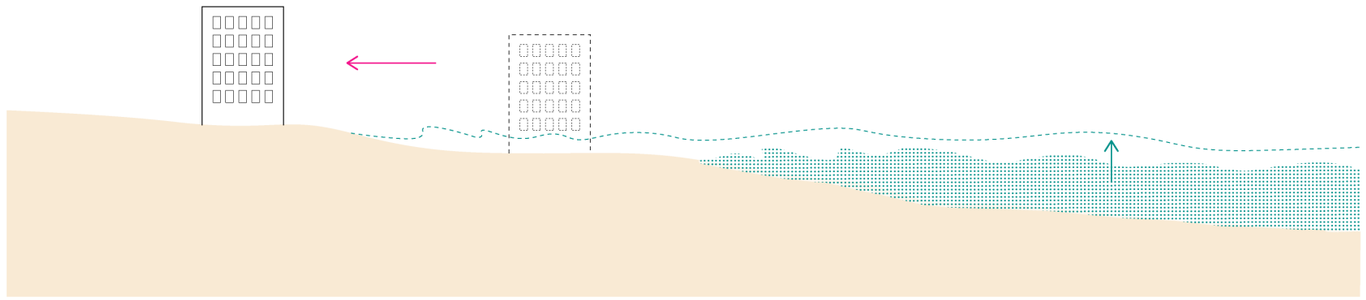
LANDLAB

CATALOGUE OF ADAPTATION MEASURES TO THE EFFECTS OF CLIMATE CHANGE IN THE COASTLINE

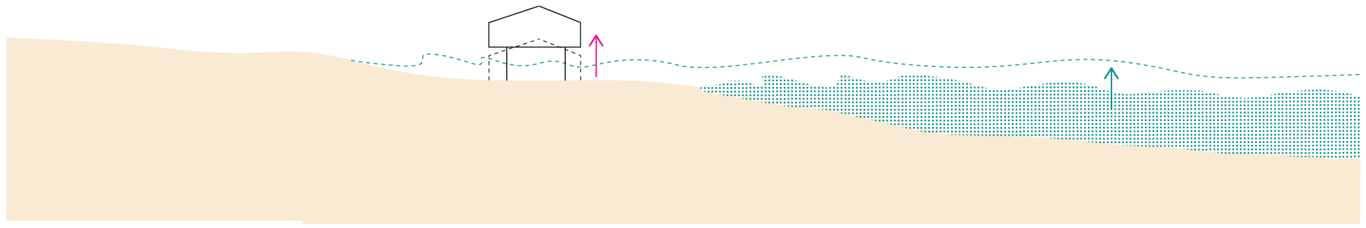
ADAPTA BLUES

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

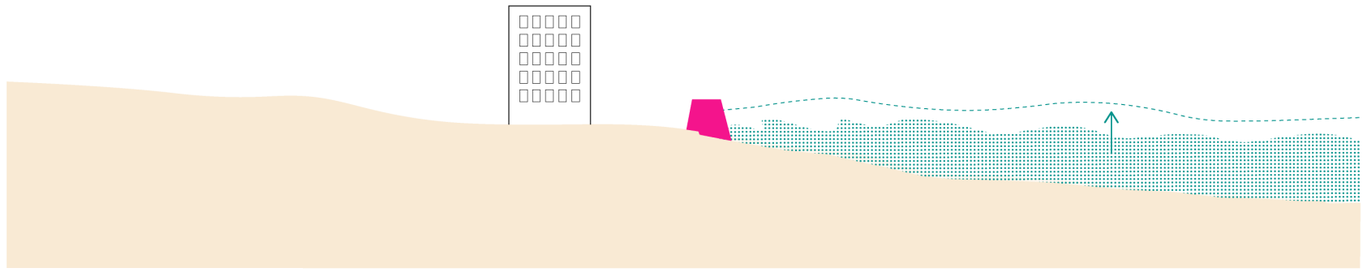
ADAPTATION STRATEGY



Retreat



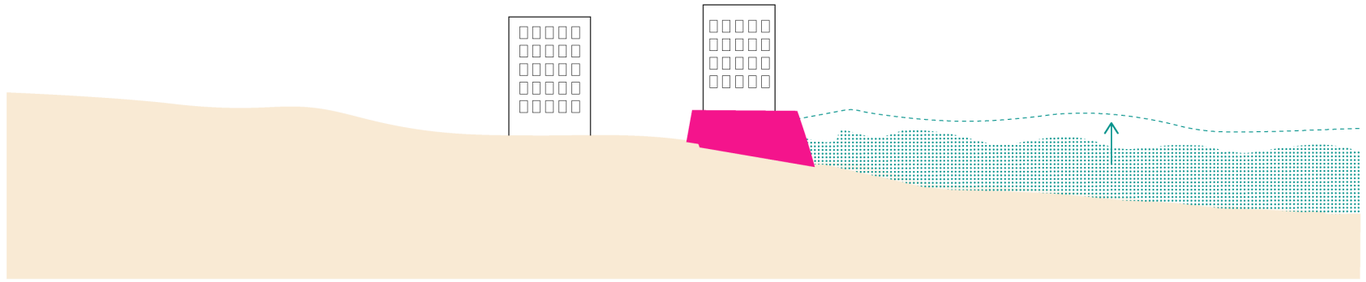
Accommodation



Protection

Hard solution

Soft solution



Move seaward

Development and occupation

MEASURES

ADAPTA BLUES

NAME

descripción

CLIMATE CHANGE ADAPTATION STRATEGIES

AVANCE
Seawards

PROTECCIÓN
Protection

ACOMODACIÓN
Consolidating

RETROCESO
Inland

CLASSIFICATION ACCORDING THE STRUCTURE OF EACH COMPONENT

Strategy and sub-strategy | Natural component | Nature-based component | Structural component | Non-structural component

PROTECTION

The coastal ecosystem has its own natural mehods to protect itself from the water-earth border effects. Due to antropization, ecological weakening, and the growing climate change adaptation threat, it is necessary to reinforce these protections or to generate new ones in when they are completely extinct.

REINFORCEMENT
Those components are the ones that adhere to an existing protection, which is in damaged or has become insufficient.

LIVING SHORELINES
Breakwater designed to allow the settlement of a biological community, incorporating co-benefits such as carbon storage, increased biodiversity and reinforcement of the structure through bioprotection.

TERRACED EDGE
Relatively flat and sloping surface in contact with the sea, which reduces wave activity.

DUNE SYSTEM
Deposits of sand and gravel shaped by wind and waves on the shoreline. It is a flexible, natural protection against erosion and flooding.

BERM
Nearly horizontal shore parallel ridge formed on the beach due to the landward transport of the coarsest fraction of the beach material by the wave uprush.

REINFORCED BANK
Whole or part of bank artificially strengthened for bank protection purposes.

REINFORCED BANK
Whole or part of a river or estuarine bank strengthened with natural materials for bank protection purposes.

REINFORCED CLIFFS
Whole or part of a coastal cliff strengthened with natural materials for bank protection purposes.

TIDE POOLS
An isolated pocket of seawater found in the ocean's intertidal zone.

BARRIER
Structures that protect the continent, lagoons, wetlands and marshlands from the wind, waves adn tidal energy.

DIKE
Manmade structure designed to protect low-lying areas from flooding from the sea or ocean.

SEAWALL
A wall or embankment erected to prevent the sea encroaching on or eroding an area of land.

OYSTER REEFS
Dense aggregations of oysters that form large colonial communities. They function as a natural filter and improve water overloaded with nutrients while acting as a barrier to reduce wave energy, prevent erosion, and fortify wetlands.

EMBANKMENT
An artificial earthen wall, often meant to prevent flooding of the hinterland.

SEAWARDS

This strategy mainly fights against the risk of erosion on the coastline. To face this threat, the coastline is advanced in order to stabilize its profile. Beyond facing danger, the benefit of this strategy is the increase of public space. It is usually used in situations where there is a lack of it.

ADVANCE THE LINE WITH SEDIMENT
Seawards components, mainly with sand or clay, through nourishing or catchment.

SEDIMENT TRAPS
Small ponds placed between the inlet and the main wetland to promote sedimentation of coarse particles before water is distributed through the wetland.

SAND NOURISHMENT
Sand addition to the coastal system to mitigate the consequences of previous erosion.

CHANGES IN GRANULOMETRIC COMPOSITION
Replacement of sands with gravels, pebbles or other sands of larger diameter to increase beach stability.

ADVANCE THE LINE WITH FLORA AND FAUNA
To advance the coastline with new ecosystems or strengthen the existing ones.

MARINE ANGIOSPERMS
Angiosperm communities that increase the available sediment for organism and attenuate water velocity associated with currents and waves

KELP FORESTS
Underwater areas with a high density of brown algae that favor attenuation of current velocity.

ADVANCE THE LINE WITH STRUCTURES
Engineering works into the sea and change coastal dyanmics.

GROYNE
A low wall or sturdy barrier built out into the sea from a beach to check erosion and drifting.

ACCOMMODATION

Through this strategy, the confrontation between land and sea is not so much sought, as the adaptation of this environment to the continuous contact between the different ecosystems. The different measures focus on generating a transition zone on the shoreline where appropriate exchanges can take place and, in this way, improve the resilience of the whole.

LAND SPONGE
Set of measures to increase the filtering capacity of the land near the coast.

COASTAL PARK
Public park designed as a protection area against maritime flooding with recreational and educational uses.

SEA REGRESSION AREA
Land reserve to mitigate the coastal regression caused by the sea level rise and storms.

FLOODING PROTECTION AREA
Protected area, free of infraestructures, designed to mitigate the coastal regression caused by sea level rise and or storms.

STRATEGICAL INTERVENTIONS ON URBAN SERVICES
Water management and urban planning techniques that aim to imitate hydrological processes in urban development by controlling runoff in the urban landscape.

RISING
Components intended to raise elements and areas of the coast that need to be protected from flooding.

ARTIFICIAL BEACH
A man-made beach designed as a sand surface on an elevated area free of the effects of flooding.

RIVERS AND ESTUARIES
Works on fluvial areas near the coast to improve its interaction with the sea.

FLOOD GATES
Control of water flows in channels by hydraulic mechanical devices.

LANDCLAIM RECOVERY
Removal of fill material to restore the shoreline and coastal habitats.

MOUTH REGENERATION
Removal of channelizations at river mouths to recover floodplains.

SALTMARSH REGENERATION
Restoration of coastal wetlands by saltmarsh communities to improve the ecosystem services of flood control and filter water.

WETLAND REGENERATION
Restoration of wetlands dominated by herbaceous communities, that form a transition between aquatic and terrestrial ecosystems.

FLORA AND FAUNA CONSERVATION
Conservation programs to protect habitats that act as regulators of the effects of climate change (erosion, flooding, saline intrusion, etc.).

RETREAT

Measures, mainly urban and territorial planning, that seek to create a safe space for flooding and protect assets by reducing exposure by setting them back.

RIVERS AND ESTUARIES
Works on fluvial areas near the coast to improve its interaction with the sea.

ASSET RELOCATION
Relocation of existing infrastructure, assets and/or real estate to a new place that is not currently at risk.

PLANNED REALIGNMENT
Procedures for creating a new position for the coastline through engineering.

NON-STRUCTURAL

They consist of a series of physical and programmatic policies designed according to the needs of a community and the level of risk to which it is exposed. Their main goal is minimizing it and improving coastal resilience. These types of programs seek to avoid uncomscious development and help the population prepare against floods.

EARLY WARNING SYSTEMS
A warning system that can be implemented as a chain of information communication systems and comprises event detection and decision subsystems for early identification of hazards (in time to minimize the effects of the event)

RISK TRANSFER MESAURES
Development of communication tools about the risk on the coastal area

MEDIA TRAINING
Development of training programs in communication about the status and actions on the coast.

RESEARCH ON COASTAL RESILIENCE
Support for projects that investigate new adaptation mechanisms or the improvement of existing ones.

EDUCATION PROGRAMS IN RESILIENCE
Transfer of "know-how" on coastal adaptation in educational programs from kindergarten to university.

REGULATORY

Regulation measures that complement, complete, or partially replace the structural ones include modifications in public policies, management practices, regulatory policies, and tax collection policies.

COASTAL PROTECTION PLAN
Development of a protection plan to preserve the goods and services of the littoral areas.

INSTITUTIONAL AND MANAGEMENT MESAURES
A set of measures to promote coordinated and coherent action in climate change adaptation and risk management on the coast.

MOBILITY MANAGEMENT
Development of an optimal public transportation network to reduce the need for private vehicles. It also includes changes in the mobility of the area.

STRATEGIC RETREAT POLICIES
Management of human settlements and infrastructures to delay their position to safety areas.

SPECIFIC PLANNING SYSTEMS
Development of coastal planning for climate change adaptation and risk prevention.

WATER MANAGEMENT POLICIES
Water cycle planning and management system, both for the water supply and wastewater systems. It includes plans, projects and actions.

