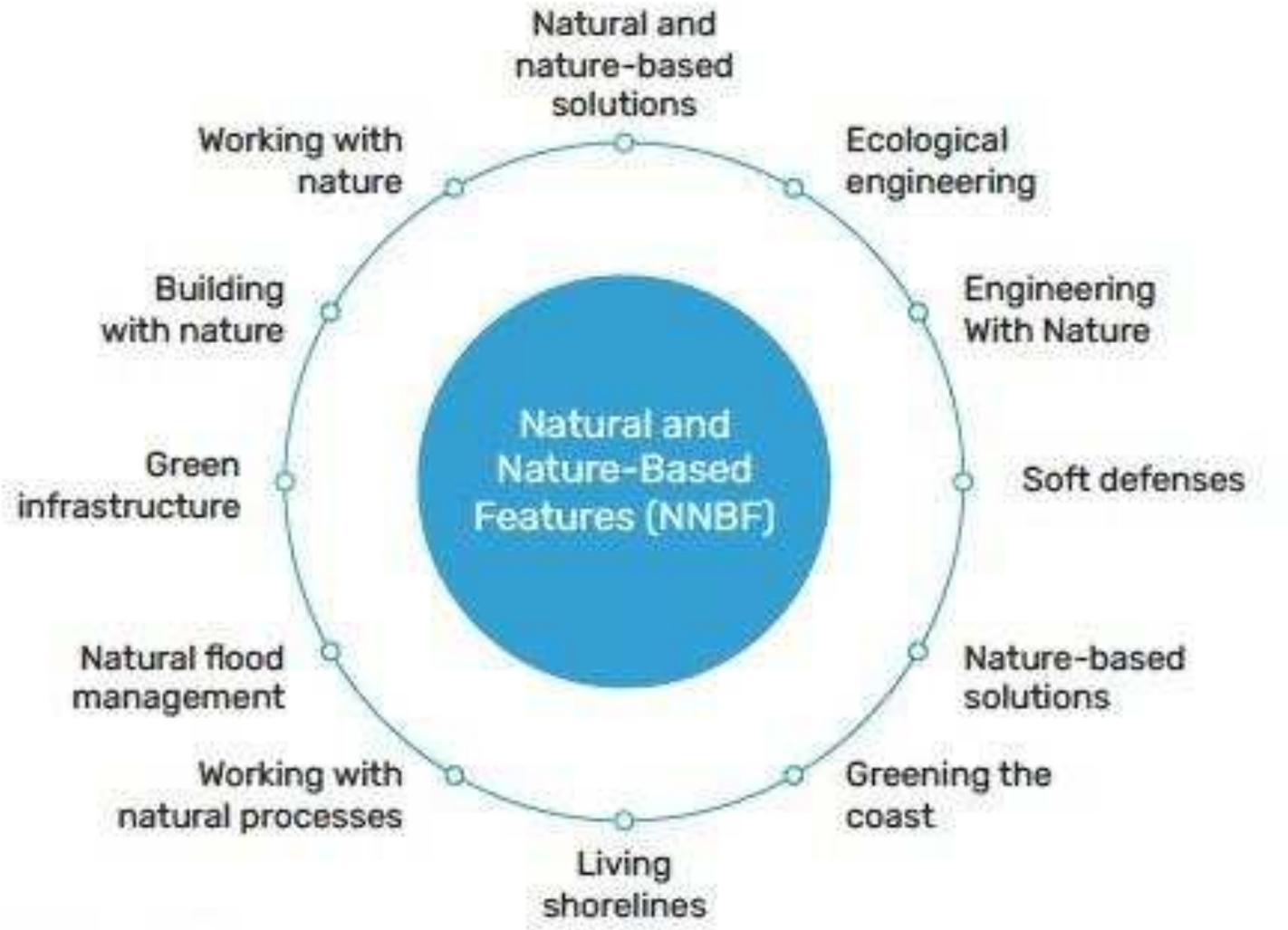
(2013)



The transition between green and grey

The coastal perspective

Figure 1.1. *Terms Related to NNBF*



Source: Nigel Pontee, Jacobs

A relevant barrier

1. The terms NbS is still relatively new and connected with a large set of other similar terms with a strong dependency on the community your get involved
2. Attempts from different organizations are converging but there is still a need for standardization
3. Still, this is a concept unknown for relevant stakeholders and key players in the value chain of NbS implementation
4. Important barrier

2

GOVERNMENT, POLICY SUPPORT AND INTEGRATION

The international increasing support and relevance of NbS in policies, strategies and agendas is boosting the adoption by governments, the integration in different policy contexts and the upscaling and mainstreaming of NbS in different geographies

A few examples:

NbS have been prioritised by European Union (EU) environmental policy agendas

(EU Biodiversity Strategies, EU Green Infrastructure Strategy, EU Research & Innovation Agenda for Nature-Based Solutions, EU Strategy on Climate Change Adaptation, The European Green Deal, and the EU Nature Restoration Law),

Worldwide

(The Sendai Framework for Disaster Risk Reduction, and The New Urban Agenda)
are considering Nbs as a solution to face environmental, social and economic challenges in a sustainable way.

Sustainable Development Goals (SDGs) and 2030 Agenda (UN)
"Rio conventions" (Convention on Biological Diversity; Convention to Combat Desertification; UN Framework Convention on Climate Change) or the UN Decade on Ecosystem Restoration 2021–2030
are integrating Nbs as part of the solution space to achieve their goals

Source: i-SANA GROUP, IHCANTABRIA (2023)

NbS implementation is also fostered from several European directives

- Floods Directive,
- Habitats and Birds Directives
- Water Framework Directive
- et al.

mostly targeting
public stakeholders

because they will clearly benefit reaching their targets.

But how far are we heading?

But how far are we heading?

Example 1: Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives

An economic activity contributes substantially to climate change adaptation if:

The adaptation solutions implemented:

(a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

(b) favour nature-based solutions [6] or rely on blue or green infrastructure [7] to the extent possible;

(c) are consistent with local, sectoral, regional or national adaptation plans and strategies;

(d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;

(e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity

But how far are we going?

(6) Nature-based solutions are defined as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions'. Therefore, nature-based solutions benefit biodiversity and support the delivery of a range of ecosystem services

Compliance with the EU Taxonomy affects ESG policies & access to finance of EU private companies

Example 2: The Taskforce on Nature-related Financial Disclosures ("TNFD") Framework (2022)

It seeks to provide organisations and financial institutions with a risk management and disclosure framework to identify, assess, manage and report on nature-related dependencies, impacts, risks and opportunities ("**nature-related issues**"), encouraging organisations to integrate nature into strategic and capital allocation decision making.

Both are relevant drivers for the involvement of the private sector in the implementation and finance of NbS

In Spain (Ministry of Ecological Transition):

- Green infrastructure strategy (2021)
- NbS are a priority in the National Adaptation Plan (PNACC) (2020)
- Spanish National Strategy for Climate Change Adaptation in Coastal Areas (2017)

Spanish Law on Climate Change and Energy Transition (2021)

8. El PNACC **promoverá y priorizará** la adaptación al cambio climático basada en ecosistemas, el desarrollo de las infraestructuras verdes y las soluciones basadas en la naturaleza.

Artículo 26. *Fomento de la capacidad de absorción de los sumideros de carbono*.

1. Las Administraciones Públicas competentes promoverán la identificación, clasificación, cartografía, aumento y mejora de los sumideros de carbono, incluidos los **sumideros de carbono azul** definidos por el Grupo Intergubernamental de Expertos sobre el Cambio Climático, así como su evaluación y contabilización a partir de las fuentes de información existentes

……. se **fomentarán las acciones que resalten las externalidades positivas que proporcionan los sumideros de carbono terrestres y marinos,**

These existing efforts on biodiversity, climate, environment and sustainable development are boosting and could affect NbS design, planning and implementation at different scales.

One may conclude that conceptual government and policy support is clearly present

but

Are we ready to face the challenge?

Do we have developed a complete value chain to design, plan, implement, operate & maintain, monitor, finance, insure……acceptable and reliable NbS?

If so, in what environments are we able to allow upscaling and relocation of solutions?

Are we able to develop solutions fulfilling stakeholders' needs and levels of admissible risk?

If not, what is missing?

3

FINANCING

Investment needs in NbS to:

- Limit climate change below 1.5°C
- Halt biodiversity loss
- Achieve land degradation neutrality

Does not consider coastal protection or other ecosystem services

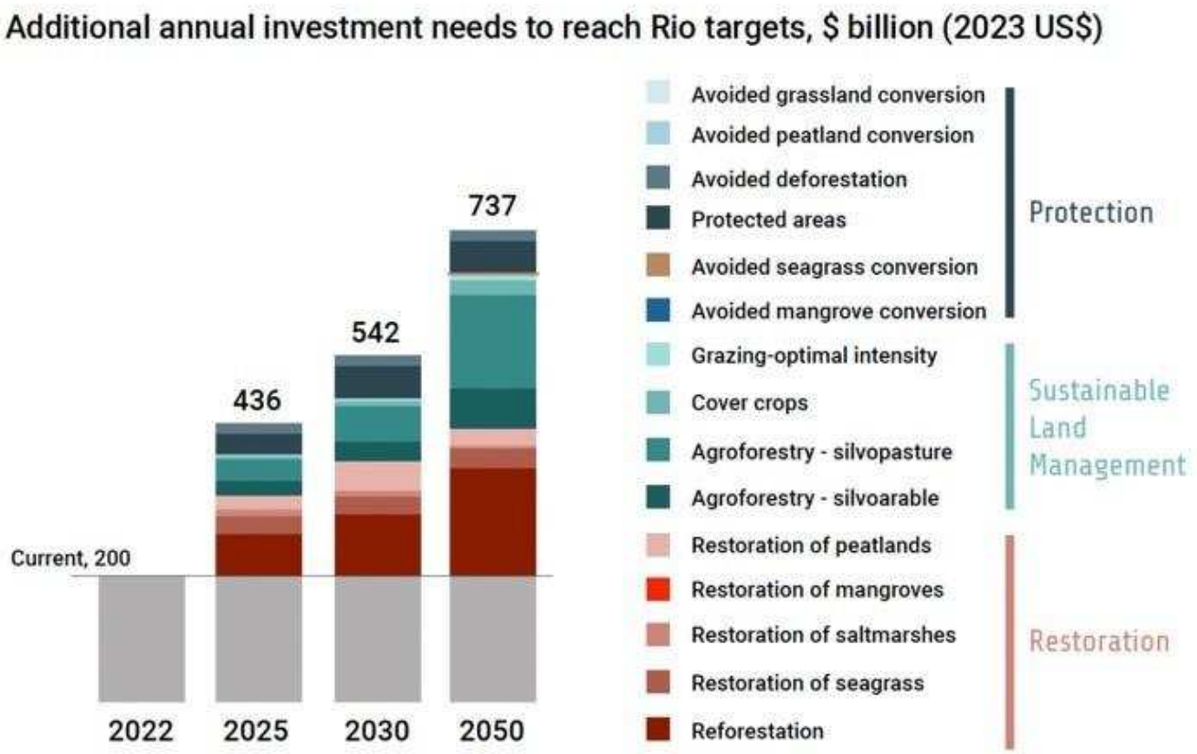


Figure 1: Annual current (2022) and required NbS investment to reach Rio Targets, including limiting climate change to below 1.5°C, halt biodiversity loss and achieve land degradation neutrality. Source: UNEP (2023b).

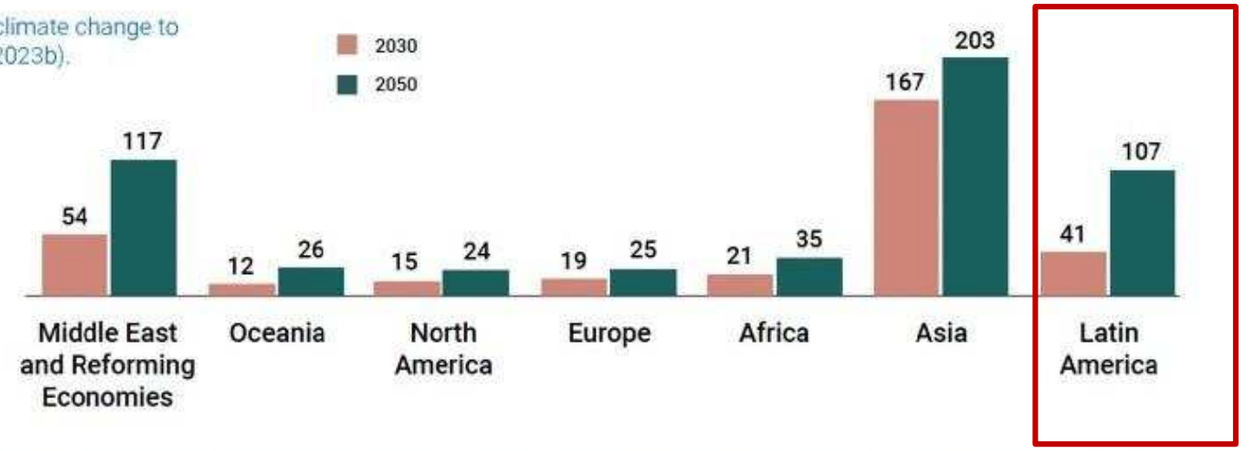


Figure 2: Additional NbS investment needs per year by region, Rio-aligned, $ billion (2023 US$). Source: UNEP (2023b).

Source: Van Raalte, D. and Ranger, N. Global Center on Adaptation (2023)

Types of investors in NbS

Table 2: Different types of investors in NbS. Source: Produced by the author drawing from various reports (Convergence, 2022; Earth Security, 2021; EIB, 2023; Flammer et al., 2023; UNEP, 2022a).

Investor Type	Description	Type	Profit Motive	Examples
Governments/ Municipalities	Various governmental bodies and organizations across levels responsible for governing and providing public services to citizens	Public Sector	Typically, low	Indonesian Government; Jambi (Indonesia) Provincial Government; Dutch Ministry of Economic Affairs and Climate Policy; UK's Department for Business, Energy & Industrial Strategy; Surrey County Council
Development Agencies/ Multi-Donor Funds	Entities with pooled resources from multiple countries to support development initiatives and projects in various regions or sectors	Public/ Quasi-Public Sector	Typically, low to medium	Private Infrastructure Development Group (PIDG), Green Climate Fund (GCF); Canadian Climate Fund for the Private Sector in the Americas (C2F); Clean Technology Fund (CTF); United States Agency for International Development (USAID); Global Environment Facility (GEF)
Multilateral Development Bank/ Development Financial Institutions	MDBs are internationally chartered financial institutions, supported by multiple countries, aimed at fostering economic development in less affluent nations, whereas DFIs are government or quasi-government entities that invest in low- and middle-income countries.	Public/ Quasi-Public Sector	Varies but typically medium	The International Finance Corporation (IFC); The Nederlandse Financierings-Maatschappij voor Ontwikkelingslanden N.V. (FMO); Inter-American Development Bank (IDB Invest); U.S. International Development Finance Corporation (DFC)
Foundations/ NGOs	Private/third sector non-profit entities that work towards addressing social and humanitarian issues through charitable activities and projects.	Private/ Third Sector	Typically, low	Shell Foundation; David & Lucile Packard Foundation; The Rockefeller Foundation; Conservation International; Omidyar Network; Engineers Without Borders Canada; Global Partnerships; Good Energies Foundation; Grantham Foundation;
Impact Investors	Private sector organisations or individuals that seeks to invest in projects or companies with the intention of generating positive social or environmental impacts alongside financial return	Private Sector	Varies from low to high	Ceniarth LLC; Calvert Impact Capital; Global Energy Efficiency & Renewable Energy Fund; Land Degradation Neutrality Fund; responsAbility Investments AG; Oikocredit; Acumen; Builders Vision
Commercial Investors	Private sector entities such as private equity and venture capital firms, institutional investors, financial institutions, and asset managers that invest capital in businesses and projects for potential financial returns	Private Sector	Typically, high	Blackrock; Algemene Pensioen Groep (APG); Barclays; Rabobank; Canada Pension Plan Investments (CPP); The Hongkong and Shanghai Banking Corporation Limited (HSBC); Lombard Odier Investment Managers
Businesses	Private sector entities involved in various industries and sectors, providing goods and services to customers	Private Sector	Typically, high	Shell; Unilever; Marfrig Group; Mondi; Bunge; Cargill; Golden Agri Resources (GAR); Apple; Microsoft

Source: Van Raalte, D. and Ranger, N. Global Center on Adaptation (2023)

Types of financial instruments used to finance NbS

Table 3: Different types of financial instruments used to finance NbS. Source: Produced by authors.