MEASURE DESCRIPTION

ADAPTA BLUES

MEASURE	CLAS. LEVEL 2	STATEGY AND FAMILY

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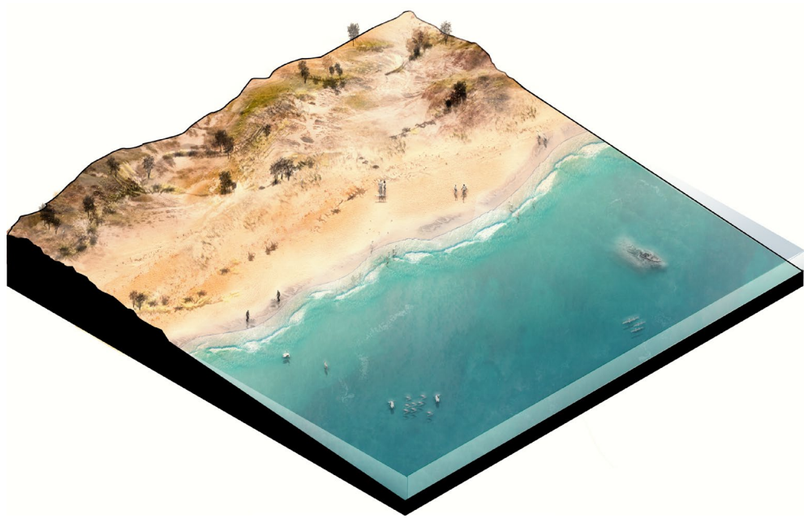
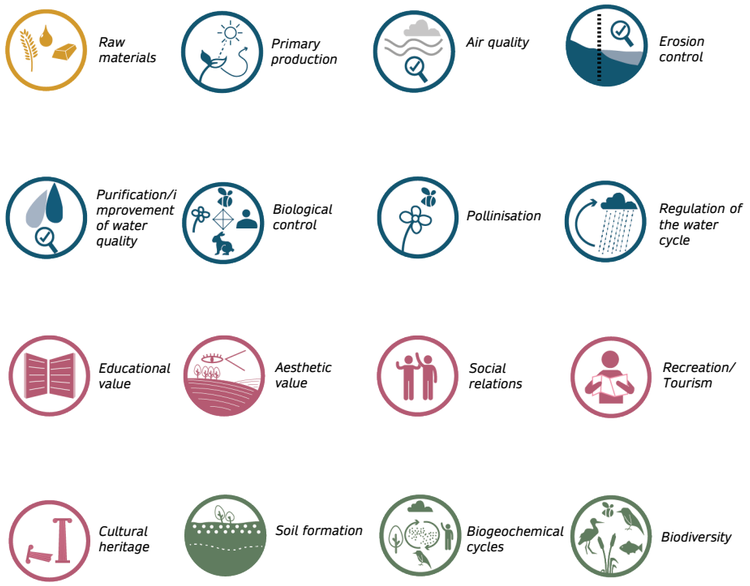
SCALE OF ACTION

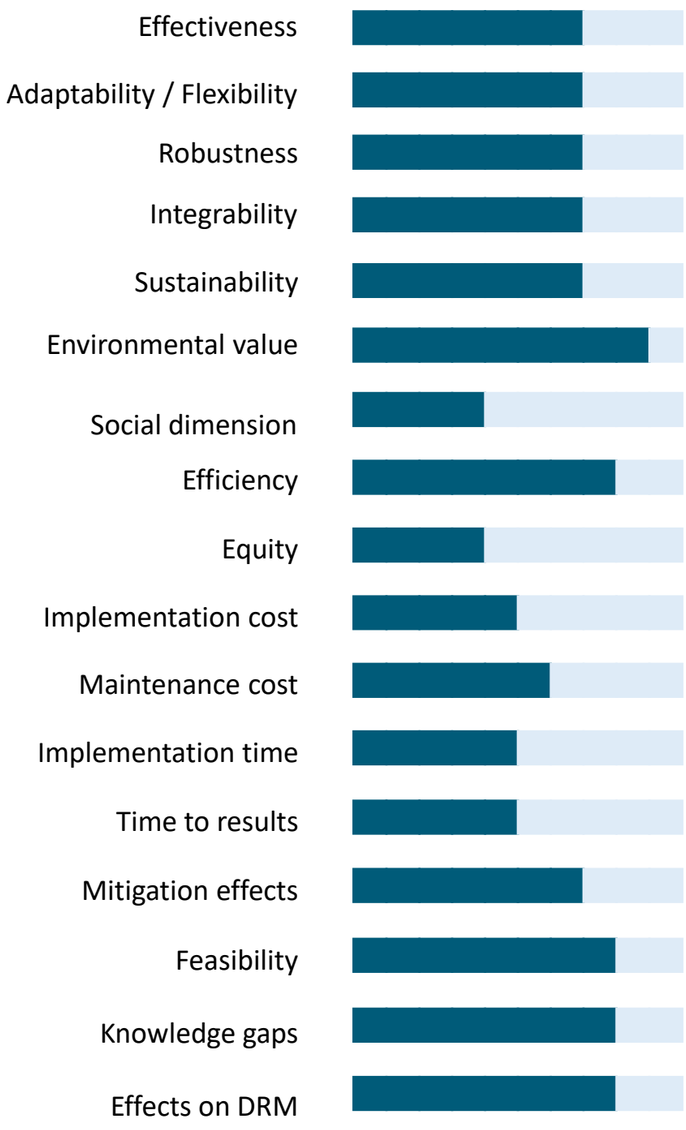
RISK / IMPACT ON THE TARGET



ECOSYSTEM SERVICES



INDICATORS



Captadores de arena en Bogue Banks, Estados Unidos. Source: NOAA

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https://example.com

https://example.com

https://example.com

https://example.com

INDICATORS

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ASSESSMENT CRITERIA

EFFECTIVENESS

Ability to achieve the expected effect. One solution is more effective when the desired results are achieved with greater intensity.

Each strategy is effective depending on the site. On a very wide beach the advance is not effective, but on a beach without sand it may be, if combined with groynes and fill.

ADAPTABILITY / FLEXIBILITY

Ability to accommodate or adjust to circumstances different then those of the design.

A solution is adaptable in the long term when it shows the capacity to evolve into the future. Adaptability is related to the irreversibility of the measure, and to the capacity to allow changes to adjust to the evolution of the problem.

Accommodating measures (warning systems, management, transfer, etc.) are very adaptable, as they do not compromise the long term. Non-regret or win-win measures are adaptive.

If the pH rises, a reef-bio, can adapts to new species coming in, on the other hand, if the swell changes, the measure can maintain some functionality.

Retreat is not adaptive, because the service has already been lost in the retreat zone.

ROBUSTNESS

A solution is more robust when it shows the ability to assume environmental conditions variability.

If the evolution of the climate is different than projected, the measure still solves the problem. If the wave height increases, the measure still maintains its usefulness. Up to what value of the deviation does the measure still work? The measure application should leave us far from its breaking threshold to admit more severe future conditions.

INTEGRABILITY

The more integrable a solution is, the more it is able to be integrated into larger-scale solutions or to be linked to other solutions of any scale.

If a previous plan exists, the measure can be easily integrated. Administratively, the application of the measure does not require the generation of new legislation but fits directly into existing legislation. Hence, it fits in with the existing administrative figures and with the agents involved, who recognise and understand it.

The strategy or measure has already been implemented before and it is already integrated into planning.

Accommodation is easy to integrate, regression is difficult to integrate.

In diked areas, the protection strategy may simply be integrable.

SOCIAL DIMENSION

The social dimension is given by the extension of the social service provided, in the sense of incorporating value of social uses or solving conflict between activities.

EFFICIENCY

The more efficient solution makes a better use of the resources employed.

The solution minimises the combination of efforts made and residual damage (not avoided). Achieves a lot of benefits with little sacrifice (economic, people, assets...). In principle, retreat is not very efficient because the sacrifices can be enormous. However, if the retreat consists of eliminating a road that gives access to a beach, then it may be an admissible measure as it increases its efficiency.

EQUITY

The more equitable a solution is, the more it is able to specifically address the needs of the most disadvantaged groups, minorities, lower income levels, women.

A solution is adaptable in the long term when it shows the capacity to evolve in the future. It has a double vision. On the one hand, to benefit all equally, and on the other hand, to help disadvantaged groups to improve their situation with a view to a balance with wealthier groups or areas (closing the gap).

There may be a measure whose efficiency is not high, but by focusing on helping disadvantaged minorities, its application is relevant, depending on the objective. Equity is related to the socio-economic characteristics of the population in the area. It serves to eliminate the bias of ease of action in wealthy areas. Ease of action appears when only assets at risk are considered.

SUSTAINABILITY

A solution lasts longer when it can be extended over time while maintaining the service it provides.

It has to do with the capacity of the measure taken to physicallydeteriorate. A breakwater can last as long as its useful life because a priori it will not deteriorate. A sand reclamation can fulfil its function for years but in the future it could become unsustainable. This durability can be related to maintenance costs.

ASSESSMENT CRITERIA

IMPLEMENTATION COST

Cost associated with the design and the measure implementation.

It includes all the necessary resources: preliminary studies, materials, implementation if needed, manpower, etc... The lower the implementation cost, the higher this indicator is.

A hard structure will have a high cost associated with its design, materials, construction, etc. On the other hand, a citizen awareness plan, although it can be as complicated as we want it to be, will have a lower cost.

IMPLEMENTATION TIME

This is the time elapsed from the time the measure implementation is decided until it is considered to have been implemented. The higher this indicator is, the shorter the time.

TIME TO RESULTS

The higher this indicator is, the shorter the "time to results".

This is the time that elapses from the time the measure has been implemented until it begins to deliver the service for which it was designed. A grey structure generates protection from the moment of implementation so that this "time to results" is reduced. In contrast, a measure that requires the cultivation of species may take some time until the growth of the species begins to generate the service for which it was designed.

MITIGATION EFFECTS

An adaptation measure has an effect on mitigation when its implementation leads to, increased or reduced greenhouse gases. For example, if the energy needed to implement the measure is obtained through fossil fuels, a mitigation effect will occur. This indicator is higher the more positive effects it has on mitigation. A neutral measure would be at 5/10. Below (1-4) would be detrimental measures and above (6-10) would be beneficial measures. For example, measures based on the conservation and restoration of "plant" communities would be rated above 5 for their carbon sequestration capacity.

MAINTENANCE COST

This is the cost of the measure once it has been implemented. This indicator aims to give a measure of the resources needed to maintain the functional characteristics of the measure. The higher this indicator is, the lower the maintenance cost.

ENVIRONMENTAL VALUE

A solution has a greater environmental value when it creates better environmental conditions for the survival of ecosystems and/or when it generates new ones adapted to local conditions.

TECHNICAL FEASIBILITY

A measure is the more technically feasible the more resources are available for its implementation, such as tools, equipment, skills, expertise, etc. Highly dependent on the context.

SCIENTIFIC KNOWLEDGE GAPS

The knowledge gap refers to the degree of scientific development of the concept underpinning the measure, of previous technical experience of its implementation, and the existence of prototypes or models supporting the usefulness of its application.

It has to do with examples that can be assimilated in other locations, such as with the existence of measures with a similar conceptual basis on which a variation is proposed, etc. This indicator is greater the wider the knowledge gap is.

EFFECTS ON DRM

A measure has a greater effect on DRM the more it contributes in parallel to further improving disaster risk management.

The concepts of CCA and DRM are related and overlap to some extent, in some cases sharing the objectives of reducing present and future risks based on sustainable development. This indicator seeks to measure whether the implementation of the measure can lead to any parallel benefits for disaster management, and the higher and better these benefits are, the greater the indicator is.

PROTECTION MEASURES

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RETREAT

Measures, mainly urban and territorial planning, that seek to create a safe space for flooding and protect assets by reducing exposure by setting them back.

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- **ASSET RELOCATION** — Relocation of existing infrastructure, assets and/or real estate to a new place that is not currently at risk.
- **PLANNED REALIGNMENT** — Procedures for creating a new position for the coastline through engineering.

NON-STRUCTURAL

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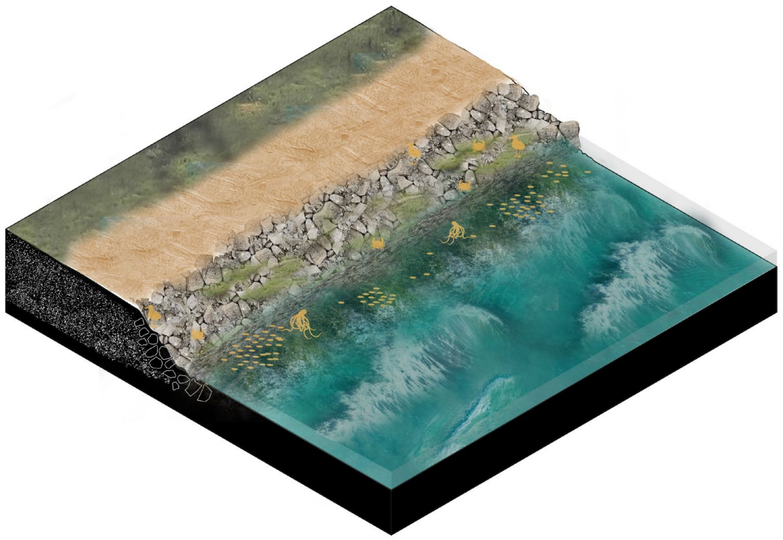
LANDLAB

LIVING SHORELINES

STRUCTURAL EbS

PROTECTION WITH REINFORCEMENT

A living shoreline is a protected, stabilized coastal edge made of natural materials such as plants, sand, or rock. Unlike a concrete seawall or other hard structure, living shorelines grow over time.
Living shorelines incorporate as many natural elements as possible which create more effective buffers in absorbing wave energy and protecting against shoreline erosion



ECOSYSTEM SERVICES

- Raw materials
- Erosion control
- Purification/improvement of water quality
- Regulation of the water cycle
- Educational value
- Biodiversity
- Soil formation
- Biogeochemical cycles

SCALE OF ACTION

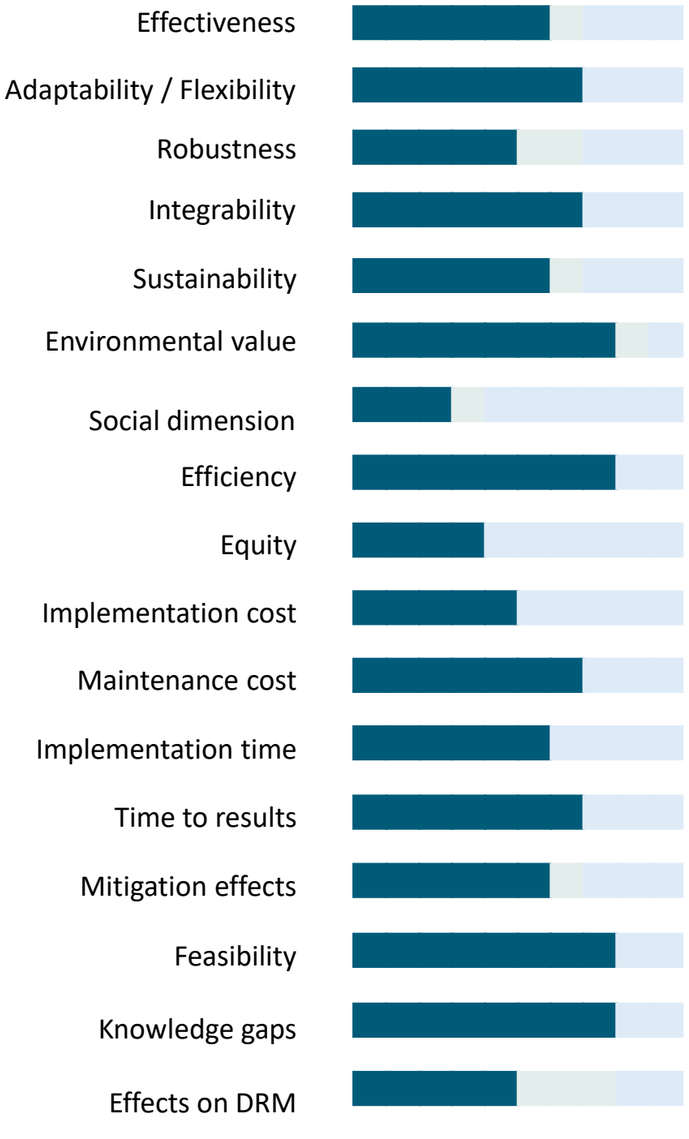
Local

RISK / IMPACT ON THE TARGET

Coastal flooding

Coastal erosion

INDICATORS



Live shorelines in the harbour of Cala Ratjada, Mallorca, Spain. Source: Econcrete Tech.