Category	Subcategory	Description	Private or Public Market	Financial Return for Investor	Liquidity	Investor Control Over Investee
Grant-Based	Grant	Non-repayable funds typically provided by governments, foundations, or organizations to support sustainable projects and initiatives.	Private	NA	Low	Typically, low (as no ownership or repayment requirement)
	Redeemable Grant	A grant to support sustainable projects and initiatives that may need to be repaid if certain conditions are not met or objectives are not achieved, or simply repaid after a certain period.	Private	Principal	Low	Typically, low-medium (as no ownership)
Debt-Based	Private Loans	Funds borrowed from a lender, to be repaid with interest over an agreed period. Loan agreements can include customised E&S conditions.	Private	Interest and principal	Low	Typically, high (as direct relationship)
	Mezzanine Loans	Funds borrowed from a lender, to be repaid with interest over an agreed period and some form of equity participation (e.g., profit share). Loan agreements can include customised E&S conditions.	Private	Interest, principal and other	Low	Typically, high (as direct relationship)
	Private Notes	Debt instruments issued by entities to raise capital from investors, often with a specified interest rate and maturity date. Notes can include customised E&S conditions.	Private	Interest and principal	Low	Typically, medium (as usually many noteholders)
	Green Bonds	Debt securities with a defined use of proceeds issued explicitly to finance or refinance projects or activities with positive environmental impacts.	Private or Public	Interest and principal	Low	Typically, low (as indirect relationship)
	Social Bonds	Debt securities with a defined use of proceeds issued explicitly to finance or refinance social projects or activities that achieve positive social outcomes and/or address a social issue.	Private or Public	Interest and principal	Low	Typically, low (as indirect relationship)
	Sustainability Bonds	Debt securities with conditions that are structurally linked to the issuer's achievement of climate or broader SDG goals, such as through a covenant linking the coupon of a bond.	Private or Public	Interest and principal	Low	Typically, low (as indirect relationship)
	Sustainability Linked Bonds	Debt securities with a defined use of proceeds issued explicitly to finance or re-finance a combination of green and social projects or activities.	Private or Public	Interest and principal	Low	Typically, low (as indirect relationship)
	Blue Bond	Debt security to raise capital to finance marine and ocean-based projects that have positive environmental, economic and climate benefits.	Private or Public	Interest and principal	Low	Typically, low (as indirect relationship)
Equity-Based	Private Equity	Investments in private companies or projects in exchange for ownership stakes and potential returns on investment.	Private	Dividends and value appreciation	Low	Typically, high (depends on ownership level)
	Public Equity	Ownership shares in publicly traded companies, providing investors with ownership and potential dividends.	Public	Dividends and value appreciation	High	Typically, low (depends on ownership level)
	ESG ETFs	Exchange-traded funds that focus on companies or projects meeting ESG criteria.	Public	Dividends and value appreciation	High	Typically, low (as indirect relationship)
Derivative-Based	Carbon Credits	Tradable units representing reductions in GHG, incentivizing emission reduction efforts. Typically sold over the counter on the voluntary carbon market.	Private or Public	Value appreciation	Low to medium	Typically, low to medium (as may have no direct contractual relationship)
Other	Debt-for-Nature Swap	An arrangement where a country's debt is exchanged for funding for environmental conservation or sustainability initiatives.	Private	Depends	Low	Typically, low to medium (as debt is forgiven and at sovereign level)

Barbados
Belize
Ecuador

Source: Van Raalte, D. and Ranger, N. Global Center on Adaptation (2023)

Barriers for NbS financing

Source: Van Raalte, D. and Ranger, N. Global Center on Adaptation (2023)

- NbS is still a relatively new concept
- The return on investment on NbS is not yet evident
- NbS are typically location and environment specific
- Quantifying and disseminating results is complex
  - *Evaluating the effectiveness of projects is difficult*
  - *Quantifying the impact on biodiversity, carbon sequestration, and other ecosystem services requires sophisticated assessment methods and significant resources.*
  - *Communicating these results in a clear and compelling manner to investors and stakeholders is challenging, in part due to a lack of standardisation (López-Portillo Purata et al., 2022).*
- Lack of supportive policy .....or incentives???

nature climate change

REVIEW ARTICLE

PUBLISHED ONLINE: 29 OCTOBER 2013 | DOI: 10.1038/NCLIMATE1970

The role of coastal plant communities for climate change mitigation and adaptation

Carlos M. Duarte[1,2,3,*], Iñigo J. Losada[4], Iris E. Hendriks[2], Inés Mazarrasa[2] and Núria Marbà[2]

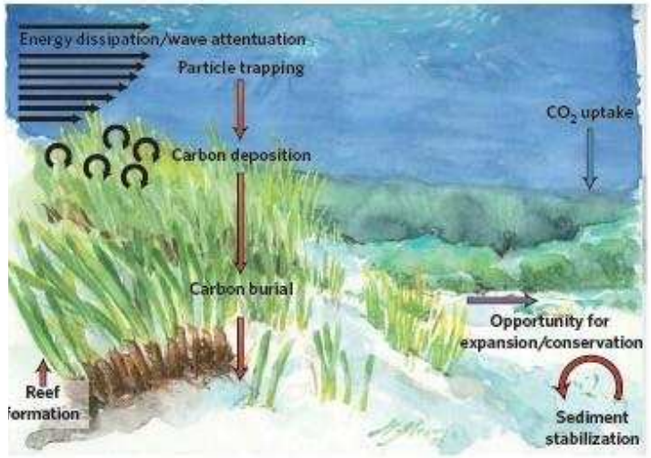
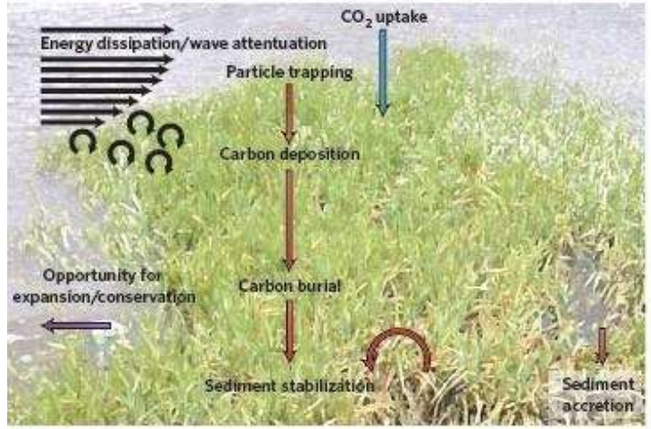


Figure 1 | Key processes of vegetated coastal habitats for climate change mitigation and adaptation. Processes that affect the capacity for climate change mitigation (CO_2 sinks) and adaptation (shore line protection from rising sea level) are shown for seagrass meadows (upper panel), salt marshes (middle panel) and mangrove forests (lower panel). Blue arrows indicate transport of atmospheric or dissolved material, red arrows show transport of particulates and purple arrows indicate vegetative growth.



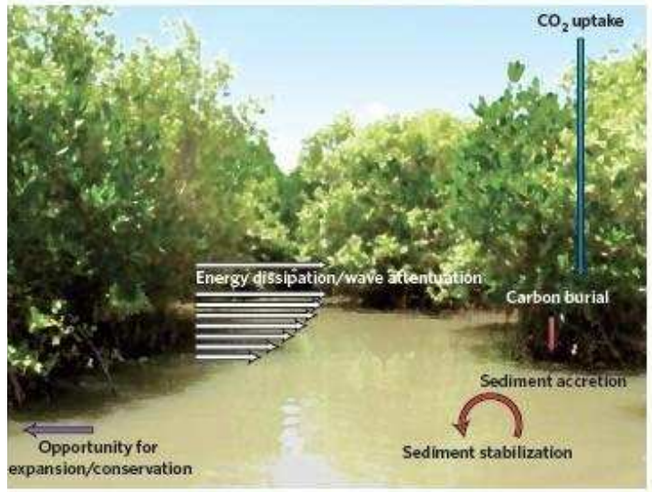


Table 4 | Eco-engineering solutions for coastal areas in the Netherlands.

Environment	Problem	Eco-dynamic design	Area		
Tidal	Erosion of the intertidal area	Surplus Sand nourishment[a] Shellfish reefs[b] Circle-shaped nourishment[c]	Delfland Eastern Scheldt Eastern Scheldt	a	
	Coastal erosion	Sand dunes Wetlands		b	
	Flooding (waves)	Optimizing texture of dykes by ecological growth	North Sea	c	
Non-tidal	Flooding (storms)	Semi-natural floodplains Willow floodplains[d]	IJsselmeer Noordwaard	d	

"Quantifying the impact on biodiversity, carbon sequestration, and other ecosystem services requires sophisticated assessment methods and significant resources"

"Evaluating the effectiveness of projects is difficult"

RESEARCH ARTICLE

The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defences

Siddharth Narayan[1]*, Michael W. Beck[2], Borja G. Reguero[3], Iñigo J. Losada[4], Bregje van Wesenbeeck[5], Nigel Pontee[6], James N. Sanchirico[7], Jane Carter Ingram[8], Glenn-Marie Lange[9], Kelly A. Burks-Copes[10]

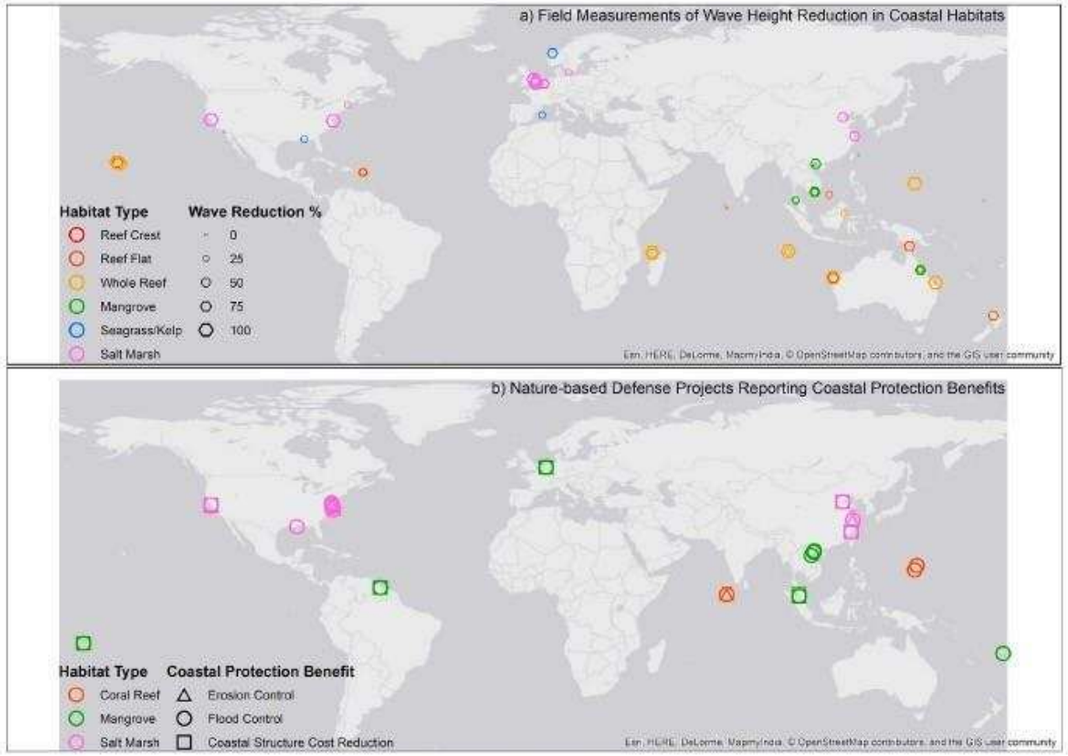
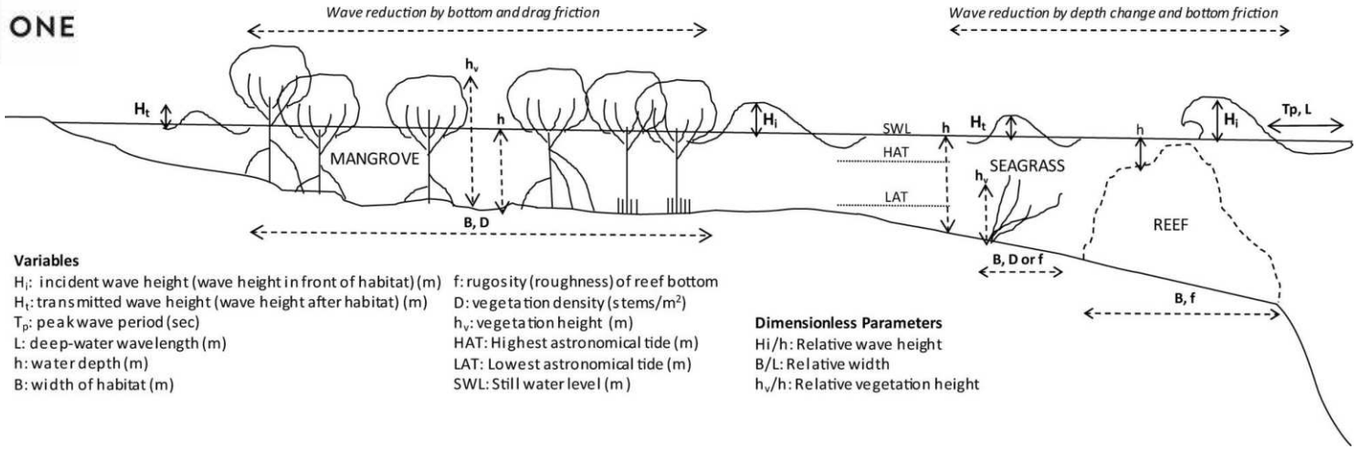


Fig 2. Global map of a) wave height reduction in natural defences (n = 69) and b) Coastal protection benefits from restoration projects (n = 52). Panel (a) maps wave height reduction measurements in coral reefs, salt marshes, mangroves, seagrass beds, kelp beds; Panel (b) maps restoration projects reporting coastal protection benefits reviewed for coral reefs, salt marshes and mangroves (the literature search did not find information on oyster reef projects that observe coastal protection benefits). Colours indicate habitat groups in both panels. Circle sizes in (a) indicate the % wave height reduction measured at each site; shapes in (b) indicate type of coastal protection benefit reported (erosion control, flood control, or protection to structures) (see Table 1). Basemap image is the intellectual property of Esri and is reprinted from Esri under a CC BY license with permission from Esri and its licensors, all rights reserved. Credits: Esri, HERE, DeLorme, NGA, USGS | Esri, HERE, DeLorme.



Variables

H_i: incident wave height (wave height in front of habitat) (m)
H_t: transmitted wave height (wave height after habitat) (m)
T_p: peak wave period (sec)
L: deep-water wavelength (m)
h: water depth (m)
B: width of habitat (m)
f: rugosity (roughness) of reef bottom
D: vegetation density (stems/m^2)
h_v: vegetation height (m)
HAT: Highest astronomical tide (m)
LAT: Lowest astronomical tide (m)
SWL: Still water level (m)

Dimensionless Parameters

Hi/h: Relative wave height
B/L: Relative width
h_v/h: Relative vegetation height

Assessment of 69 restoration projects worldwide

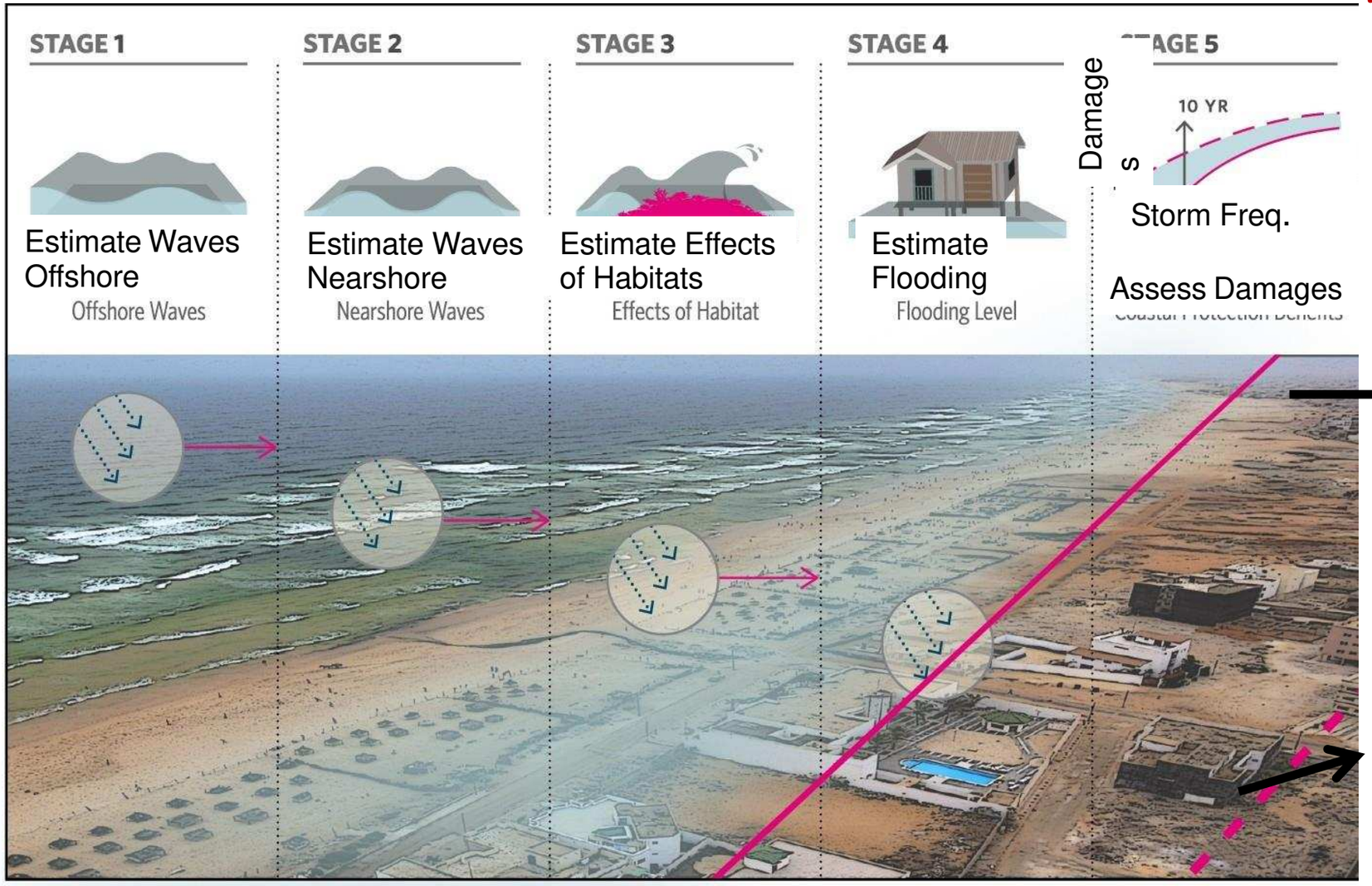
"On average, coastal habitats reduce wave heights between 35% and 71%.

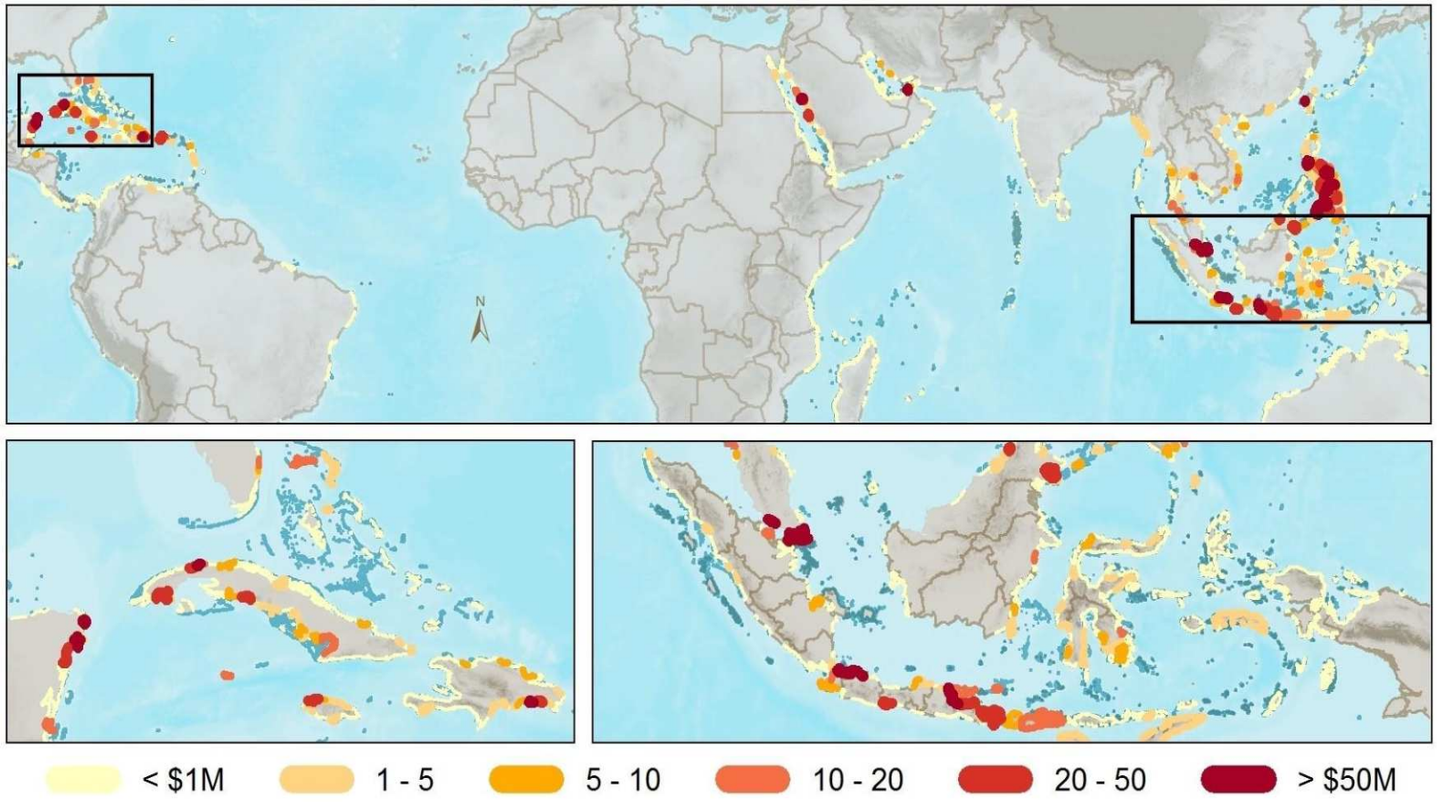
Salt-marshes: 72%,
Coral reefs: 70%;
Seagrass/kelp beds: 36%."
Mangroves : 31%;

Valuation of coastal protection services

"Evaluating the effectiveness of projects is difficult"

"lack of standardization"





The value of coral reefs for flood protection.

Circles represent the annual expected benefit from coral reefs for flood protection ($US millions). The values are the difference in annual expected damages with and without (the top 1m) of reefs

nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-018-04568-z OPEN

The global flood protection savings provided by coral reefs

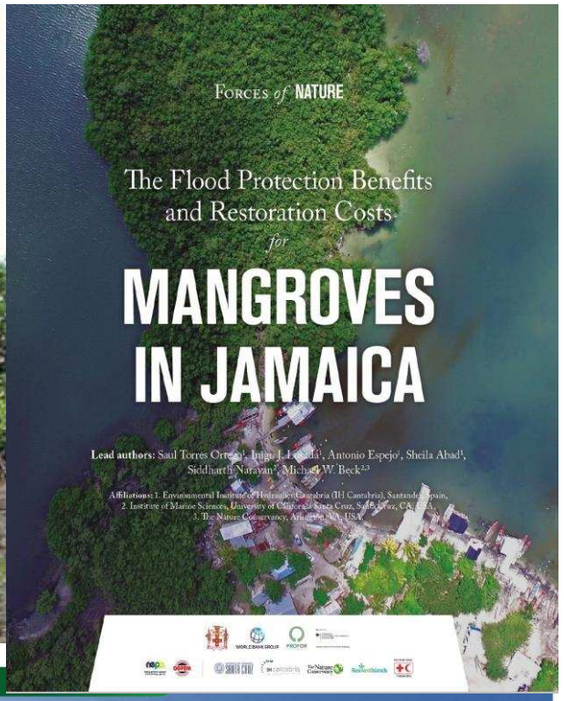
Michael W. Beck[1,2], Iñigo J. Losada[3], Pelayo Menéndez[3], Borja G. Reguero[1,2], Pedro Díaz-Simal[3] & Felipe Fernández[3]

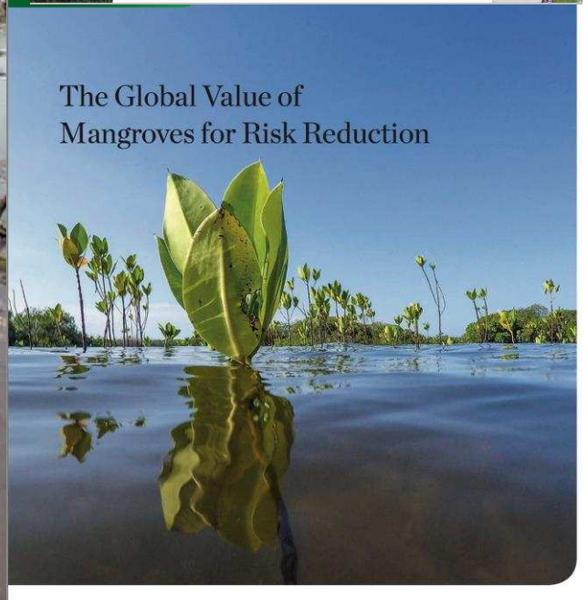
	ANNUAL EXPECTED AREA FLOODED (km²)				ANNUAL EXPECTED PEOPLE			
	Absolute		% of the total in country		Absolute		% of t	
1	Philippines	88.45	Cayman Islands	0.968	Philippines	73162	Cayman Islands	
2	Indonesia	83.20	Turks & Caicos	0.609	Indonesia	56034	Belize	
3	Cuba	79.51	Bahamas	0.224	Mexico	15391	Grenada	
4	Mexico	38.02	Kiribati	0.219	Malaysia	12340	Bahamas	
5	Bahamas	31.07	Antigua & Barbuda	0.188	Cuba	8061	Philippines	
6	Myanmar	26.21	Bermuda	0.085	Myanmar	7166	Cuba	
7	Dom. Republic	18.41	Cuba	0.072	Dom.Republic	6872	Dom. Republic	
8	Saudi Arabia	16.89	British Indian Ocean Territory	0.057	Vietnam	6319	Jamaica	
9	Malaysia	12.70	Maldives	0.053	Thailand	2077	Antigua & Barbuda	
10	Thailand	8.99	Dom. Republic	0.038	Saudi Arabia	1865	Malaysia	
11	Vietnam	8.49	Philippines	0.030	Jamaica	1687	Turks & Caicos	

A. **Annual expected benefit of reefs for flood protection** in terms of annual averted damages to built capital ($US millions per year) and relative to Gross Domestic Product (GDP).

	Annual Averted Damages		Annual Averted Damages/GDP	
1	Indonesia	639	Cayman Islands	0.98
2	Philippines	590	Belize	0.37
3	Malaysia	452	Grenada	0.30
4	Mexico	452	Cuba	0.25
5	Cuba	401	Bahamas	0.16
6	Saudi Arabia	138	Jamaica	0.14
7	Dominican Republic	96	Philippines	0.13
8	United States	94	Antigua and Barbuda	0.13
9	Taiwan	61	Dominican Republic	0.11
10	Jamaica	46	Malaysia	0.09
11	Vietnam	42	Seychelles	0.06
12	Myanmar	33	Turks and Caicos	0.06
13	Thailand	32	Guadeloupe	0.05
14	Bahamas	14	Indonesia	0.04
15	Belize	9	Solomon Islands	0.04

Beck et al. (2017)





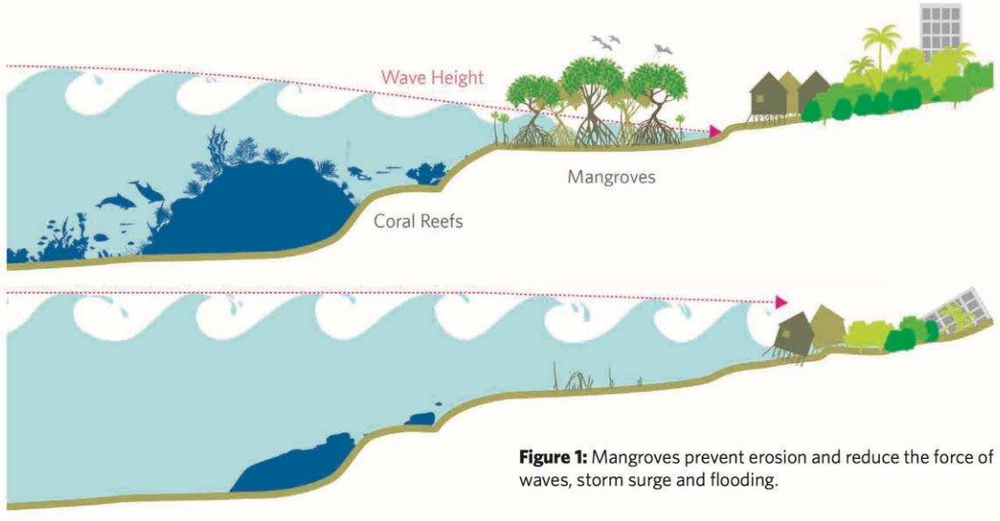
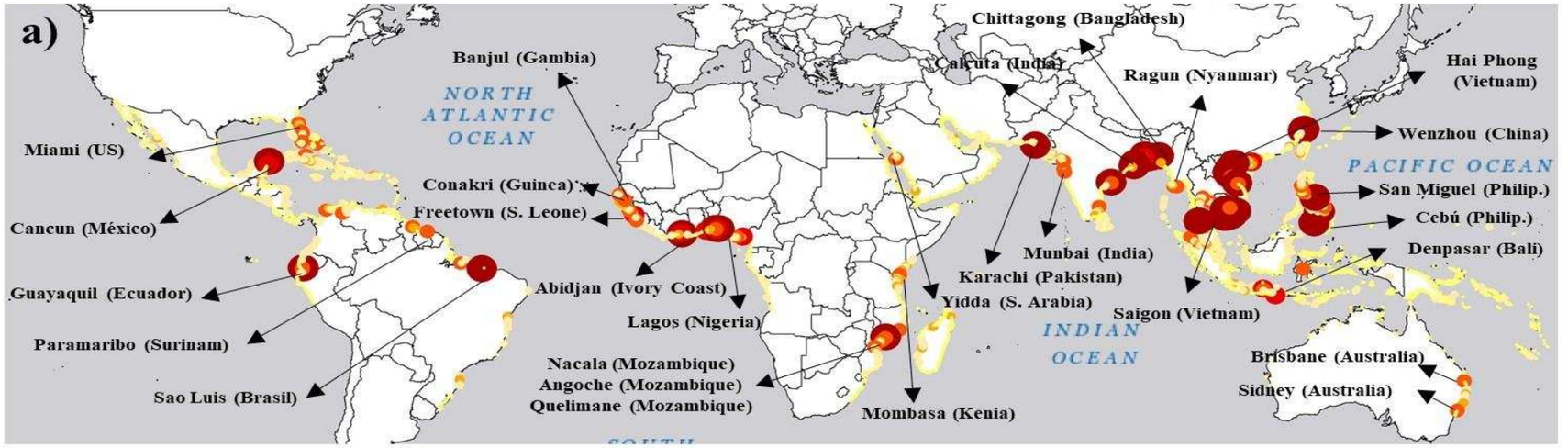


Figure 1: Mangroves prevent erosion and reduce the force of waves, storm surge and flooding.