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https://www.ecoshape.org/en/concepts/creating-rich-revetments/

https://econcretetech.com/projects/port-of-cala-ratjada-breakwater/

https://econcretetech.com/projects/pier-marina-malaga/

TERRACED EDGE

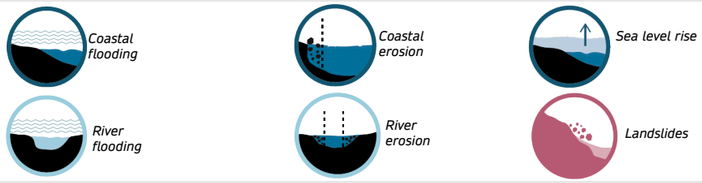
STRUCTURAL GREY

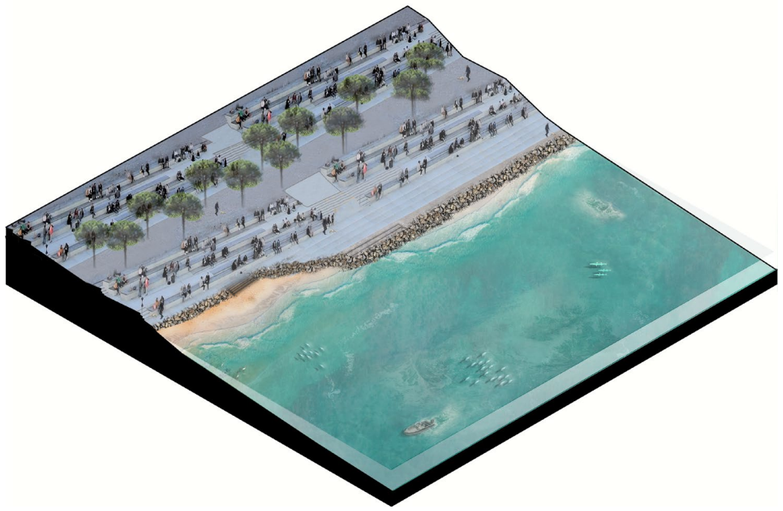
REINFORCEMENT AND BARRIER PROTECTION

Relatively flat and horizontal surface, staggered in the coastal or intertidal zone. This solution is considered when there is no space for a gentler slope, so a near-vertical solution is required. This solution is suitable when the energy of the coastal dynamics is such that bioengineered solutions cannot be relied upon. These designs can incorporate plant material.

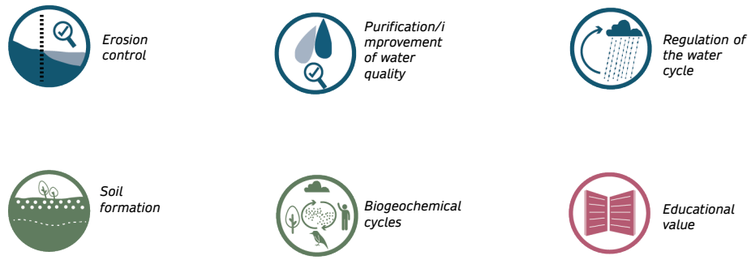
SCALE OF ACTION

RISK / IMPACT ON THE TARGET





ECOSYSTEM SERVICES



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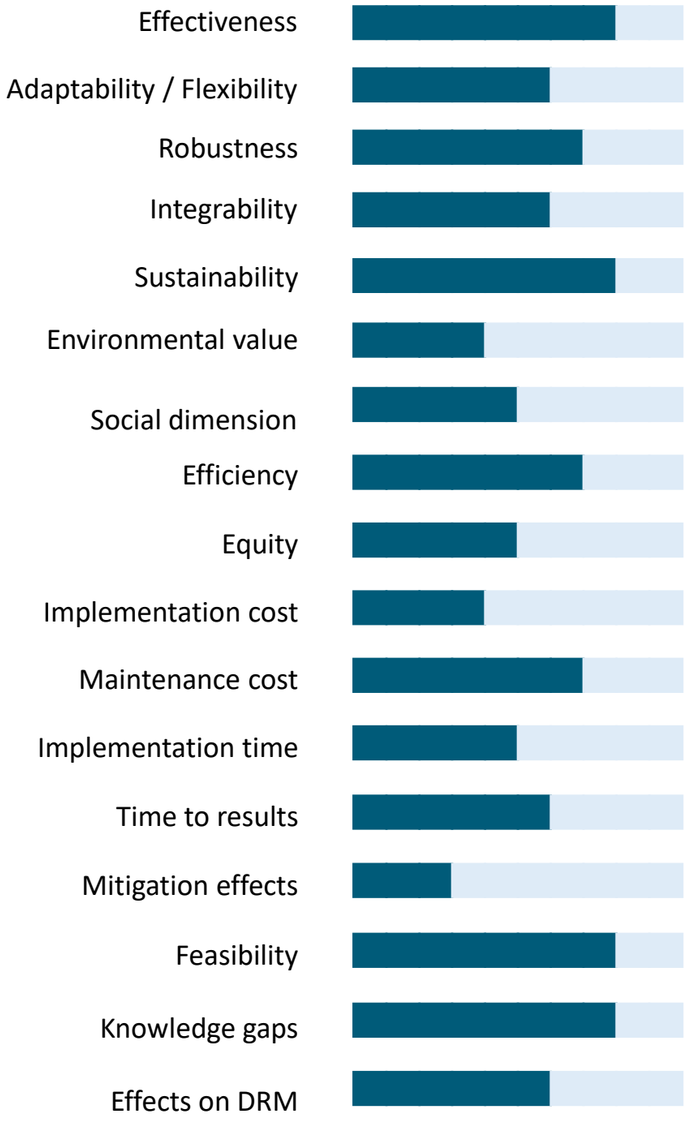

Cleveleys Coastal Protection Scheme, UK. Source: Wyre Council

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ADAPTA BLUES

DUNE SYSTEMS

STRUCTURAL EbS

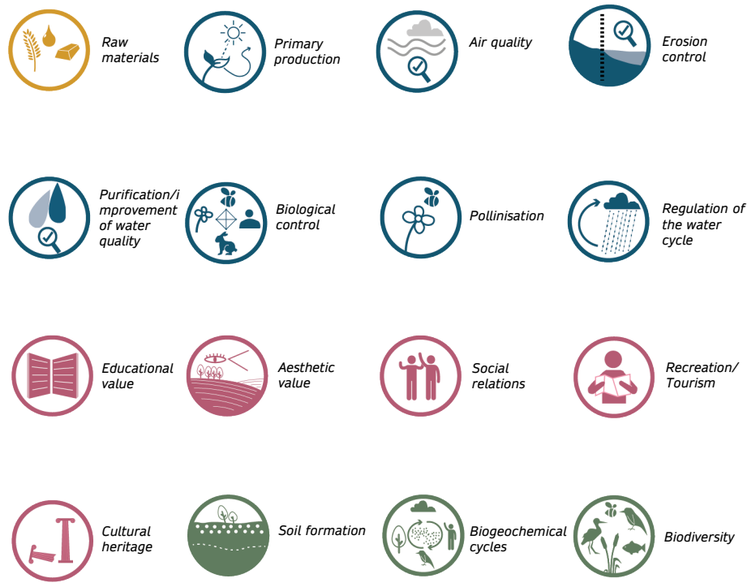
PROTECTION WITH REINFORCEMENT

Deposits of sand and gravel shaped by wind and waves on the coastal shoreline. They play a role in protecting adjacent coastal areas on the upper beach. They also store sediments during calm conditions and supply them to the beach when it is affected by high-energy wave conditions (French, 2001), contributing to erosion reduction through more efficient dissipation of wave energy and preventing inland erosion.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET

ECOSYSTEM SERVICES



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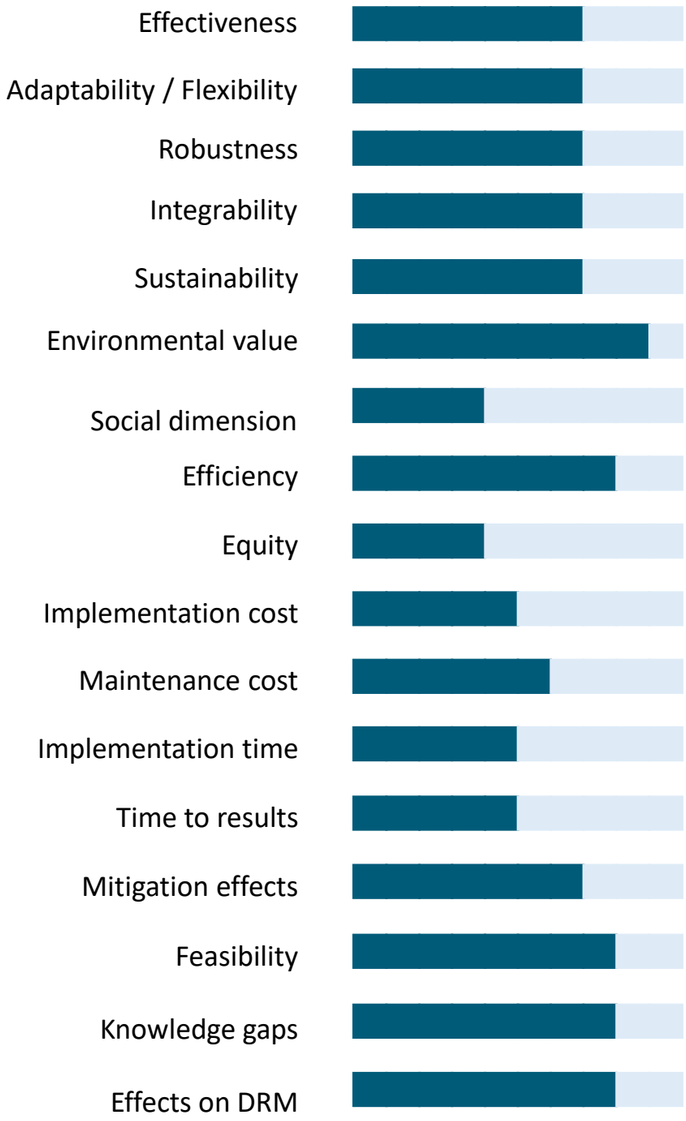

Sand catchers on Bogue Banks, United States. Source: NOAA

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BERM

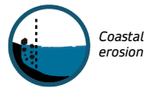
STRUCTURAL EbS

PROTECTION WITH REINFORCEMENT

Nearly horizontal shore parallel ridge formed on the beach due to the landward transport of the coarsest fraction of the beach material by the wave up rush crests.
This type of configurations can be artificially reinforced or incorporated into pre-existing containment elements as coastal protection measures.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET



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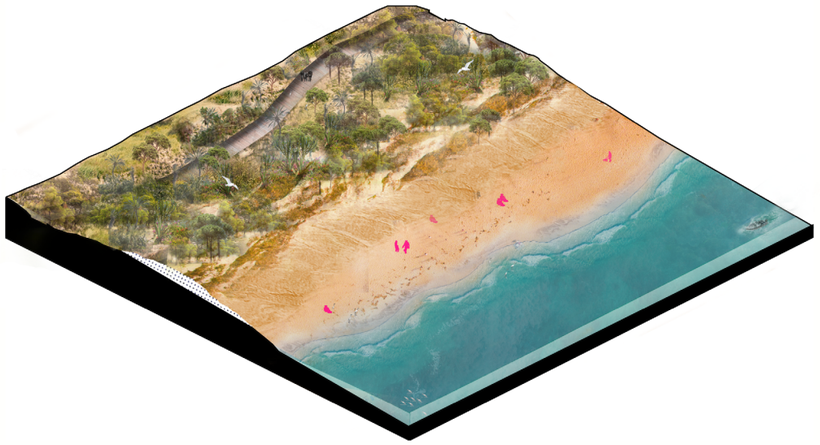

Berma at Hornsea beach, UK. Source: A Level Geography

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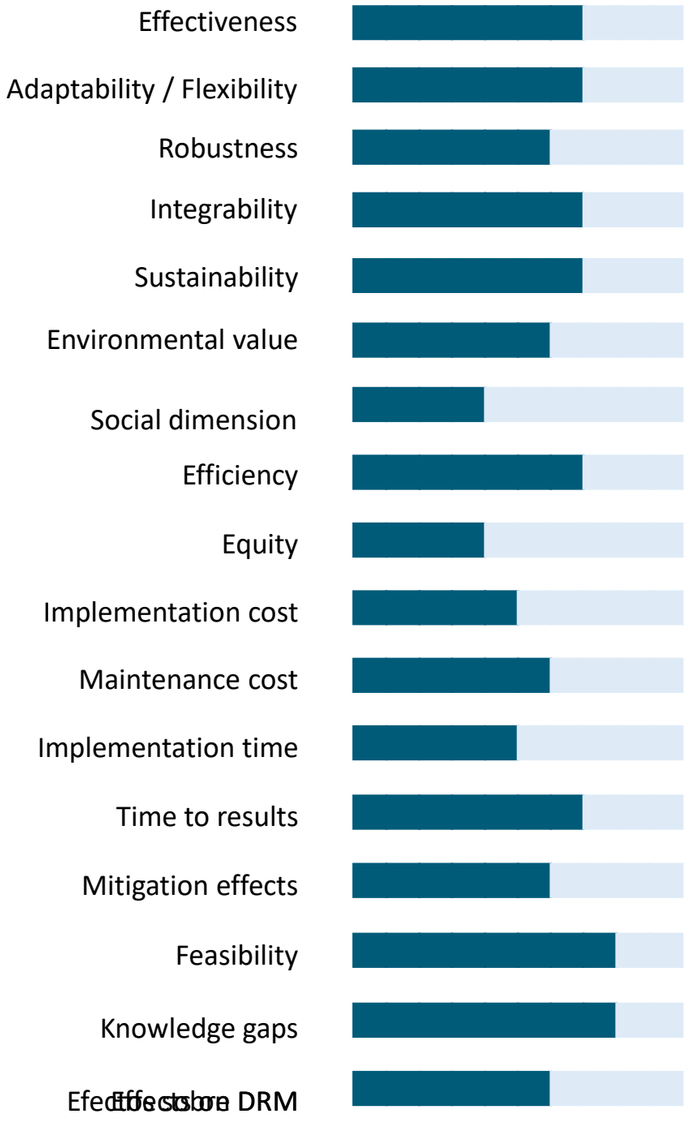
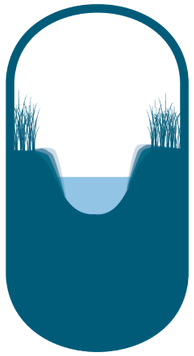


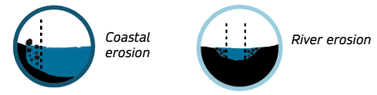


REINFORCED BANK | STRUCTURAL GRIS | BARRIER PROTECTION

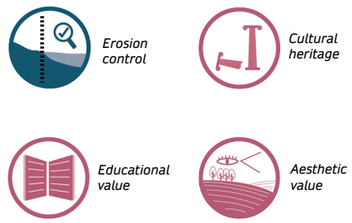
Bank reinforcement consist of artificially strengthening an excessively sloped or eroded embankment from collapse. There are many methods for stabilizing banks and embankments, such as soil structure treatment, drainage and vegetative cover, or engineered works including gabions, revetment mattresses, and different retaining wall and sheet pile structures. Stabilization measures not only act to diffuse and absorb the energy of erosive processes, but also provide structural stability to the slope.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET



ECOSYSTEM SERVICES



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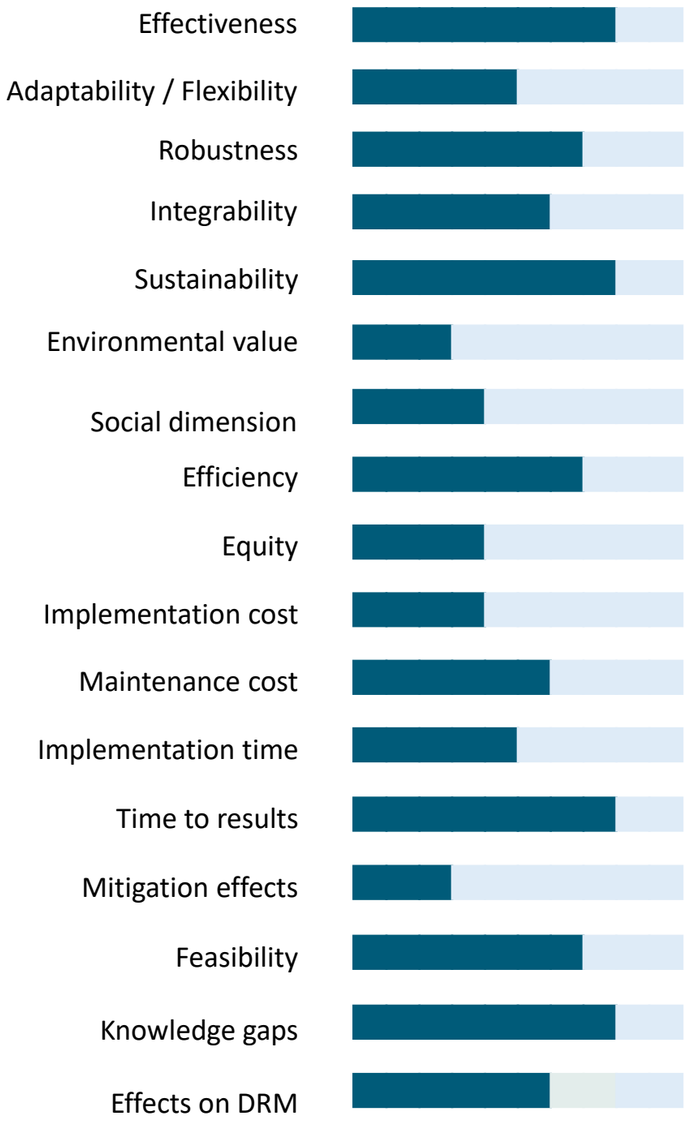

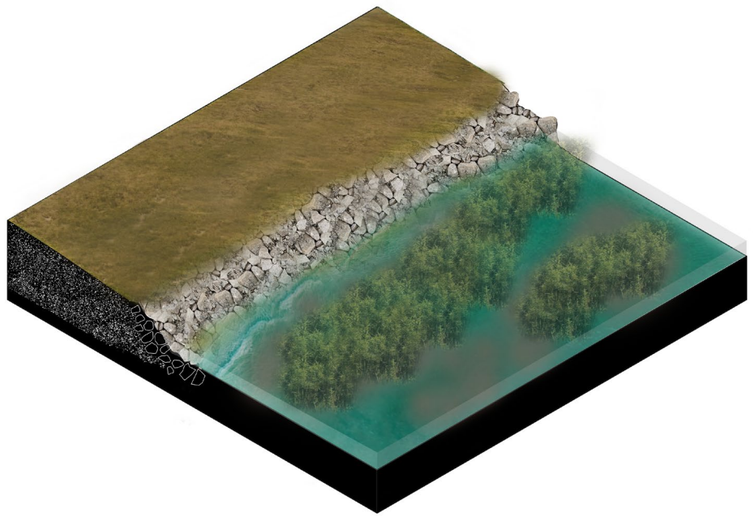

Stabilisation of the banks of the San Pedro River, Los Teques, Venezuela. Source: EcoGreen Construcciones.

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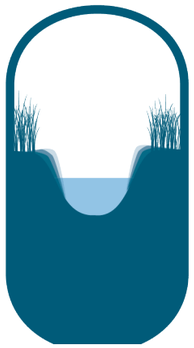
ADAPTA BLUES



REINFORCED BANK

STRUCTURAL EbS

PROTECTION WITH REINFORCEMENT

Bank reinforcement consist of artificially strengthening an excessively sloped or eroded embankment from collapse. There are many methods for stabilizing banks and embankments, such as providing integrated bank protection designs that include biological materials. Soil bioengineering is a method used to address erosion that can be applied in many ways in different systems. Hybrid approaches that employ geotextile fabrics and/or vegetation are used and can provide robust streambank protection while maximizing ecological and water quality benefits.

SCALE OF ACTION

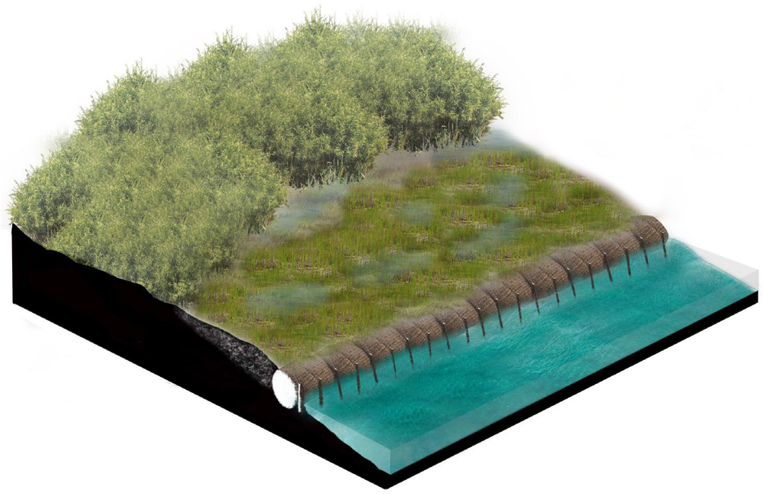
Local

RISK / IMPACT ON THE TARGET

Coastal erosion

River erosion

Alteration of ecosystems



ECOSYSTEM SERVICES

Raw materials

Primary production

Air quality

Erosion control

Purification/improvement of water quality

Pollinisation

Educational value

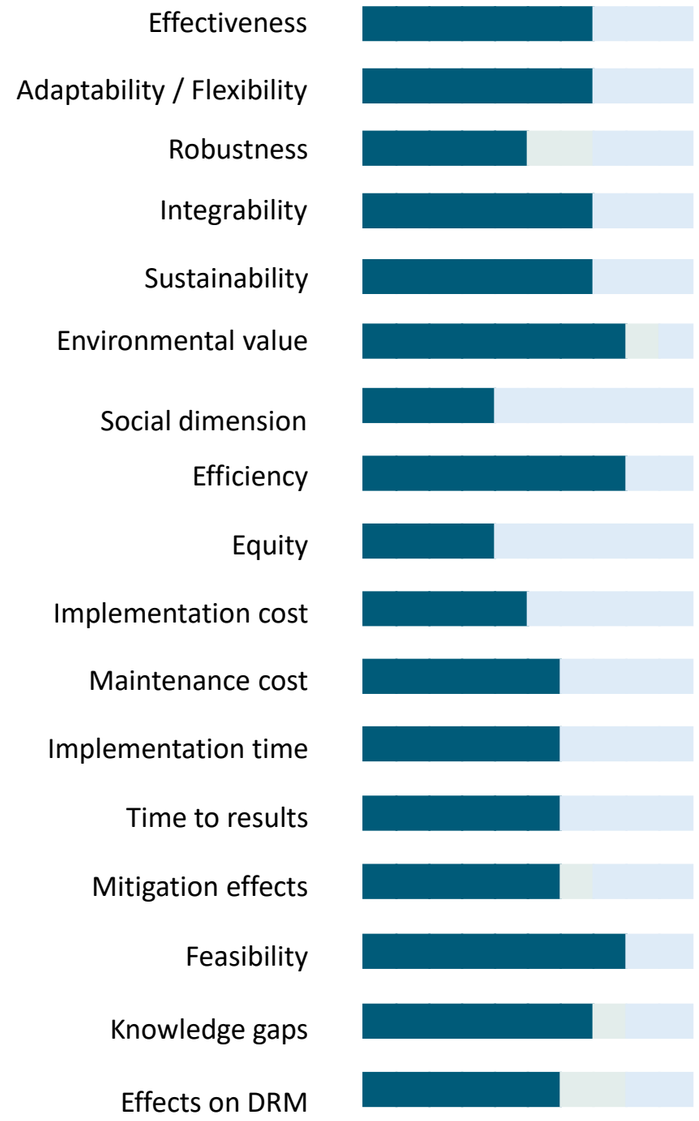
Aesthetic value

Soil formation

Biogeochemical cycles

Biodiversity

INDICATORS



Slope stabilisation process in Massachusetts. Source: New England Environmental.

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REINFORCED CLIFFS

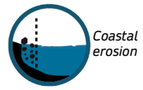
STRUCTURAL EbS

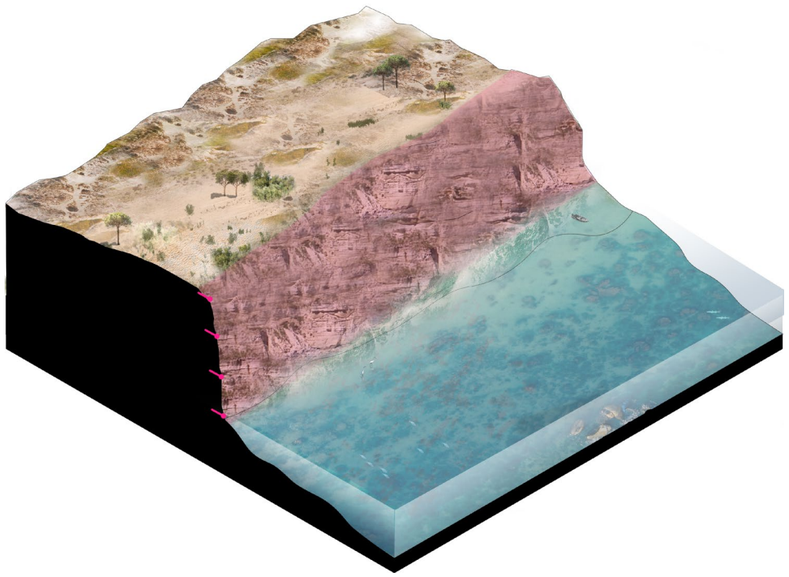
PROTECTION WITH REINFORCEMENT

Coastal cliff reinforcement is to reduce cliff erosion and its consequences (landslide, collapse, rockfall). These techniques include methods to increase slope stability and measures to reduce marine erosion at the foot of cliffs.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET





ECOSYSTEM SERVICES

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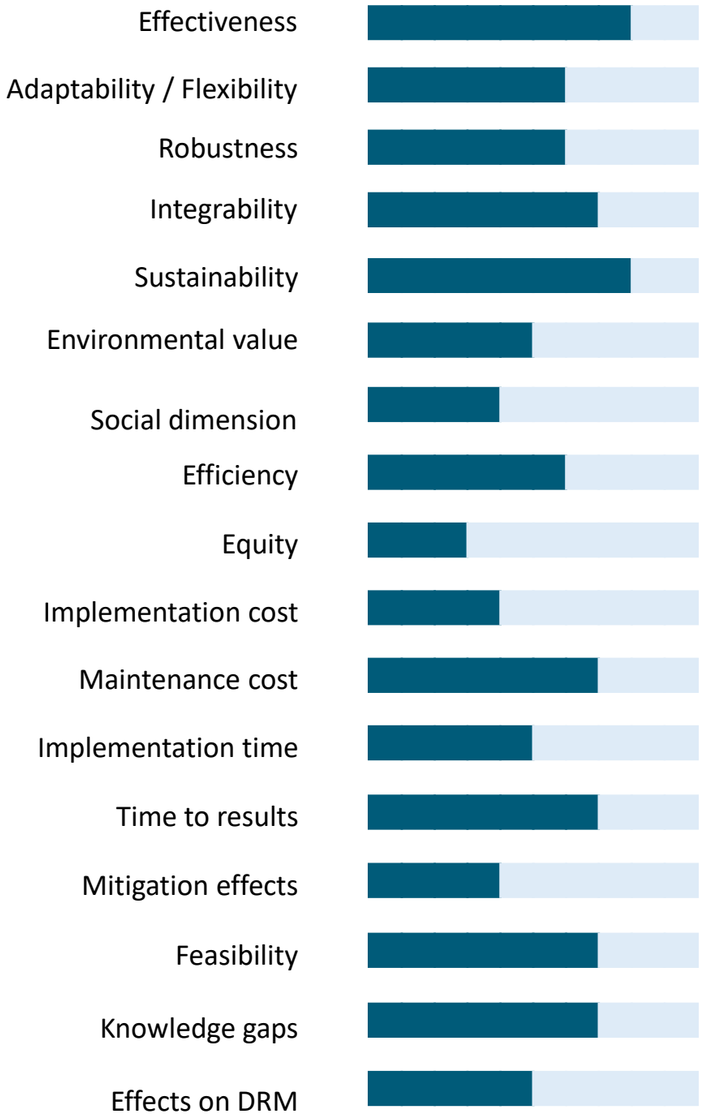

Stabilisation work at Canford Cliffs, UK . Source: BCP Council.

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ADAPTA BLUES

TIDE POOLS

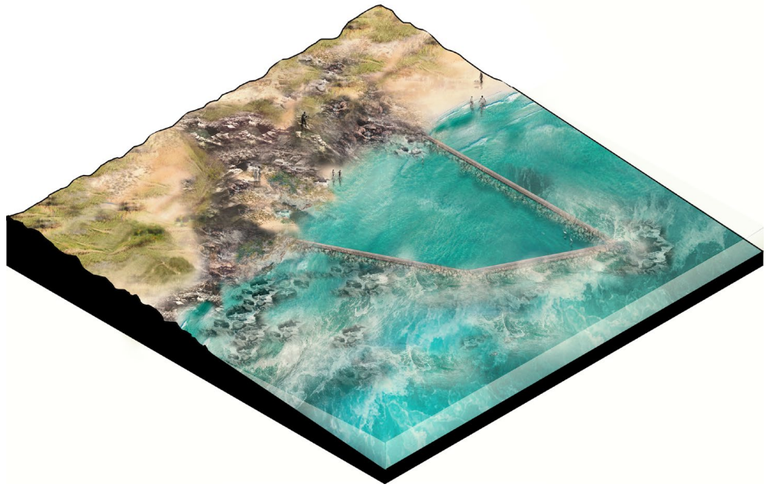
STRUCTURAL EbS

PROTECTION WITH REINFORCEMENT

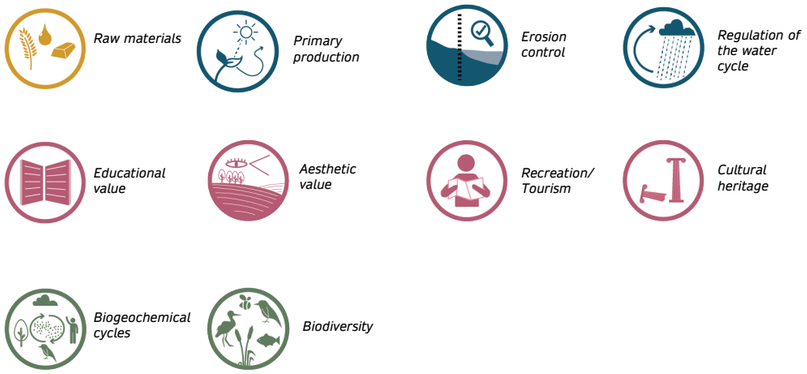
Tide pools are depressions along the shoreline of rocky coasts, which are filled with seawater that gets trapped as the tide retreats. While these small basins at the ocean's edge typically range from mere inches to a few feet deep and a few feet across, they are packed with sturdy sea life such as snails, barnacles, mussels, anemones, urchins, sea stars, crustaceans, seaweed, and small fish.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET



ECOSYSTEM SERVICES



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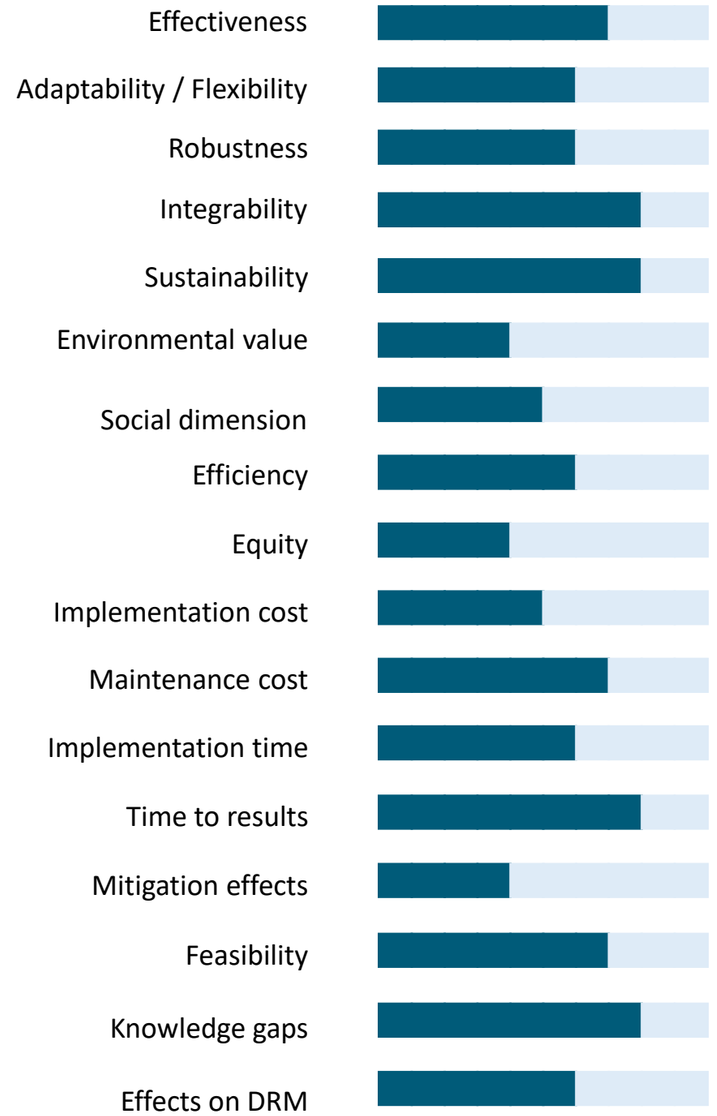

Alvaro Siza's swimming pool in Leça de Palmeira, Portugal. Fuente: ArchDaily.

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DIKE

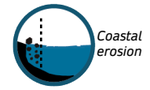
STRUCTURAL GREY

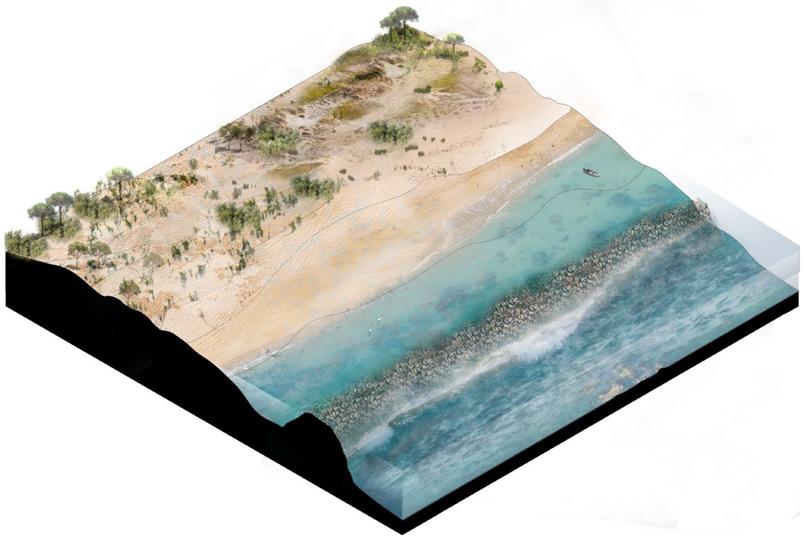
BARRIER PROTECTION

Coastal structures of different types (sloping, vertical, composite or floating) that block or completely dissipate part of the energy of incoming waves, water flow or coastal sediment drift and thus reduce coastal flooding or coastal erosion. They protect against coastal flooding due to storm surge (Pilarczyk, 1998) by dissipating or reflecting wave energy.

SCALE OF ACTION

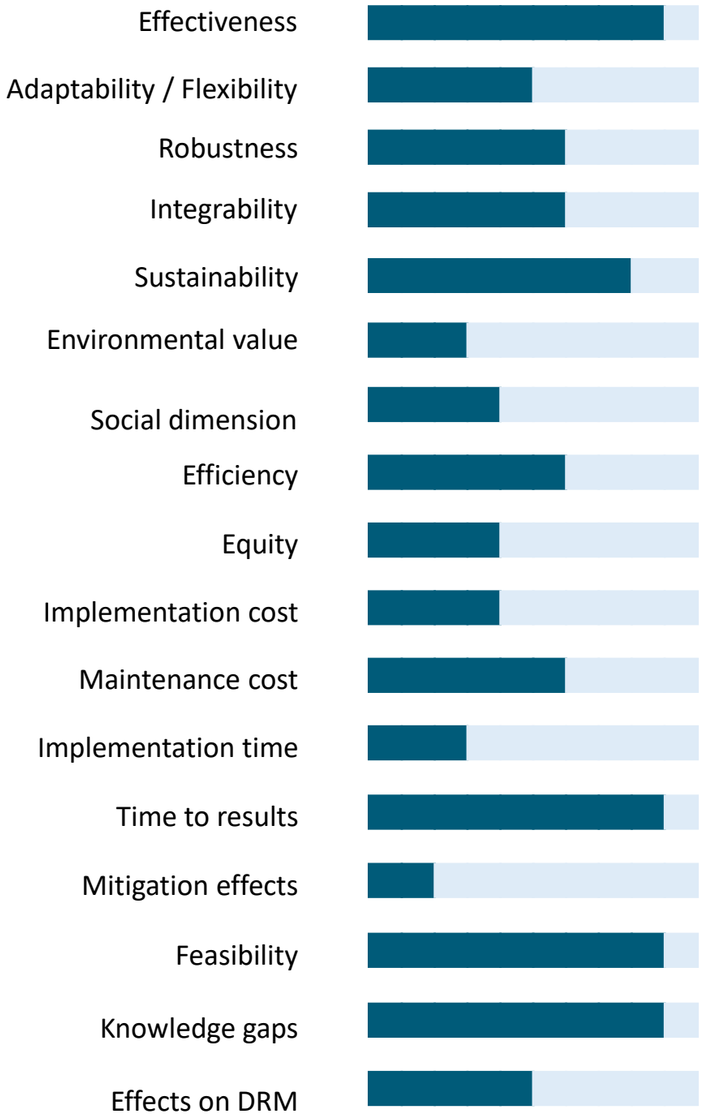
RISK / IMPACT ON THE TARGET





ECOSYSTEM SERVICES

INDICATORS



Construction of a dam. Source: DMC.

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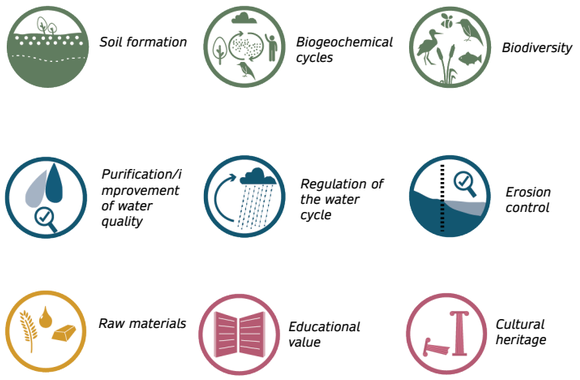
OYSTER REEFS | STRUCTURAL EbS | BARRIER PROTECTION

Oyster reefs provide important benefits by contributing to water filtration, providing food and habitat for fish, crabs and birds. Also, functioning as natural coastal protectors against ship-generated waves, sea level rise and storm surges.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET

ECOSYSTEM SERVICES



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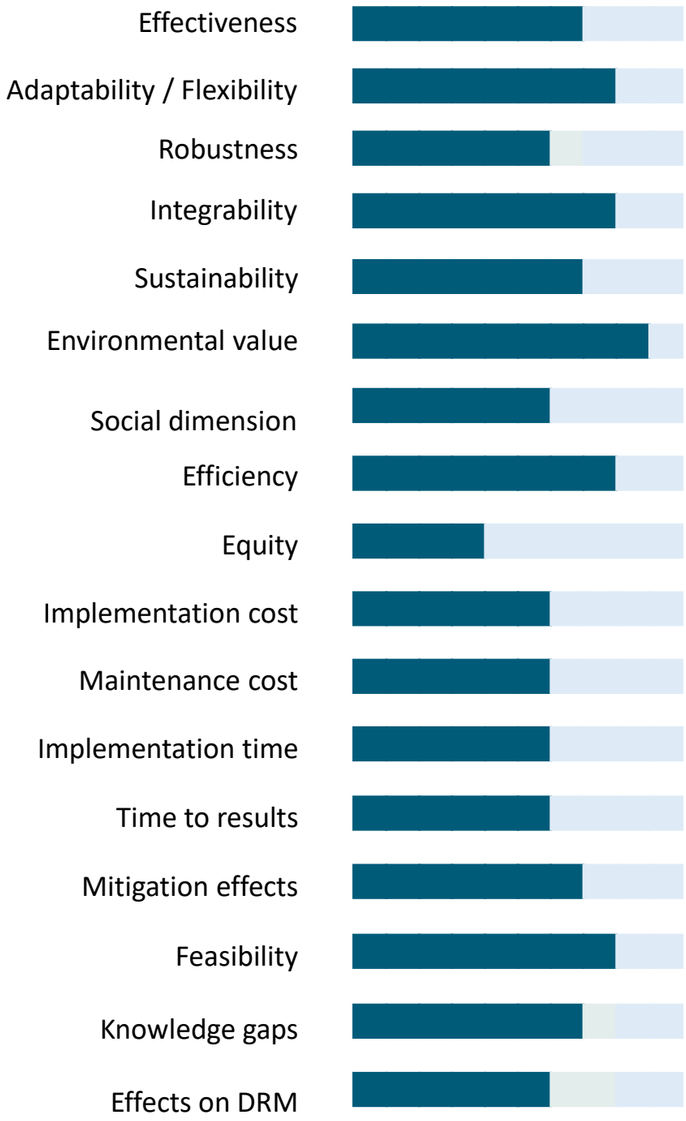

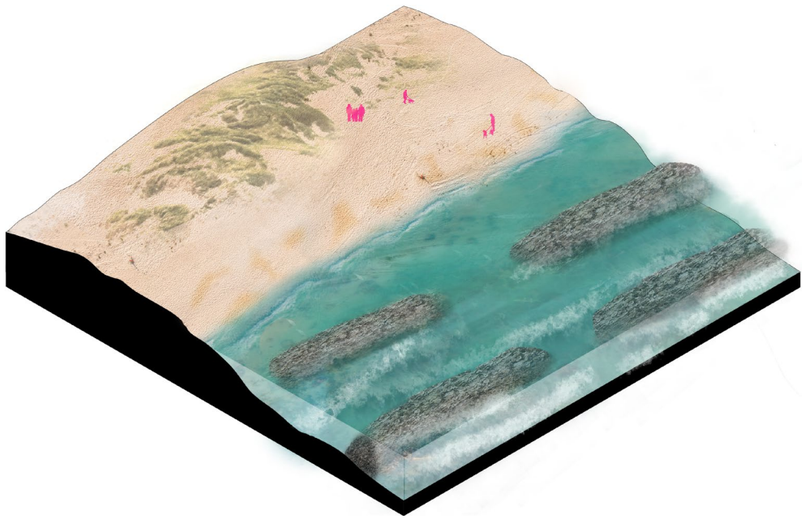

Artificial oyster reef. Source: reefball.org.