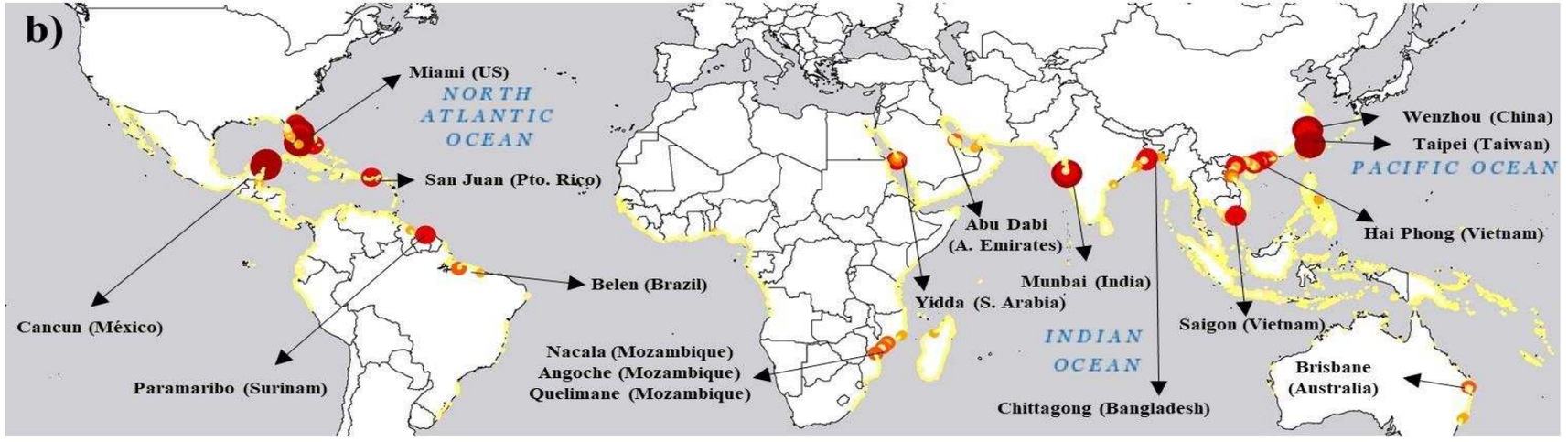
The Nature Conservancy
Protecting nature. Preserving life.

IH cantabria

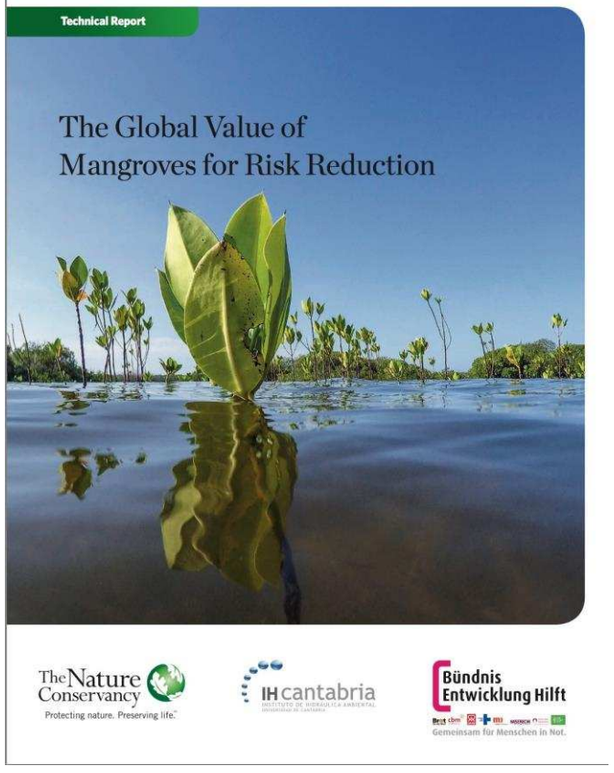
Bündnis Entwicklung Hilft
Gemeinsam für Menschen in Not.



TOTAL Expected Annual Benefits of mangroves (people)



TOTAL Expected Annual Benefits of mangroves (mill. $US)



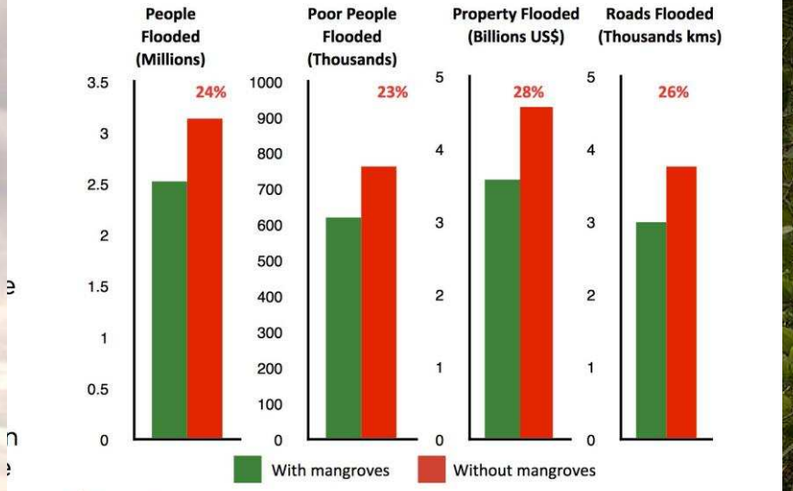


Figure 2 The bars shows the Annual Expected Damages from flooding in the Philippines under current (2010) mangrove cover (in green) and under no mangrove cover (in red), including the annual percent increase in damages to people and property if mangroves were lost.

Valuing Protective Services of Mangroves in the Philippines

Technical Report

Wealth Accounting and the Valuation of Ecosystem Services
www.wavespartnership.org

IH cantabria

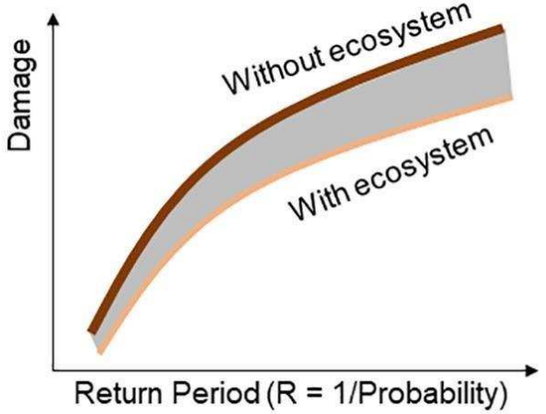
The Nature Conservancy

The Risk Reduction Benefits of the Mesoamerican Reef in Mexico

Borja G. Reguero[1*], Fernando Secaira[2], Alexandra Toimil[3], Mireille Escudero[4], Pedro Díaz-Simal[3], Michael W. Beck[1,2], Rodolfo Silva[4], Curt Storlazzi[5] and Iñigo J. Losada[3]

Hazard → **Socioeconomic Exposure** → **Vulnerability** → **RISK**

- **Hazard**: How strong? How frequent?
- **Socioeconomic Exposure**: Where? What? How many?
- **Vulnerability**: How well built?



	Hazard	Socioeconomic Exposure	Vulnerability	RISK
Data	• Historical storms distribution • Reef bathymetry and coral presence	• Population data • Economic Census data • Hotel distribution and built footprint	• Vulnerability curves (buildings, hotels and population).	• Modeled economic damages from each storm.
Methods	1. Probabilistic simulations of storms. 2. Wind, Surge and Wave fields calculation for each storm 3. Numerical modeling of coastal flooding and the effect of reefs. 4. Calculation of flood heights for each storm.	1. Downscaling of population and built capital data to 100m resolution. 2. Digitalization of hotel built footprint from satellite imagery. 3. Creation of characteristics and exposure of hotels from online queries and survey.	1. Calculate damages from historical storms. 2. Calibration of modeled damages with reported damages from the Government. 3. Calibration of exposure to reproduce historical damages. 4. Recalculation of damages. 5. Calculation of flood damages for the two scenarios: with and without the ecosystems.	1. Probabilistic analysis of damages. 2. Calculation of damages associated with each return period. 3. Calculation of the benefit as the difference in risk between the two scenarios (with and without the ecosystems). 4. Calculation of Annual Expected Damages and Benefits (integrating the probability of each storm).

The Reef & Beach Resilience and Insurance Fund

The fund features the first-ever insurance policy on nature—a stretch of coral reef and beach—based on its protective service— that will pay out to repair and restore the reef in the event of a major storm.

The fund is designed to bring new private capital to coral reef and beach protection and restoration—and demonstrate a replicable way to monetize the protective services of the reef to the tourism and hotel sectors of Cancún and Puerto Morelos, Mexico—through a public-private collaboration.

PARTNERSHIP WITH THE INSURANCE INDUSTRY NOW ALLOWS US TO MEASURE HOW MUCH RISK A REEF CAN REDUCE.

An estimated 840 million people around the world live with the risk of coastal flooding, and the health of their economies is directly related to the health of their coastal ecosystems.

HOW THE FUND WORKS

- Pay the premium to buy a parametric insurance policy on a designated stretch of reef and beach.
- Act as "self-insurance" when the beach and reef are damaged by a storm but the policy trigger is not met and there is no payout.
- Pay for the science-based restoration and maintenance that ensures the health of the reef and the beach.

KEY PLAYERS

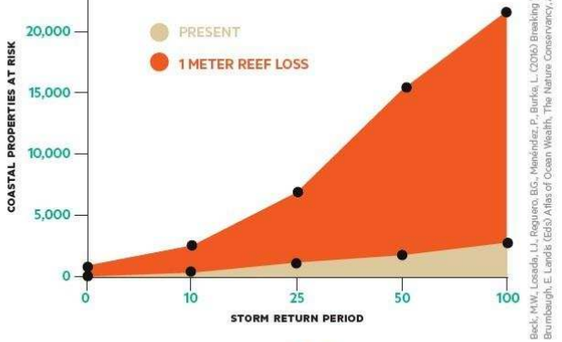
- Hotel Owners Association
- State of Quintana Roo, Mexico
- The Nature Conservancy

For more information visit us at www.nature.org/insuringnature

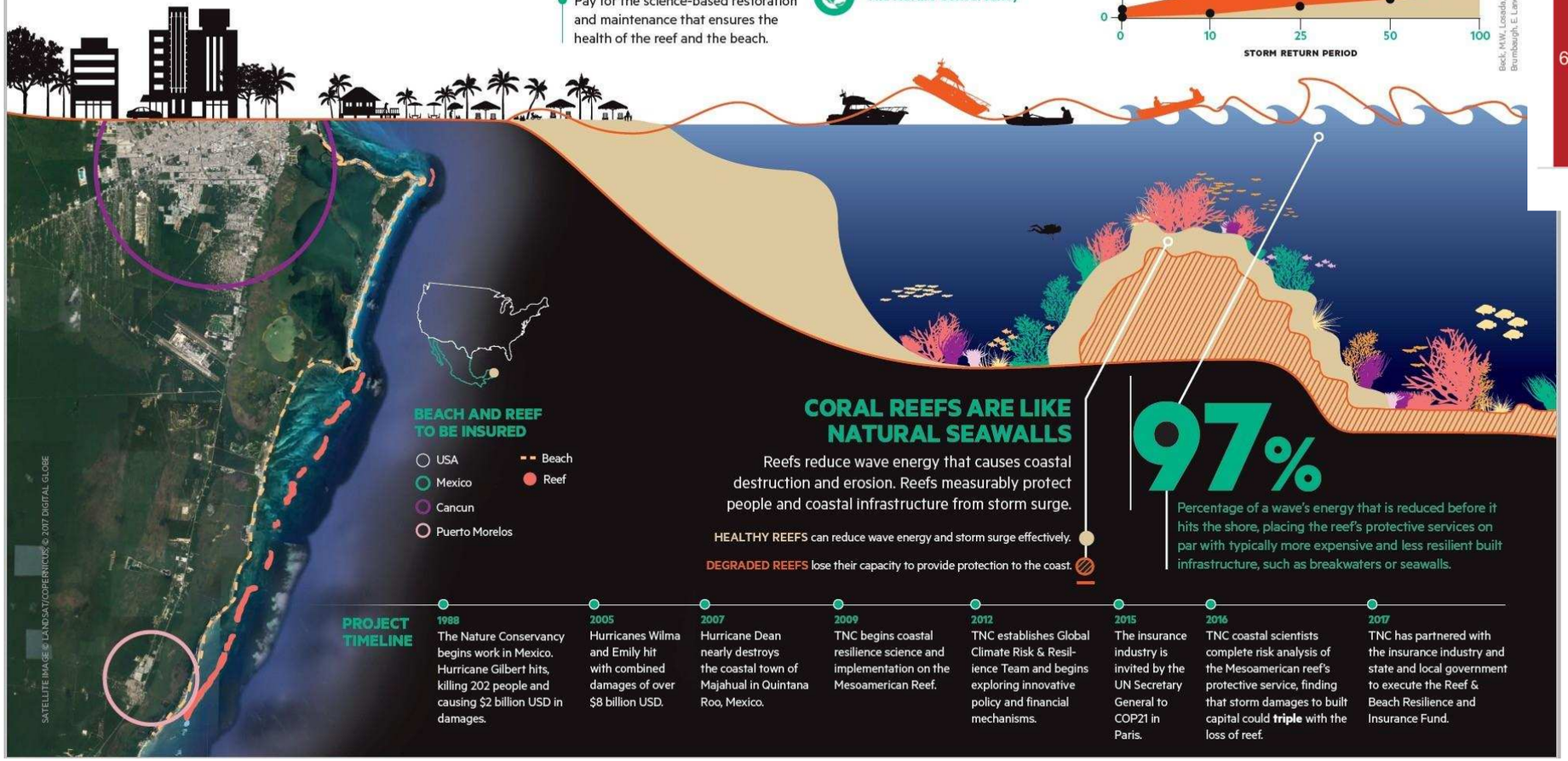
The Nature Conservancy

FLOODING IMPACTS ON COASTAL PROPERTIES

Preliminary studies show that a one-meter loss of reef height would translate into 1,300 square kilometers of inland flooding and $20 billion in lost infrastructure, imperiling the lives and livelihoods of vulnerable people.



Beck, M.W., Losada, I.J., Reguero, B.G., Menéndez, P., Burks, L. (2016) Breaking Waves. M. Spalding, R. Brumbaugh, E. Landis (Eds) Atlas of Ocean Wealth. The Nature Conservancy, Arlington, VA



BEACH AND REEF TO BE INSURED

- USA
- Mexico
- Cancun
- Puerto Morelos
- Beach
- Reef

CORAL REEFS ARE LIKE NATURAL SEAWALLS

Reefs reduce wave energy that causes coastal destruction and erosion. Reefs measurably protect people and coastal infrastructure from storm surge.

HEALTHY REEFS can reduce wave energy and storm surge effectively.

DEGRADED REEFS lose their capacity to provide protection to the coast.

97%

Percentage of a wave's energy that is reduced before it hits the shore, placing the reef's protective services on par with typically more expensive and less resilient built infrastructure, such as breakwaters or seawalls.

PROJECT TIMELINE

1988 The Nature Conservancy begins work in Mexico. Hurricane Gilbert hits, killing 202 people and causing $2 billion USD in damages.

2005 Hurricanes Wilma and Emily hit with combined damages of over $8 billion USD.

2007 Hurricane Dean nearly destroys the coastal town of Majahual in Quintana Roo, Mexico.

2009 TNC begins coastal resilience science and implementation on the Mesoamerican Reef.

2012 TNC establishes Global Climate Risk & Resilience Team and begins exploring innovative policy and financial mechanisms.

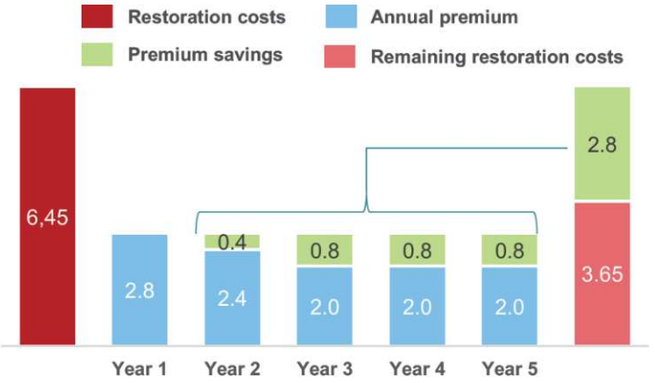
2015 The insurance industry is invited by the UN Secretary General to COP21 in Paris.