REFERENCES

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https://maritime-spatial-planning.ec.europa.eu/projects/rich-north-sea

ADAPTA BLUES

SEAWALL | STRUCTURAL GREY | BARRIER PROTECTION

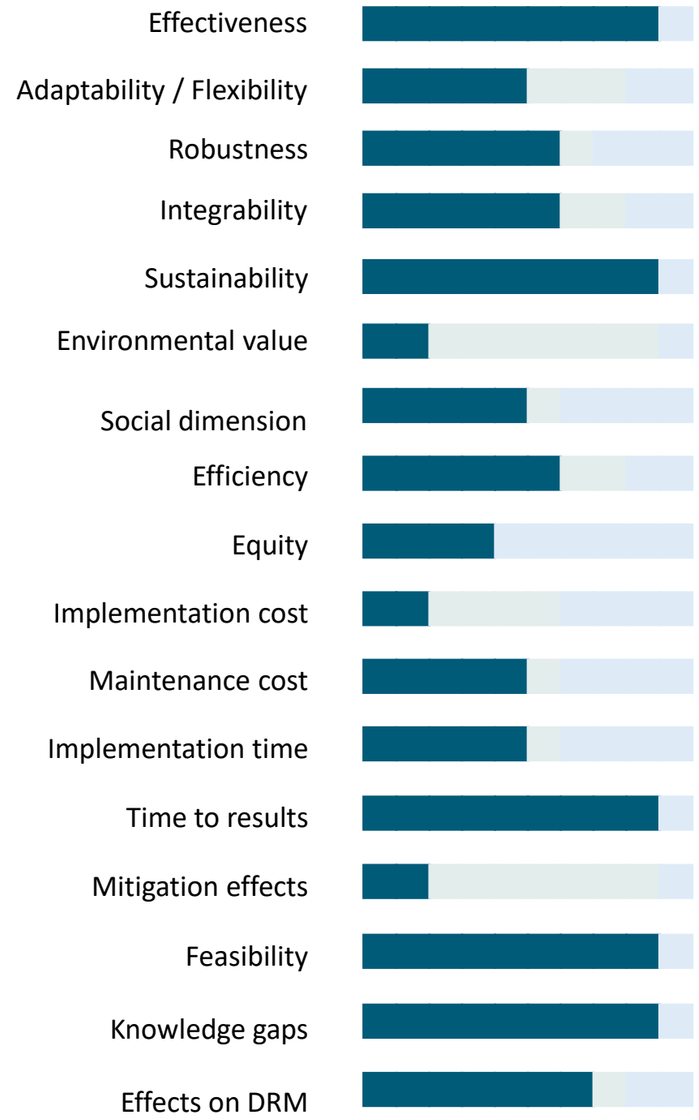
Solid structures that separate land and water areas. They are designed to prevent coastal erosion and other damage due to wave action and meteorological tides.

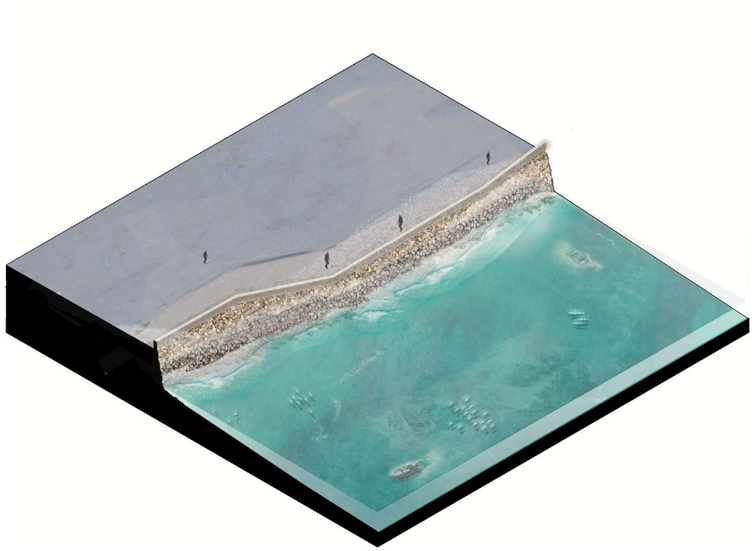
SCALE OF ACTION

RISK / IMPACT ON THE TARGET

ECOSYSTEM SERVICES

INDICATORS





Seawall in Stanley Park, Vancouver, Canada. Source: Ted McGrath via Flickr.

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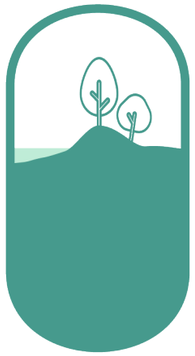


EMBANKMENT

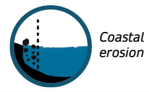
STRUCTURAL EbS

BARRIER PROTECTION

An artificial sediment barrier placed on the edge of a slope or a wall built next to a ditch to protect against potential flooding. Embankments are placed in flood-prone areas to protect them from erosion, runoff and flooding. They are usually made of compost, sand, mulch or gravel, whose density allows them to slow and retain floodwater.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET



ECOSYSTEM SERVICES

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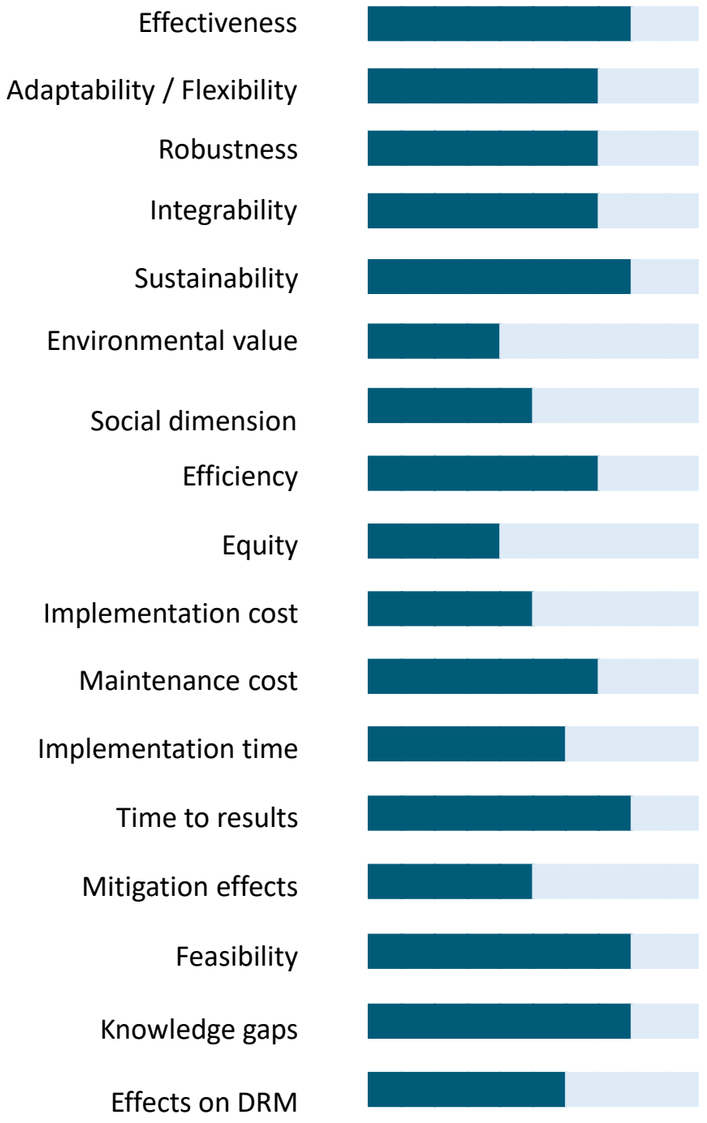

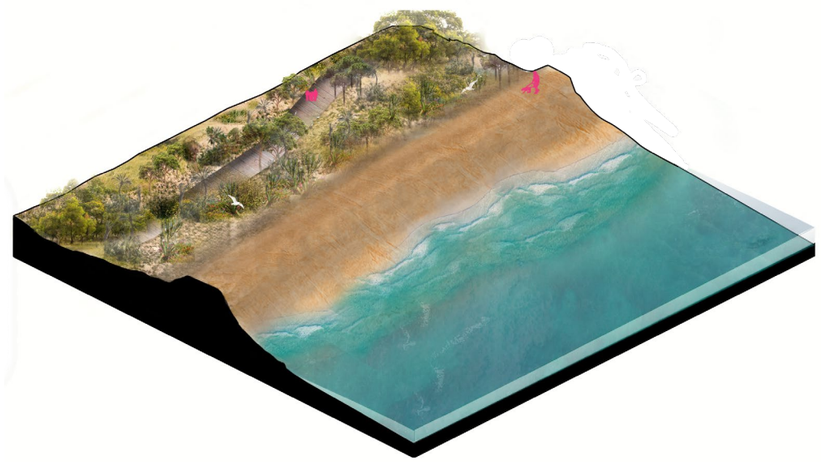

Consolidation work on the protective mote in the river Ebro. Source: El Periódico de Aragón.

REFERENCES

MOVE SEAWARD MEASURES

ADAPTA BLUES

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

NAME — descripción

CLIMATE CHANGE ADAPTATION STRATEGIES

- AVANCE — Seawards
- PROTECCIÓN — Protection
- ACOMODACIÓN — Consolidating
- RETROCESO — Inland

CLASSIFICATION ACCORDING THE STRUCTURE OF EACH COMPONENT

Strategy and sub-strategy | Natural component | Nature-based component | Structural component | Non-structural component

PROTECTION

The coastal ecosystem has its own natural methods to protect itself from the water-earth border effects. Due to antropization, ecological weakening, and the growing climate change adaptation threat, it is necessary to reinforce these protections or to generate new ones in when they are completely extinct.

- **REINFORCEMENT** — Those components are the ones that adhere to an existing protection, which is in damaged or has become insufficient.
- **LIVING SHORELINES** — Breakwater designed to allow the settlement of a biological community, incorporating co-benefits such as carbon storage, increased biodiversity and reinforcement of the structure through bioprotection.
- **TERRACED EDGE** — Relatively flat and sloping surface in contact with the sea, which reduces wave activity.
- **DUNE SYSTEM** — Deposits of sand and gravel shaped by wind and waves on the shoreline. It is a flexible, natural protection against erosion and flooding.
- **BERM** — Nearly horizontal shore parallel ridge formed on the beach due to the landward transport of the coarsest fraction of the beach material by the wave uprush.
- **REINFORCED BANK** — Whole or part of bank artificially strengthened for bank protection purposes.
- **REINFORCED BANK** — Whole or part of a river or estuarine bank strengthened with natural materials for bank protection purposes.
- **REINFORCED CLIFFS** — Whole or part of a coastal cliff strengthened with natural materials for bank protection purposes.
- **TIDE POOLS** — An isolated pocket of seawater found in the ocean's intertidal zone.
- **BARRIER** — Structures that protect the continent, lagoons, wetlands and marshlands from the land, waves adn tidal energy.
- **DIKE** — Manmade structure designed to protect low-lying areas from flooding from the sea or ocean.
- **SEAWALL** — A wall or embankment erected to prevent the sea encroaching on or eroding an area of land.
- **OYSTER REEFS** — Dense aggregations of oysters that form large colonial communities. They function as a natural filter and improve water overloaded with nutrients while acting as a barrier to reduce wave energy, prevent erosion, and fortify wetlands.
- **EMBANKMENT** — An artificial earthen wall, often meant to prevent flooding of the hinterland.

SEAWARDS

This strategy mainly fights against the risk of erosion on the coastline. To face this threat, the coastline is advanced in order to stabilize its profile. Beyond facing danger, the benefit of this strategy is the increase of public space. It is usually used in situations where there is a lack of it.

- **ADVANCE THE LINE WITH SEDIMENT** — Seawards components, mainly with sand or clay, through nourishing or catchment.
- **SEDIMENT TRAPS** — Small ponds placed between the inlet and the main wetland to promote sedimentation of coarse particles before water is distributed through the wetland.
- **SAND NOURISHMENT** — Sand addition to the coastal system to mitigate the consequences of previous erosion.
- **CHANGES IN GRANULOMETRIC COMPOSITION** — Replacement of sands with gravels, pebbles or other sands of larger diameter to increase beach stability.
- **ADVANCE THE LINE WITH FLORA AND FAUNA** — To advance the coastline with new ecosystems or strengthen the existing ones.
- **MARINE ANGIOSPERMS** — Angiosperm communities that increase the available sediment for organism and attenuate water velocity associated with currents and waves
- **KELP FORESTS** — Underwater areas with a high density of brown algae that favor attenuation of current velocity.
- **ADVANCE THE LINE WITH STRUCTURES** — Engineering works into the sea and change coastal dyanmics.
- **GROYNE** — A low wall or sturdy barrier built out into the sea from a beach to check erosion and drifting.

ACCOMMODATION

Through this strategy, the confrontation between land and sea is not so much sought, as the adaptation of this environment to the continuous contact between the different ecosystems. The different measures focus on generating a transition zone on the shoreline where appropriate exchanges can take place and, in this way, improve the resilience of the whole.

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RETREAT

Measures, mainly urban and territorial planning, that seek to create a safe space for flooding and protect assets by reducing exposure by setting them back.

- **RIVERS AND ESTUARIES** — Works on fluvial areas near the coast to improve its interaction with the sea.
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Regulation measures that complement, complete, or partially replace the structural ones include modifications in public policies, management practices, regulatory policies, and tax collection policies.

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LANDLAB

ADAPTA BLUES

SEDIMENT TRAPS

TECHNOLOGICAL STRUCTURAL

SEDIMENT ADVANCE

Sediment traps are topographic depressions, which can show different shapes and orientations, and promote sedimentation of coarse particles.
These designs should be located in easily accessible locations where sediment can be removed on a regular basis. This design features decrease sedimentation within the wetland, which lengthens the time between dredging, prevents burial of germinating seedlings, and helps limit channelization of flow paths

SCALE OF ACTION


Watershed


City


Local

RISK / IMPACT ON THE TARGET


Coastal erosion

ECOSYSTEM SERVICES


Raw materials

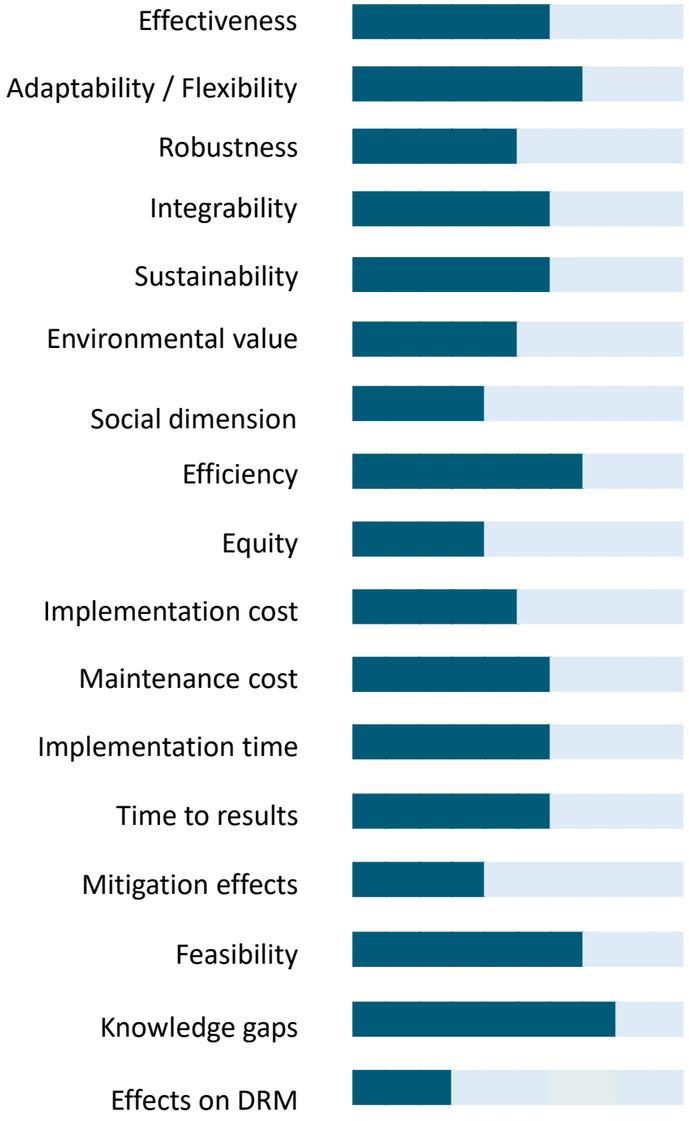

Purification/improvement of water quality


Erosion control


Soil formation


Biogeochemical cycles

INDICATORS




The semi-permeable structures as sediment trap, Sawah Luhur village, Serang-Banten, West Java © Setyawati/MFF-Indonesia, 2016

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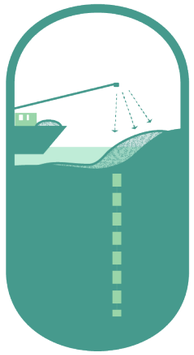
ADAPTA BLUES



SAND NOURISHMENT

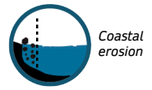
STRUCTURAL EbS

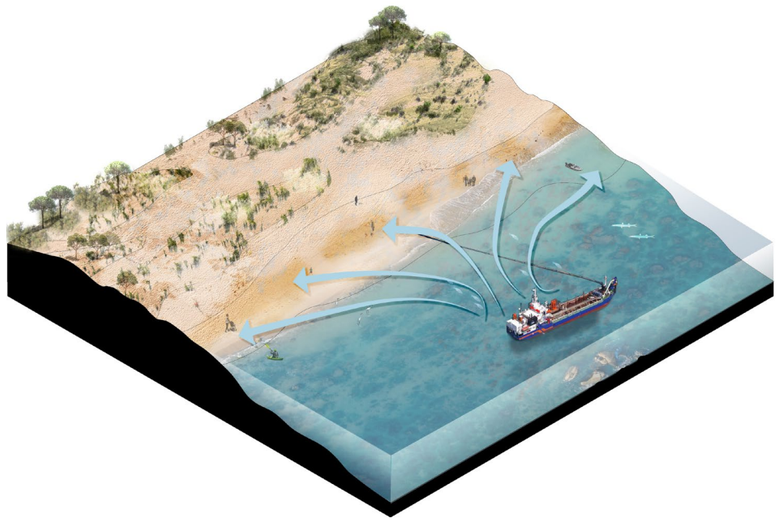
SEDIMENT ADVANCE

It is a technique based on the addition of sand to the coastal system. Borrowed sand can be obtained from inland sources or from marine dredging. It does not reduce erosion, but provides additional sediment on which continued erosional forces will act. Hence, returning the beach to its original state, if the beach is not at equilibrium after nourishment.

SCALE OF ACTION

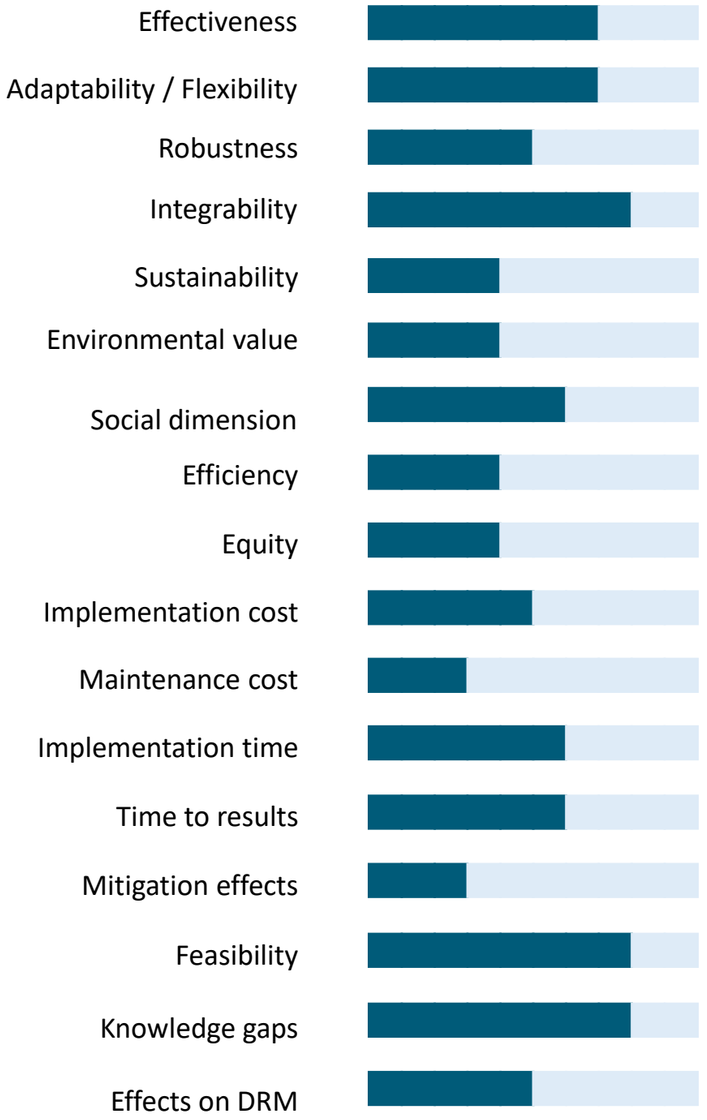
RISK / IMPACT ON THE TARGET





ECOSYSTEM SERVICES

INDICATORS



Beach regeneration works in Poole Bay, UK. Source: BCP Council.

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CHANGES IN GRANULOMETRIC COMPOSITION

STRUCTURAL EbS

SEDIMENT ADVANCE

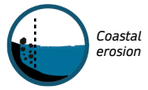
Mixed sand and gravel beaches reduce the "swash zone" on the beach surface. The resulting rising and falling velocities are more asymmetric in the area of higher gravel content, which creates a higher beachfront area slope.

SCALE OF ACTION

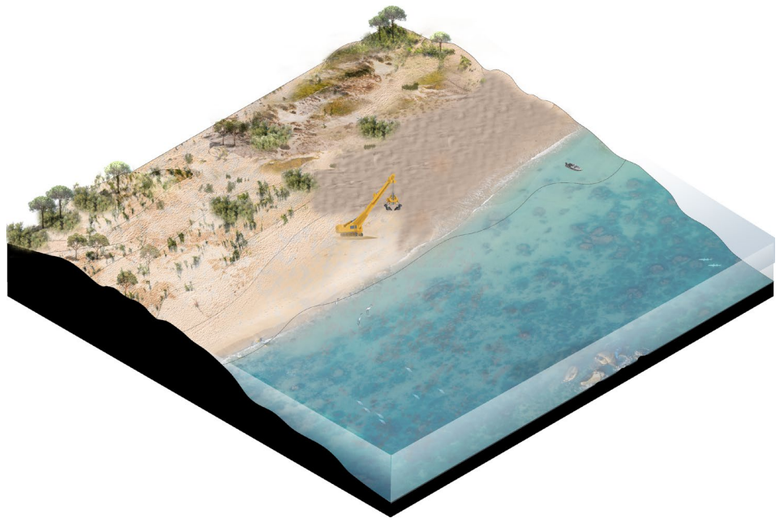
Local

RISK / IMPACT ON THE TARGET

Coastal flooding



Coastal erosion



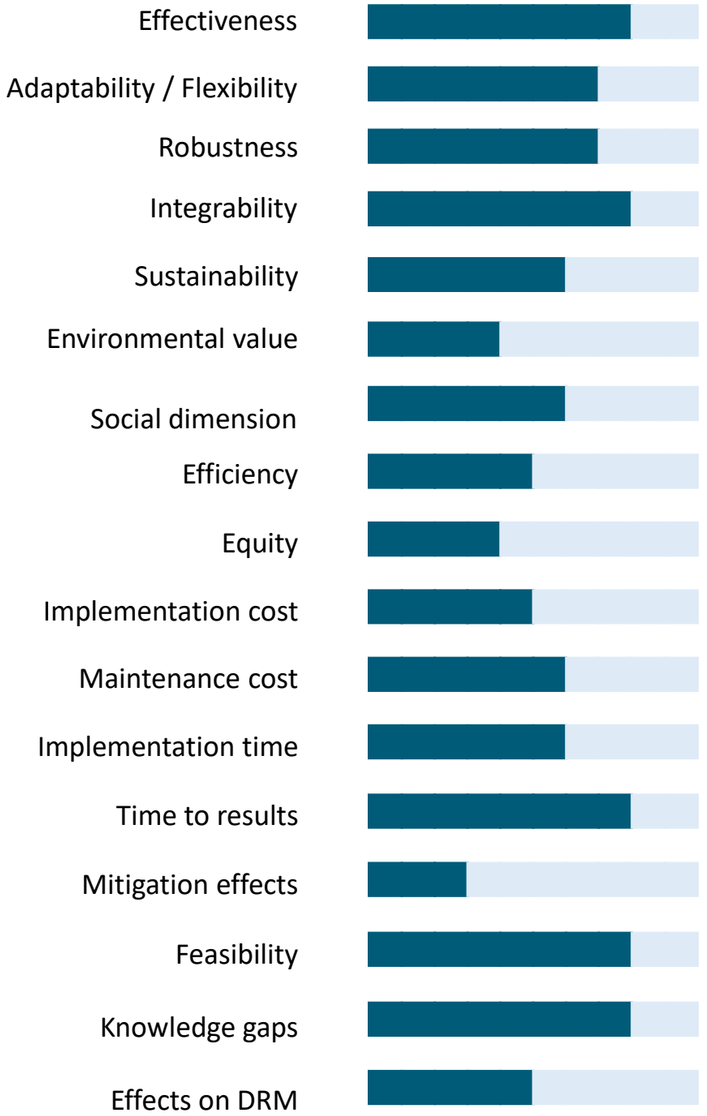
ECOSYSTEM SERVICES

Raw materials

Erosion control

Soil formation

INDICATORS



Gravel backfill in Almenara, Spain. Source: Dirección General de Costas, Government of Spain.

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ADAPTA BLUES

MARINE ANGIOSPERMS

STRUCTURAL EbS

ADVANCE WITH FLORA AND FAUNA

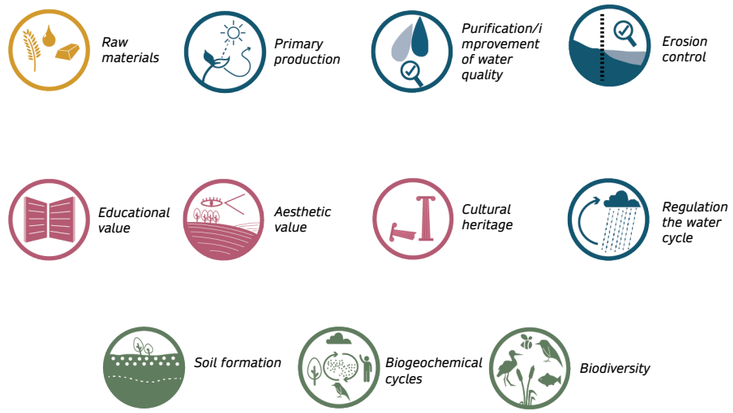
Shallow intertidal and subtidal areas, which are colonized by aquatic angiosperms that increase the available substrate for new organisms. Therefore, favoring the average elevation of substrate, and attenuating the water velocity regarding currents and waves.

SCALE OF ACTION

Local

RISK / IMPACT ON THE TARGET

ECOSYSTEM SERVICES



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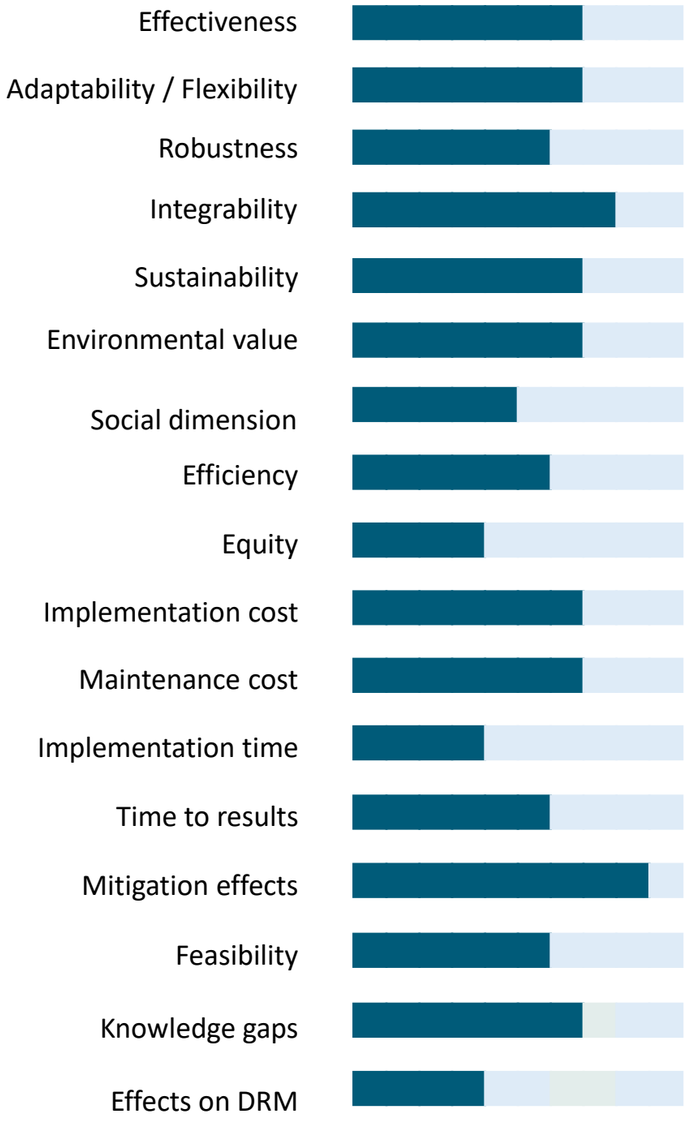

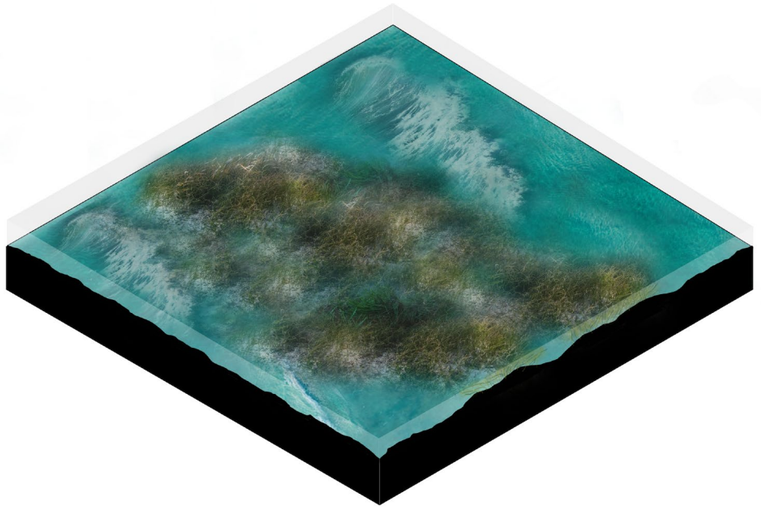

Posidonia meadows in Formentera. Source: saveposidoniaproject.org.