2016 TNC coastal scientists complete risk analysis of the Mesoamerican reef's protective service, finding that storm damages to built capital could **triple** with the loss of reef.

2017 TNC has partnered with the insurance industry and state and local government to execute the Reef & Beach Resilience and Insurance Fund.

Swiss Re

Insurance premium development ($m)



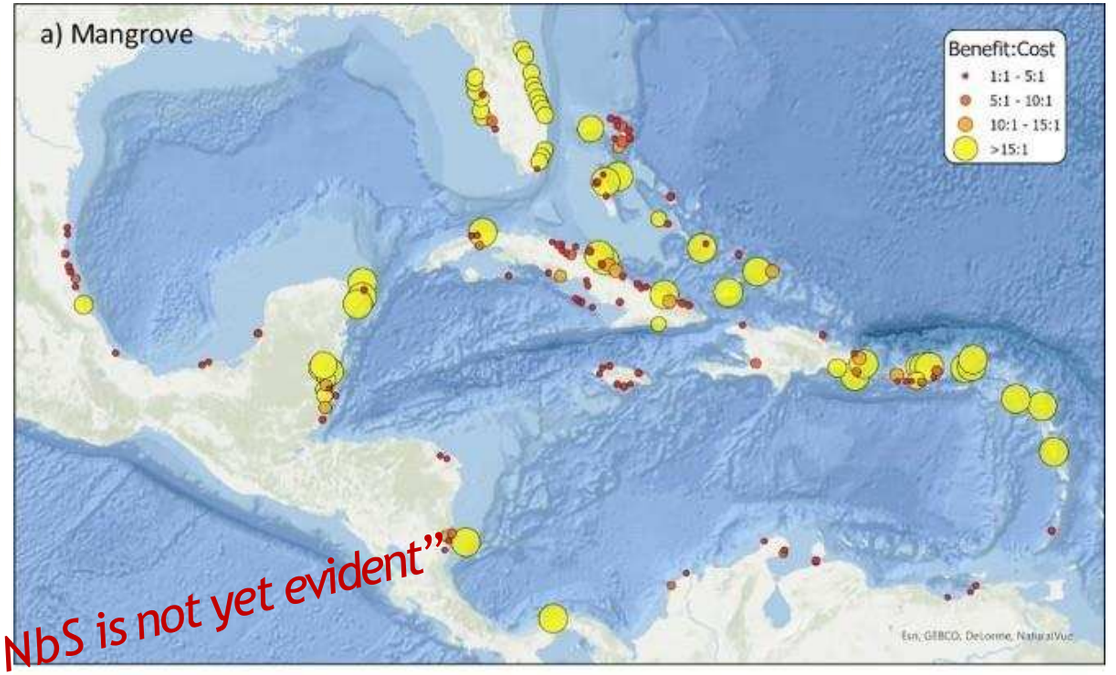
AN INSURANCE FOR CORAL REEFS

Ecosystem Services
Volume 56, August 2022, 101440

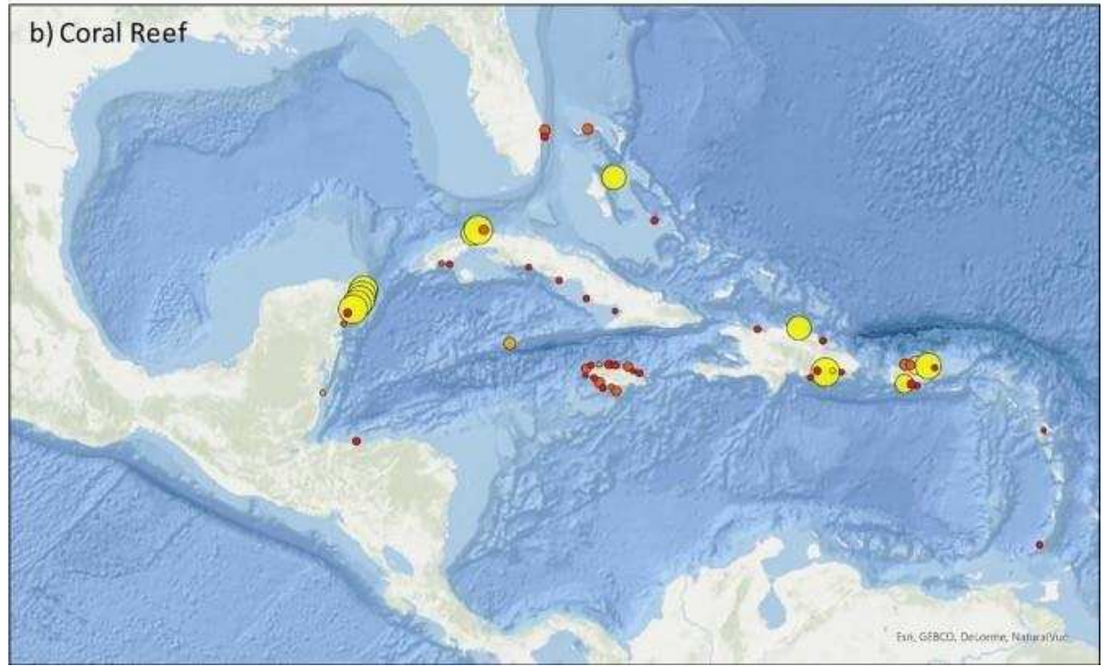
Short Communication

Return on investment for mangrove and reef flood protection

Michael W. Beck [a], Nadine Heck [a b], Siddharth Narayan [a b], Pelayo Menéndez [a c], Borja G. Reguero [a], Stephan Bitterwolf [a], Saul Torres-Ortega [c], Glenn-Marie Lange [d], Kerstin Pfliegner [e], Valerie Pietsch McNulty [f], Iñigo J. Losada [c]



"The return on investment on NbS is not yet evident"



Benefit to Cost Ratios (B:C) for a) Mangrove and b) Coral Reef restoration across the Caribbean estimated using a 30-year project life with a 4% discount rate. Results are summarized in 20-km coastal study units. Circle sizes and colors indicate B:C ratios.

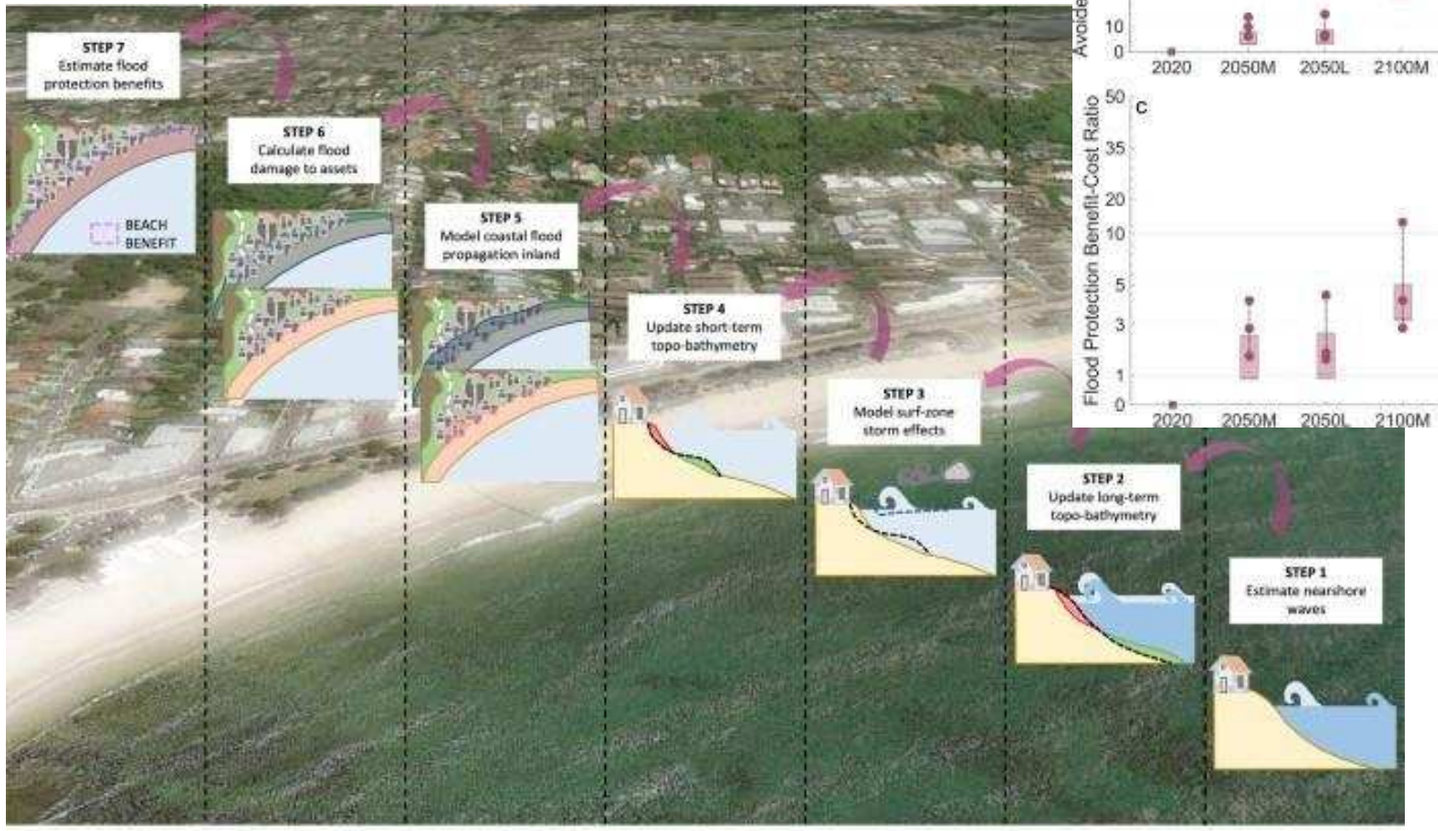
"The return on investment on NbS is not yet evident"

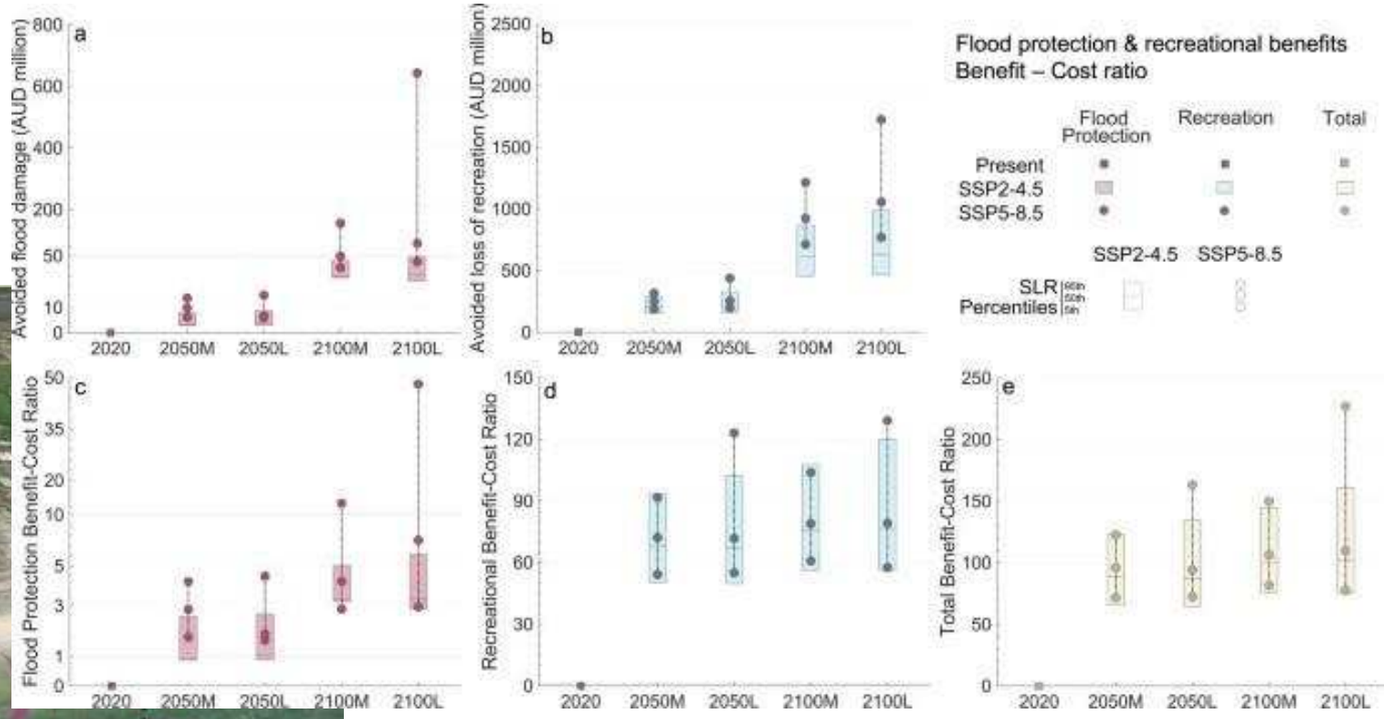
Article | Open access | Published: 12 June 2023

Demonstrating the value of beaches for adaptation to future coastal flood risk

Alexandra Toimil ✉, Iñigo J. Losada, Moisés Álvarez-Cuesta & Gonéri Le Cozannet

Nature Communications **14**, Article number: 3474 (2023) | Cite this article





This assessment includes adaptive management allowing shoreline time variability

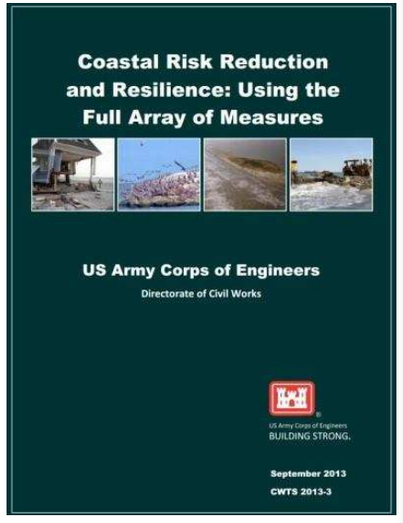
Essential for NbS

4

NbS PROJECT LIFE CYCLE: CHALLENGES

DRAFT - DO NOT DISTRIBUTE

Use of Natural and Nature-Based Features in Coastal Systems March 2014



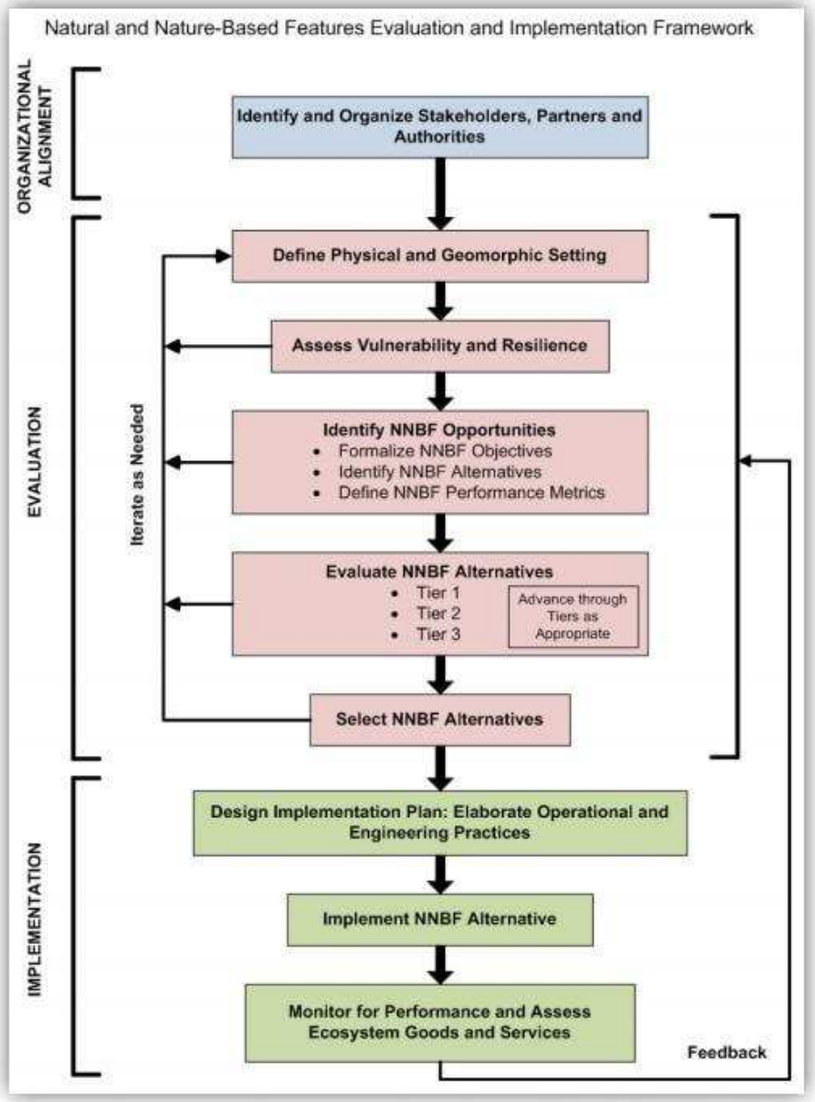
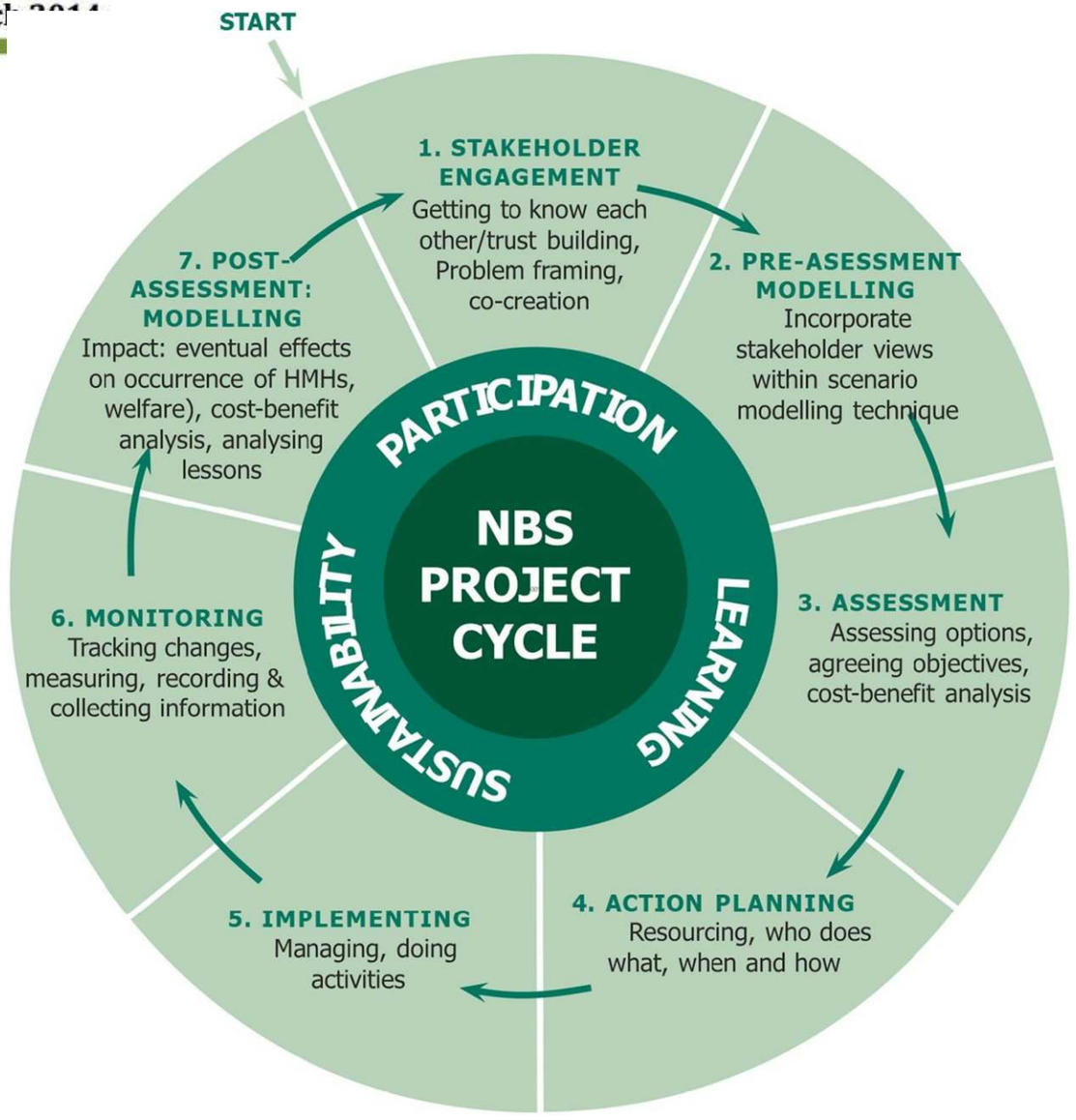


Figure 0-1. Natural and nature-based features evaluation implementation framework.



Source: Kumar et al. (2021)

Recommended steps or activities to be carried out throughout the lifecycle of a NbS project,

Activities	Phase of application
ES appraisal and ecosystem assessment.	All phases
Multi-stakeholder participatory process.	All phases
Identification of target sites, understanding of the geographical context, and definition of project goals.	Pre-implementation
Problem framing, risk identification and scenario modelling/simulation.	Pre-implementation
Development of the strategy and NbS measures (use of specific modelling methods and tools).	Pre-implementation
Preliminary cost-benefit analysis (CBA) and consideration of alternatives.	Pre-implementation
Multi-criteria decision analysis (MCDA).	Pre-implementation
Impact evaluation and performance assessment.	Post-implementation
Post-implementation CBA.	Post-implementation
Analysis of learned lessons.	Post-implementation

Source: i-SANA GROUP, IHCANTABRIA (2023)

The OPERANDUM approach- Open Air Laboratories (OALs)

Co-creation of NbS: different parties come together in order to create a mutually beneficial outcome. It implies the continuous exchange of knowledge in a recursive or iterative process.

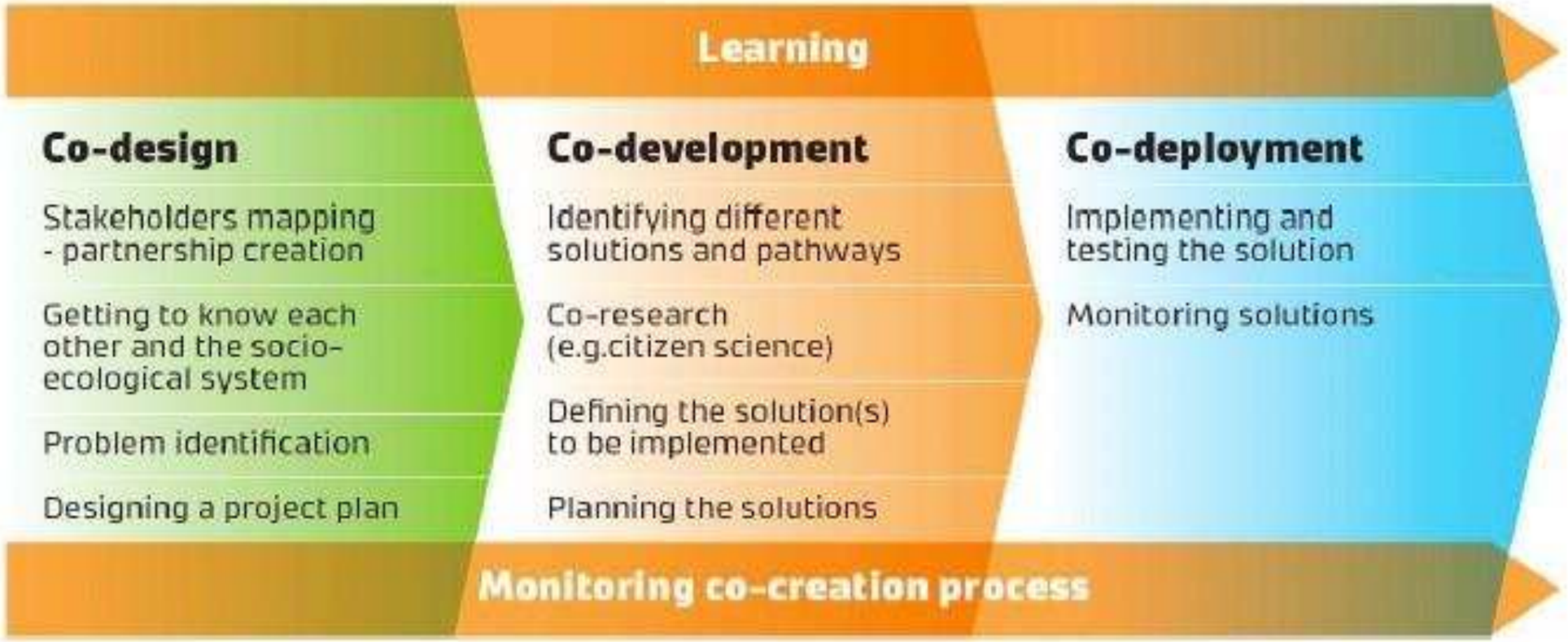


Figure 12: Co-creation in OPERANDUM.

Source: OPERANDUM PROJECT (2021)

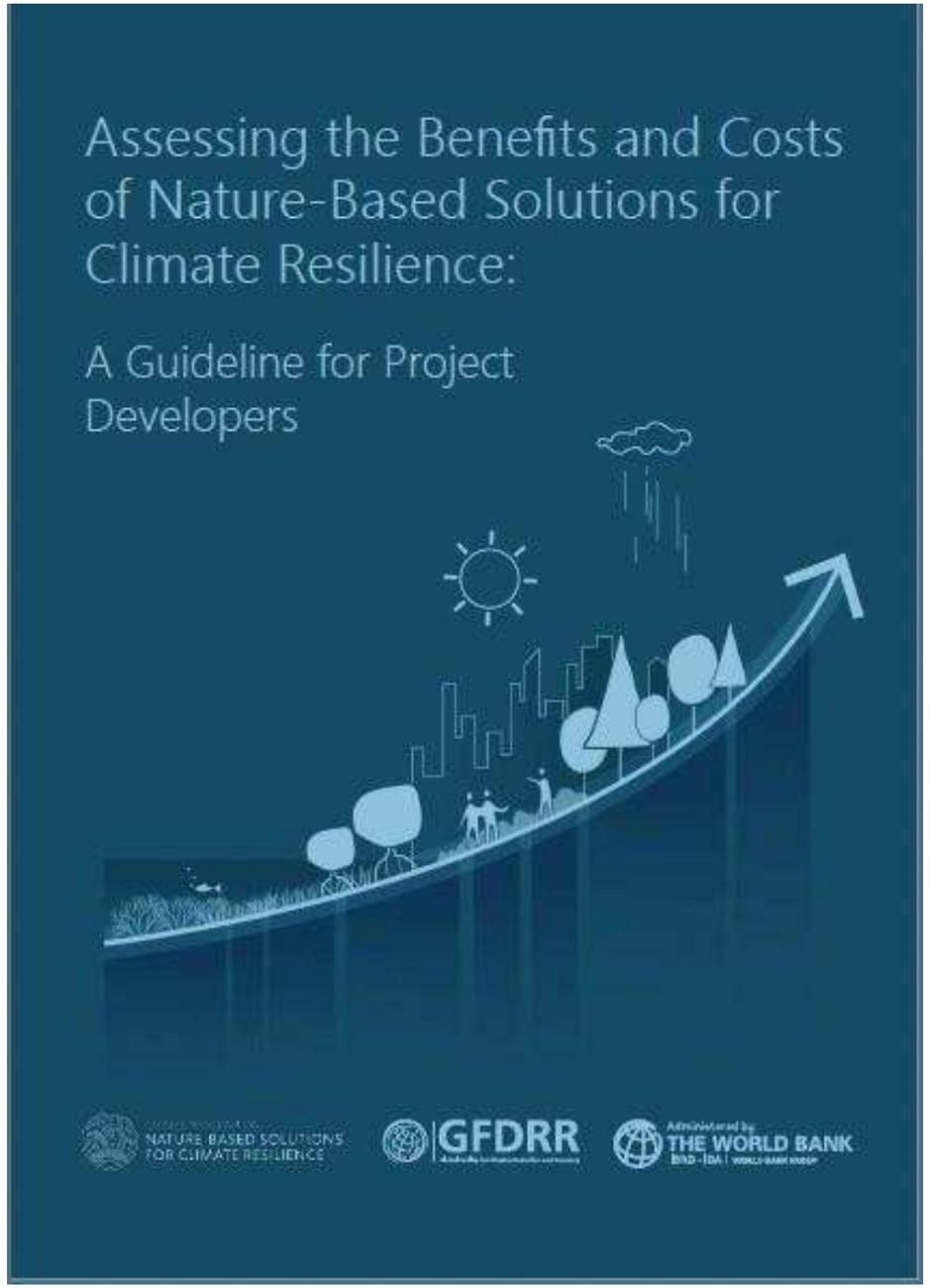
The OPERANDUM approach- Open Air Laboratories (OALs)

Co-design: a process where the problem and the target area is identified as well as the stakeholders, their aspirations, shared values or common interests and aims regarding the project and the target area.

Co-development: In this phase by using the variety of expertise and knowledge of the group potential solutions for the problem are jointly developed and with the help of some research if needed.

Co-deployment: In this phase, the solutions will be implemented and monitoring of the solutions will be established. The monitoring, as well, can be conducted with the stakeholders.

Monitoring: Monitoring is an essential part of the co-creation. It can focus on the outputs/outcomes of the processes (NBS) as well as the process itself. It shapes the way the process is structured and resourced ensuring that it is reflective and adaptive as much as it is generative. Monitoring and associated assessment is also an important element for learning.



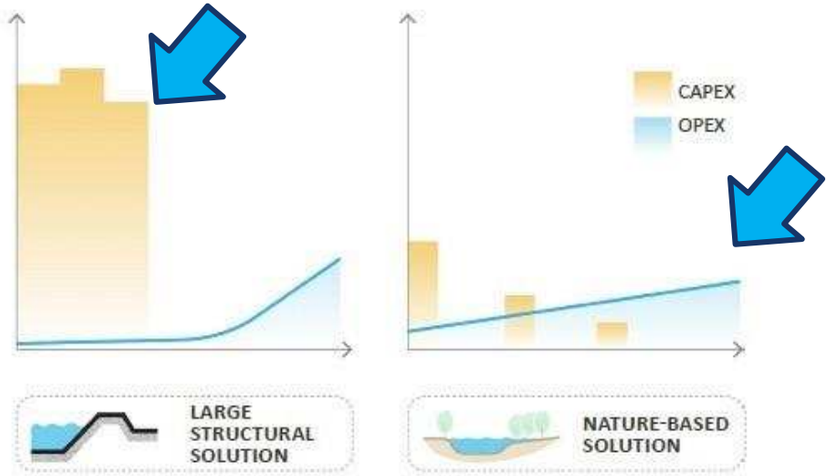
(2023)

Table 3-3. NBS cost components

CAPEX	OPEX	Transaction costs	Opportunity costs [a]	Disservices
- Design and planning - Securing permits - Land acquisition - Community resettlement - Site preparation - Construction - Tree planting	- Monitoring labor and technology - Tree and vegetation maintenance - Invasive species removal - Land use (for example, rent or other payments to landowners) - Land protection, including managing and controlling access	- Scoping studies and other technical assistance - Community engagement / stakeholder outreach - Goal setting and prioritization	- Value of using land for other purposes such as agriculture or residential/ commercial development - Opportunity cost of local labor and materials used for implementing the NBS project	- Negative impacts from NBS (for example, mosquitoes, pests)

Source: Original table for this publication.
Note: CAPEX = capital expenditures; NBS = nature-based solutions; OPEX = operating expenses.
a. Avoid double counting between opportunity cost and CAPEX/OPEX cost components. For example, do not include land acquisition costs in CAPEX and the opportunity cost of land.

Figure 3-2. Illustrative cost and benefit timelines for NBS and gray infrastructure solutions



Source: Adapted from **Wishart et al. 2021.**

Costs are still unknown for the full lifecyle

Lack of evidence and meaningless w/o considering performance

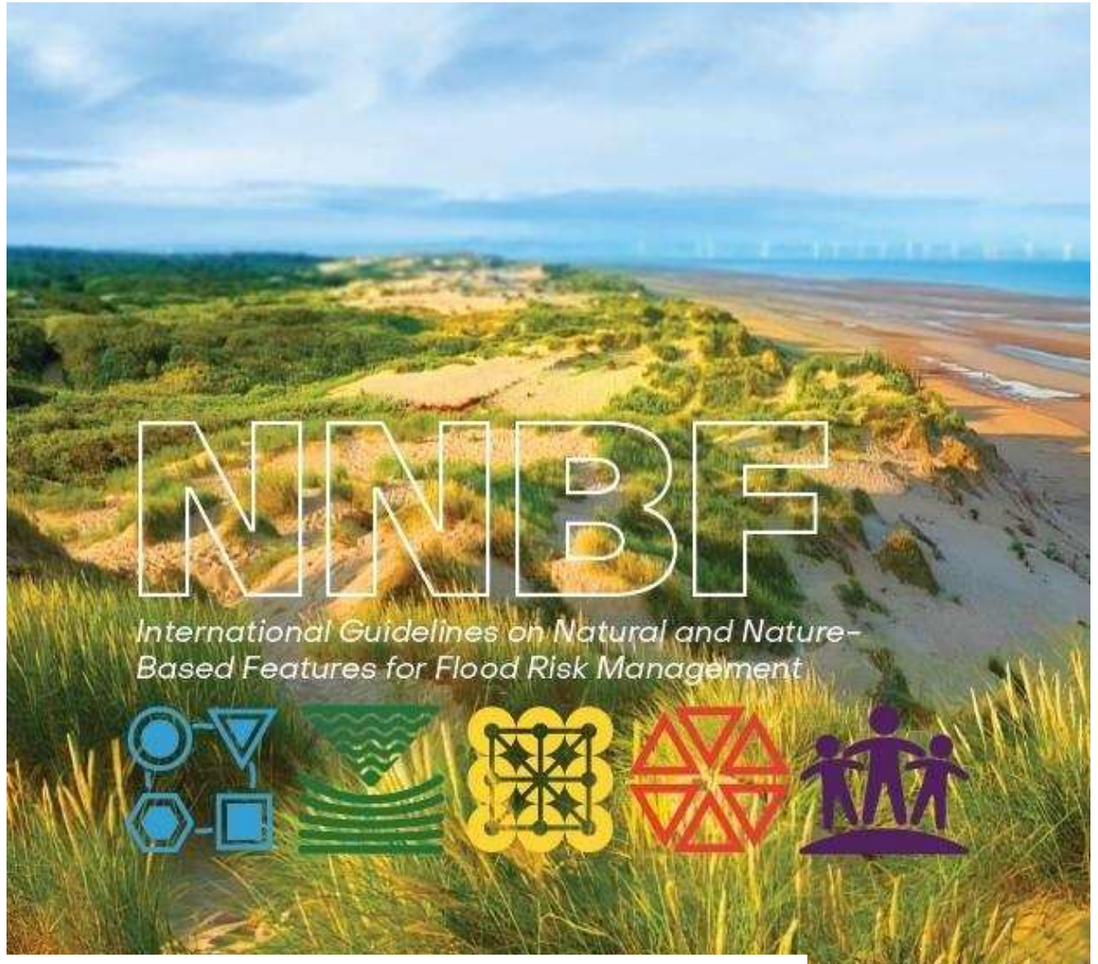


Figure 5.1. *SPRC Model for NNBF with Connections to Performance Categories and Metrics*

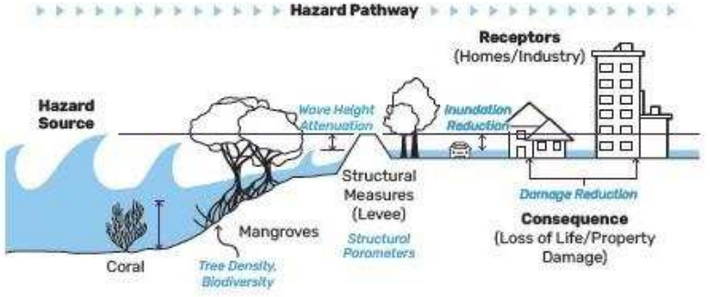
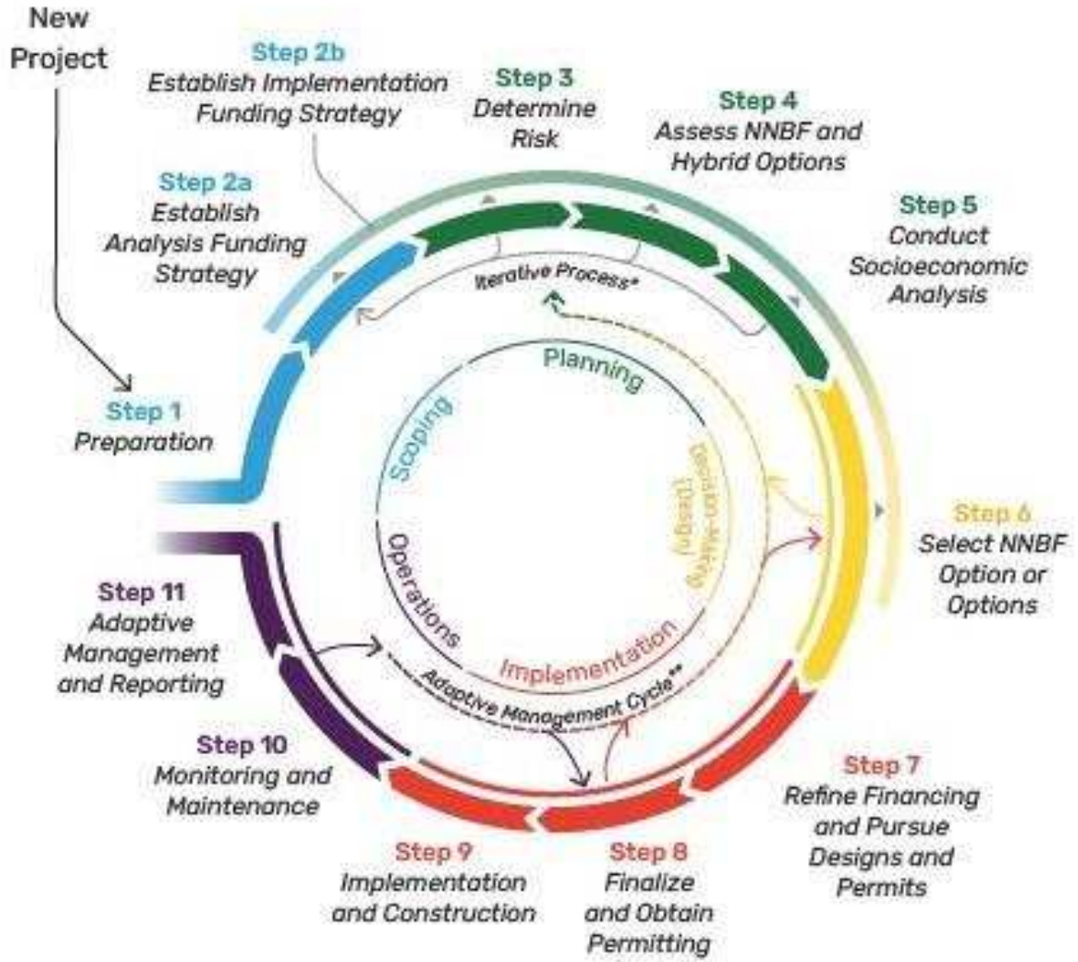


Figure 2.3. *Framework Phases and Their Corresponding Steps in Undertaking NNBF Projects*



*Iterative process to identify practical and preferred NNBF options

**Adaptive management cycle that supports practical and preferred NNBF options

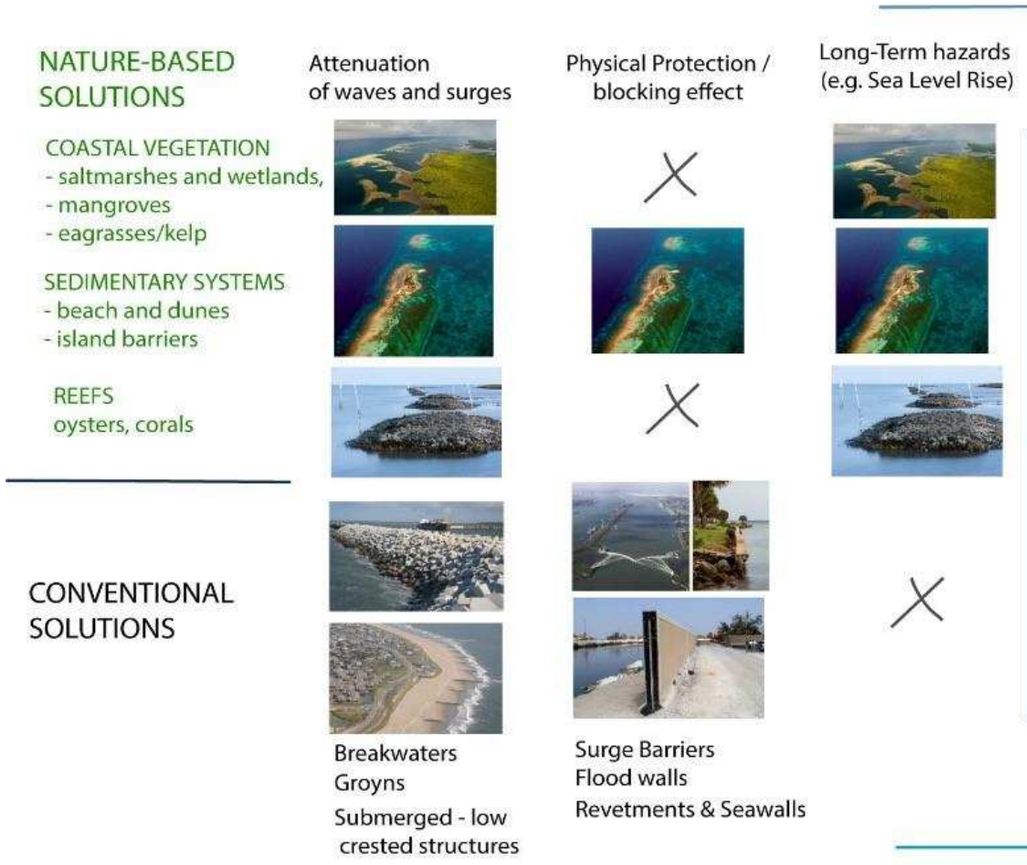
(2021)

NBS vs Grey: An engineering perspective

Can we establish a parallelism between conventional engineering and the design, implementation and maintenance of NBS for DRR and CCA applications ?

NBS vs Grey: An engineering perspective

NATURE-BASED SOLUTIONS	Reduces Vulnerability	by	- Providing co-benefits - Increasing coping capacity and resilience
CONVENTIONAL SOLUTIONS	Increases Vulnerability	by	- Decreasing incentive for adaptation - Decreasing perceived risk and awareness



NATURE-BASED SOLUTIONS	Reduces Exposure	by	- Creating a Green buffer effect, restrains development
CONVENTIONAL SOLUTIONS	Increases Exposure	by	- Incentivates development in hazard prone areas

Reguero, van Wesenbeeck, Losada et al. (in prep.)

NBS vs Grey: An engineering perspective

- TIME / DESIGN LIFE: Engineered structures have a design life, typically 20–50 years, and are built for design environmental, climatic, and anthropogenic conditions over that period.

- TIME / PERFORMANCE: Ecosystems remain in place for much longer periods of time depending on climate and human drivers. How do we measure the variability of the expected service over time, especially during the expected service life of our NBS or hybrid solution?

- BOUNCE-BACK: A major difference between NBS and conventional engineered structures is that ecosystems are highly dynamic and **may** be able to recover and regenerate following damage, (i.e. "bounce back"). Engineered structures do require human intervention for maintenance and repair after damage.

- SPACE : Coastal ecosystems influence – and are influenced by – processes acting at spatial scales that are typically larger than an engineering structure. Design and management at the landscape scale (integrally to the coastal processes involved)

NBS vs Grey: An engineering perspective

Reguero, van Wesenbeeck, Losada et al. (in prep.)

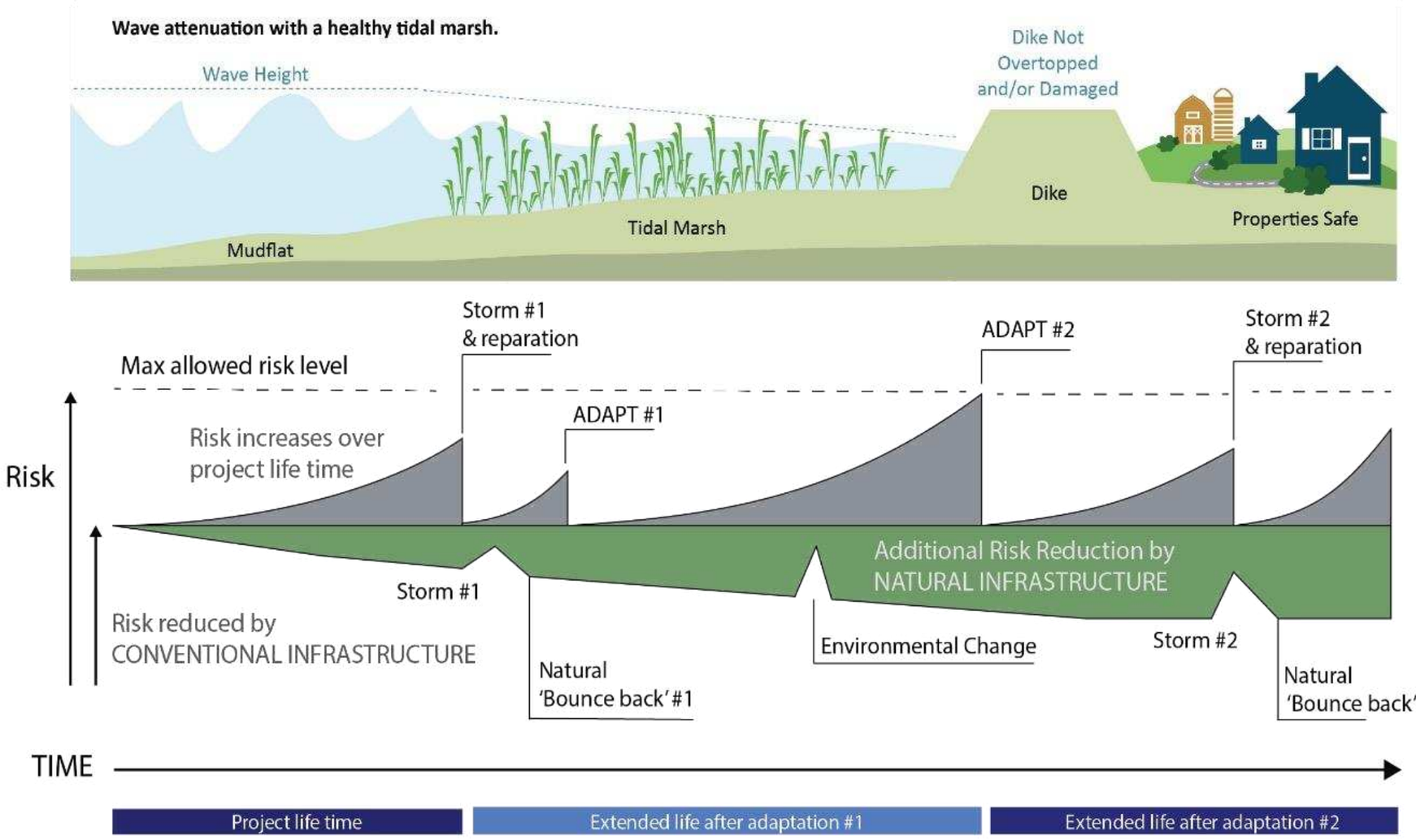
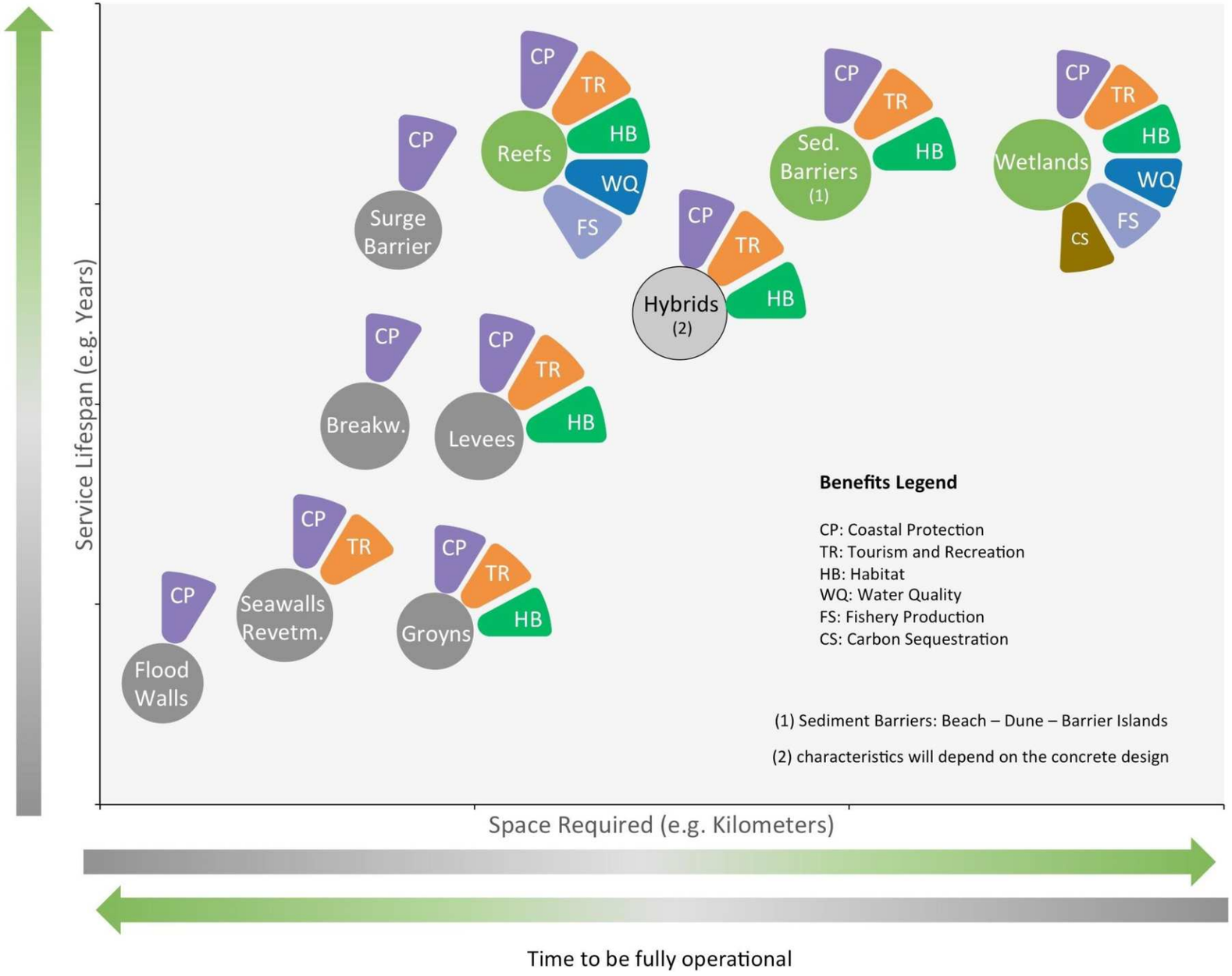


Figure 4. Integrating green and gray in climate risk adaptation. Risk changes over time; Conventional defenses can reduce much of this risk, but their effectiveness deteriorates over time (gray shading), which requires planning maintenance and upgrades. Nature-based solutions can supplement these conventional measures by increasing performance gradually and recovering after damaging events, although eventual stressors can impact their performance

Moving from conceptual to real life needs proof of concept and reliable evidence

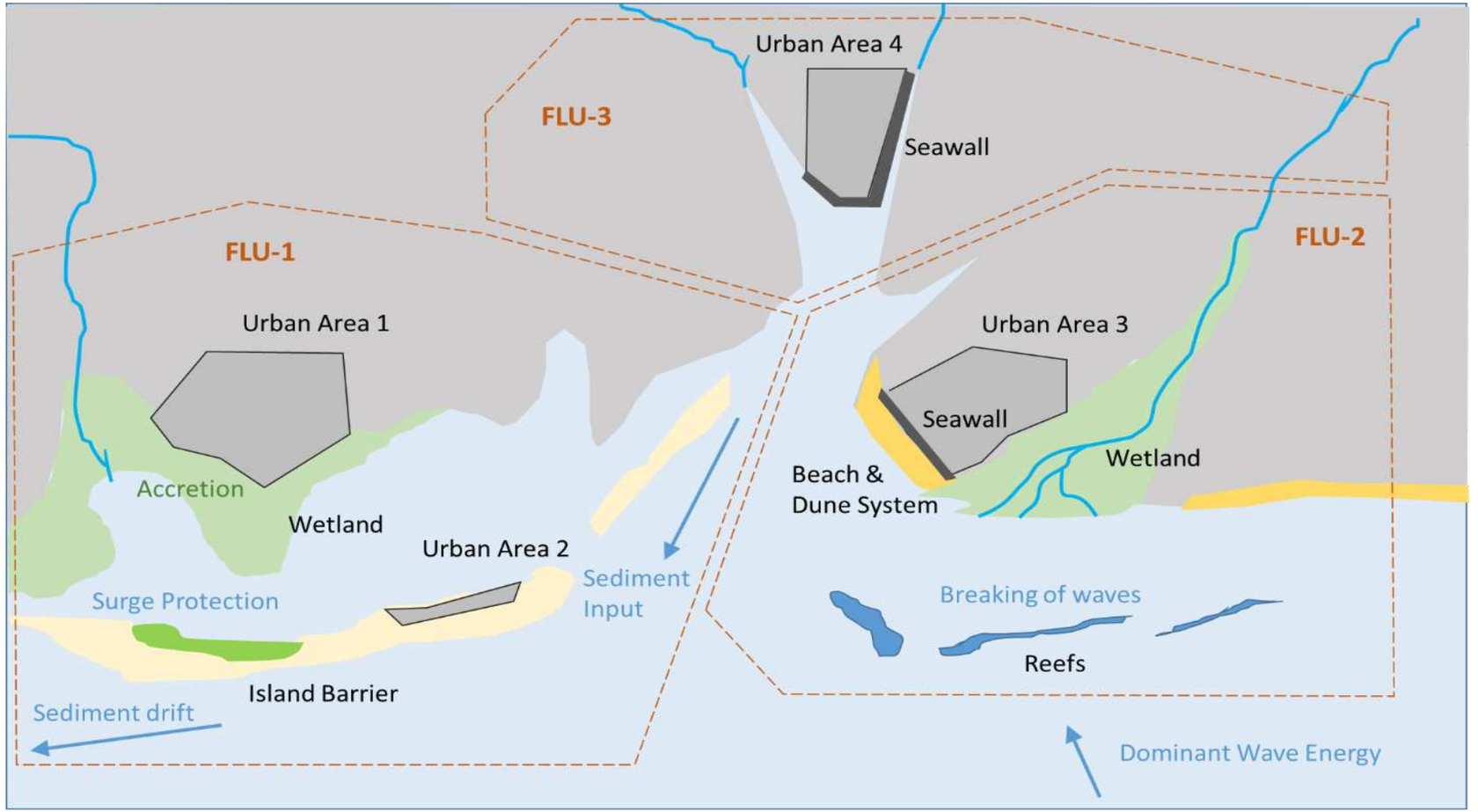
Co-benefits and externalities is a competitive advantage but only if quantified/valued

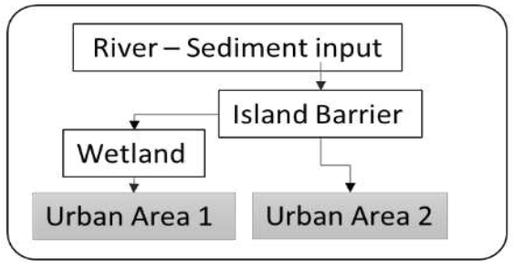


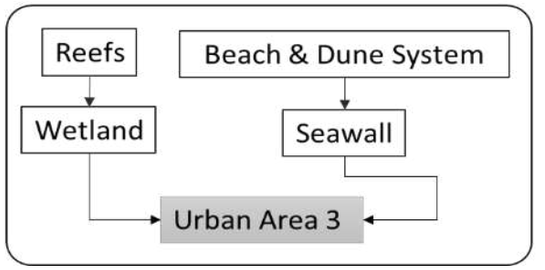
Services and differences of CI and NI for coastal protection. The different coastal defenses typologies vary by spatial and temporal scales, but also by the co-benefits they provide. Services (in colors) are represented for different types of Natural and Conventional Infrastructure across space requirements (x-axis) and service duration or lifespan (y-axis).

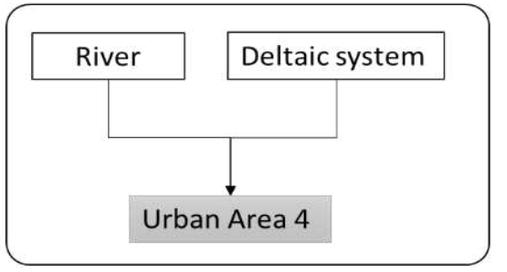
Reguero, van Wesenbeeck, Losada et al. (in prep.)

Co-benefits and externalities are a competitive advantage of NbS but only assessed at the proper scales and interconnections (systemic approach to coastal resilience)









Landscape Functional Units (FLUs) partition of the coastal zone. Coastal resilience should be built from interconnected elements (green and/or gray) operating at the scale of the physical and ecological processes

Reguero, van Wesenbeeck, Losada et al. (in prep.)

Ecosystem connectivity assessent is essential

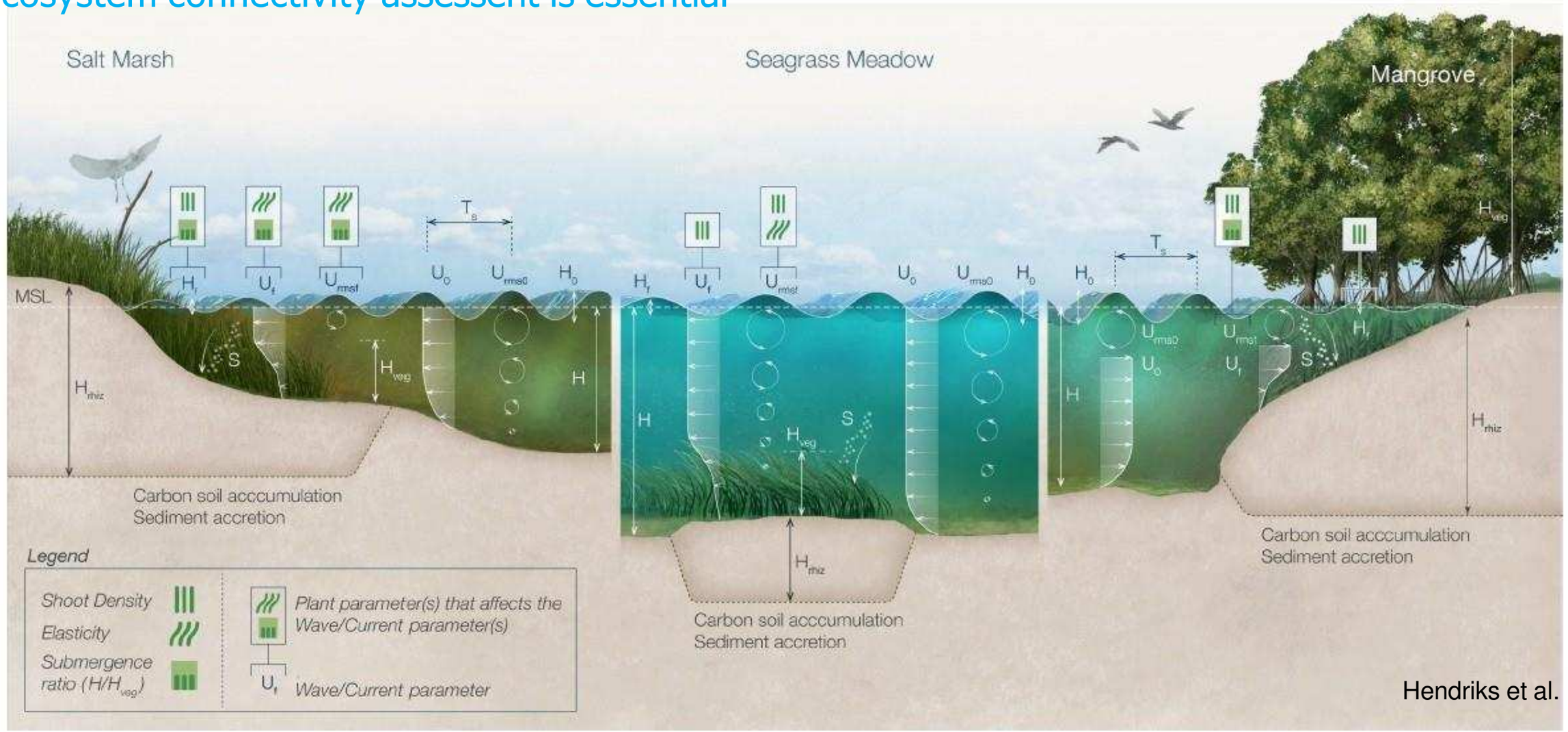


Figure 3. Schematic drawing of the significant influence of vegetation´s structural parameters on hydrodynamics and sediment accretion. Three ecosystems are represented, salt-marshes (left), seagrasses (middle) and mangroves (right) macroalgae are not represented. For each ecosystem (with H_{rhiz}, as depth of rhizomes) significant effects of structural parameters (Shoot density, Elasticity and Submergence ratio H/H_{veg}, Legend: lower left-hand side) on wave or current parameters is displayed and S stands for sedimentation. The addition of 0 denotes the hydrodynamic conditions before entering the vegetation, while f (friction) defines the state after passing the vegetation field. U signifies velocity and H wave height, while the addition rms signals orbital wave conditions)

5

RECOMMENDATIONS

RECOMMENDATIONS

- The use of NBS as part of our portfolio of solutions for coastal resilience is highly context-specific, requiring careful evaluation, planning, project design, construction, maintenance and monitoring.
- There are still important research and methodological gaps that need to be addressed before NBS can be fully operational as part of our solutions portfolio.
- Do not reinvent the wheel. Take advantage of existing guidelines and experience worldwide and adapt it to your needs. Develop multidisciplinary working groups.
- Especially in coastal applications, assess the existing ecosystems and the ones to be implemented as part of a coastal system considering cascading effects and fault trees associated to the relevant ecosystem services.
- Develop demonstration projects for which the full value chain is assessed and covered.
- Without extensive monitoring of existing ecosystems and implemented NbS upscaling and replication will fail.
- Keep an open mind: coastal resilience will depend on a mix of green, grey and hybrid solutions

EUCDs COL01: Nature-based solutions for climate change adaptation in coastal cities and island systems in Colombia

Funded by the European Union

¡MUCHAS GRACIAS!

"The best NBS is the one that already exists"

Iñigo J. Losada

CEMarin Corporation Center of Excellence in Marine Sciences
IH cantabria INSTITUTO DE HIDRÁULICA AMBIENTAL UNIVERSIDAD DE CANTABRIA
ZMT LEIBNIZ-ZENTRUM für Marine Tropenforschung

QUESTIONS