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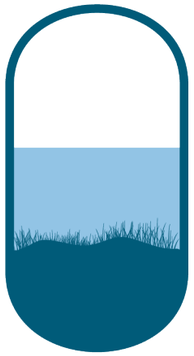
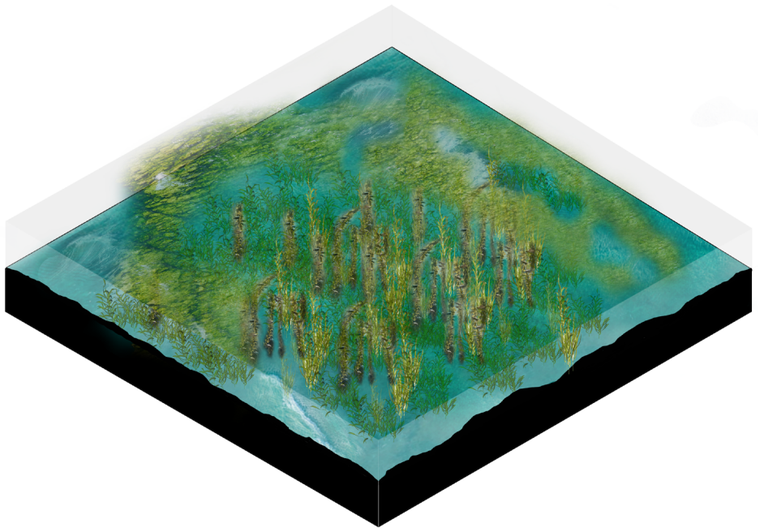


KELP FORESTS

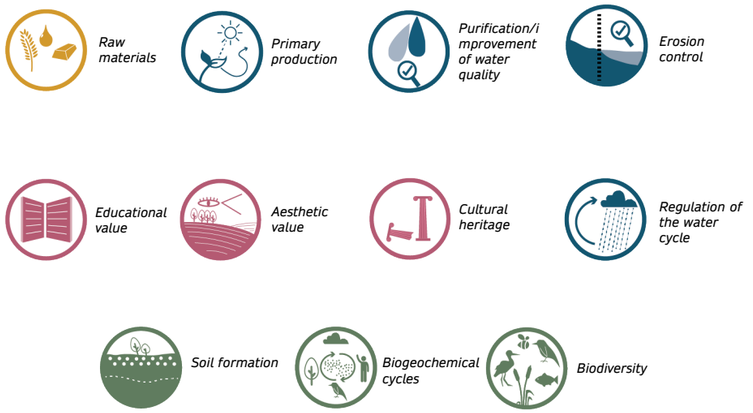
STRUCTURAL EbS

ADVANCE WITH FLORA AND FAUNA

Subtidal areas with a high density of brown algae that favor the attenuation of current velocities while generating co-benefits associated with carbon sequestration (blue carbon) and increased biodiversity.



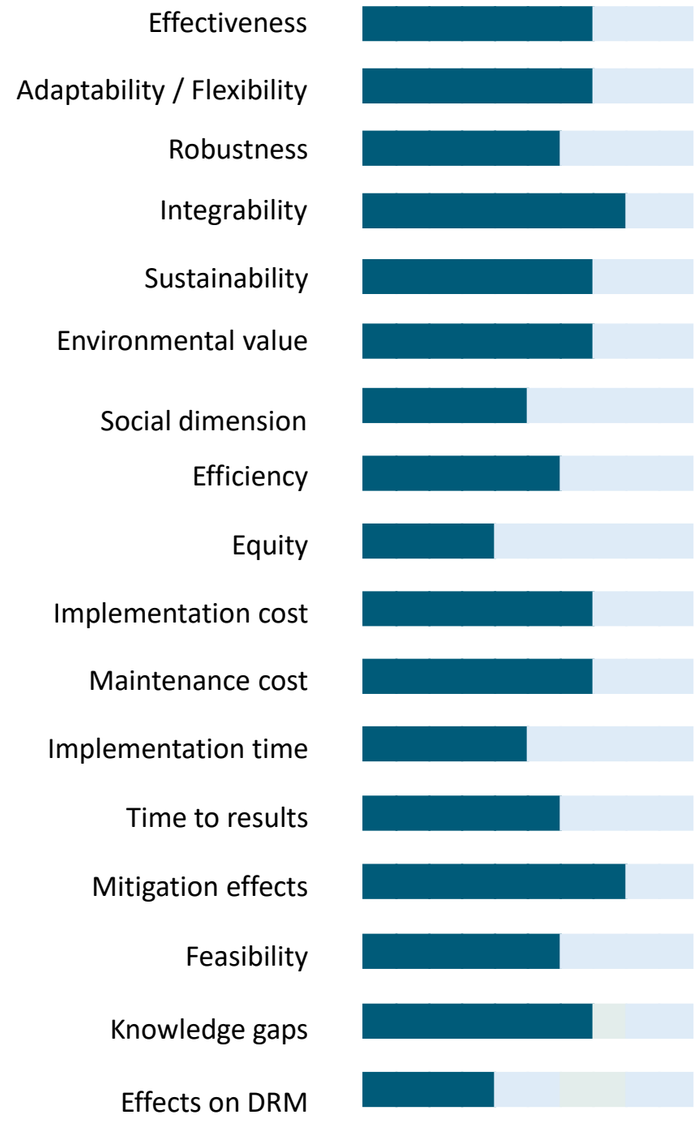
ECOSYSTEM SERVICES



SCALE OF ACTION

RISK / IMPACT ON THE TARGET

INDICATORS



Kelp Forest in Cabrillo, California. Source: National Park Service.

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GROYNE

STRUCTURAL GREY

ADVANCE WITH STRUCTURES

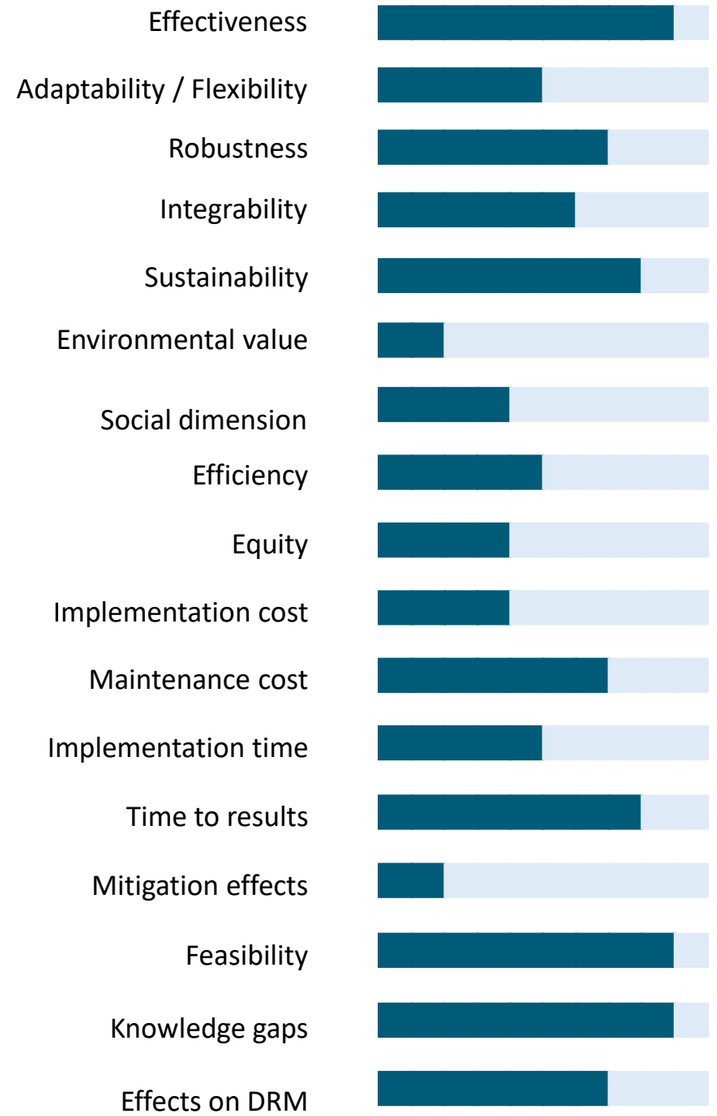
A groyne is a shore protection structure built perpendicular to the shoreline of the coast (or river), over the beach and into the shoreface (the area between the nearshore region and the inner continental shelf), to reduce longshore drift and trap sediments.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET

ECOSYSTEM SERVICES

INDICATORS



Groynes at the Alambrada del Rompido, Spain. Source: Sol89 Architects.

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ACCOMMODATION MEASURES

ADAPTA BLUES

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

NAME

[descripción]

CLIMATE CHANGE ADAPTATION STRATEGIES

AVANCE
Seawards

PROTECCIÓN
Protection

ACOMODACIÓN
Consolidating

RETROCESO
Inland

CLASSIFICATION ACCORDING THE STRUCTURE OF EACH COMPONENT

Strategy and sub-strategy | Natural component | Nature-based component | Structural component | Non-structural component

PROTECTION

The coastal ecosystem has its own natural methods to protect itself from the water-earth border effects. Due to antropization, ecological weakening, and the growing climate change adaptation threat, it is necessary to reinforce these protections or to generate new ones in when they are completely extinct.

REINFORCEMENT
Those components are the ones that adhere to an existing protection, which is in damaged or has become insufficient.

LIVING SHORELINES
Breakwater designed to allow the settlement of a biological community, incorporating co-benefits such as carbon storage, increased biodiversity and reinforcement of the structure through bioprotection.

TERRACED EDGE
Relatively flat and sloping surface in contact with the sea, which reduces wave activity.

DUNE SYSTEM
Deposits of sand and gravel shaped by wind and waves on the shoreline. It is a flexible natural protection against erosion and flooding.

BERM
Nearly horizontal shore parallel ridge formed on the beach due to the landward transport of the coarsest fraction of the beach material by the wave uprush.

REINFORCED BANK
Whole or part of bank artificially strengthened for bank protection purposes.

REINFORCED BANK
Whole or part of a river or estuarine bank strengthened with natural materials for bank protection purposes.

REINFORCED CLIFFS
Whole or part of a coastal cliff strengthened with natural materials for bank protection purposes.

TIDE POOLS
An isolated pocket of seawater found in the ocean's intertidal zone.

BARRIER
Structures that protect the continent, lagoons, wetlands and marshlands from the wind, waves adn tidal energy.

DIKE
Manmade structure designed to protect low-lying areas from flooding from the sea or ocean.

SEAWALL
A wall or embankment erected to prevent the sea encroaching on or eroding an area of land.

OYSTER REEFS
Dense aggregations of oysters that form large colonial communities. They function as a natural filter and improve water overloaded with nutrients while acting as a barrier to reduce wave energy, prevent erosion, and fortify wetlands.

EMBANKMENT
An artificial earthen wall, often meant to prevent flooding of the hinterland.

SEAWARDS

This strategy mainly fights against the risk of erosion on the coastline. To face this threat, the coastline is advanced in order to stabilize its profile. Beyond facing danger, the benefit of this strategy is the increase of public space. It is usually used in situations where there is a lack of it.

ADVANCE THE LINE WITH SEDIMENT
Seawards components, mainly with sand or clay, through nourishing or enrichment.

SEDIMENT TRAPS
Small ponds placed between the inlet and the main wetland to promote sedimentation of coarse particles before water is distributed through the wetland.

SAND NOURISHMENT
Sand addition to the coastal system to mitigate the consequences of previous erosion.

CHANGES IN GRANULOMETRIC COMPOSITION
Replacement of sands with gravels, pebbles or other sands of larger diameter to increase beach stability.

ADVANCE THE LINE WITH FLORA AND FAUNA
To advance the coastline with new ecosystems or strenghten the existing ones.

MARINE ANGIOSPERMS
Angiosperm communities that increase the available sediment for organism and attenuate water velocity associated with currents and waves

KELP FORESTS
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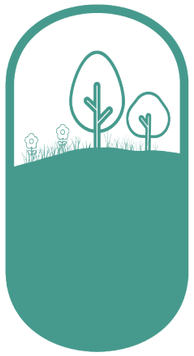
LANDLAB

ADAPTA BLUES

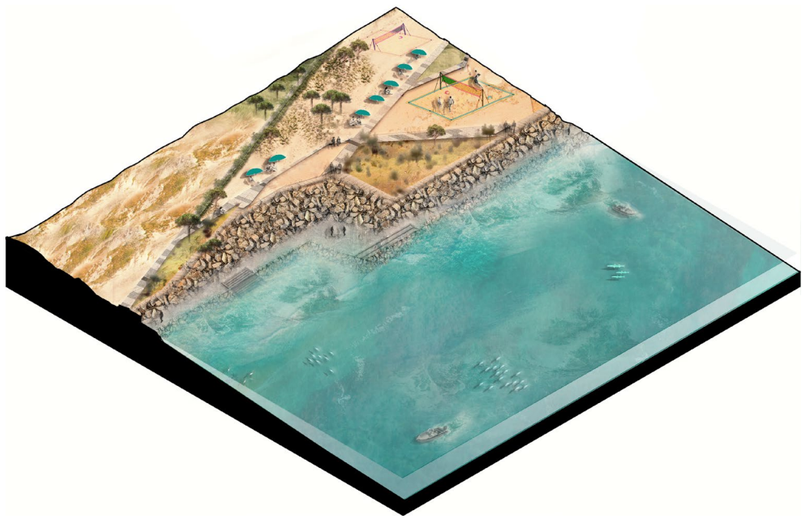


COASTAL PARK

STRUCTURAL EbS

ACCOMMODATION SPONGING

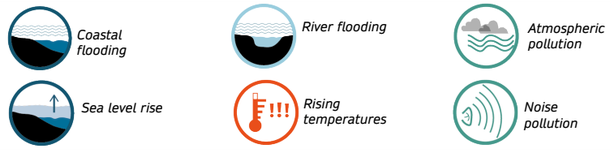
Littoral parks are communal recreational spaces designed to be flooded with minimal damage during storms or floods. These parks are typically previously developed spaces - whether for industrial, commercial or residential purposes - that have suffered repeated flood damage over time and whose original use no longer serves their intended function. Although they are often created by public entities, it is not uncommon for a private project to include it as part of a larger design. They are most common along riverbanks.



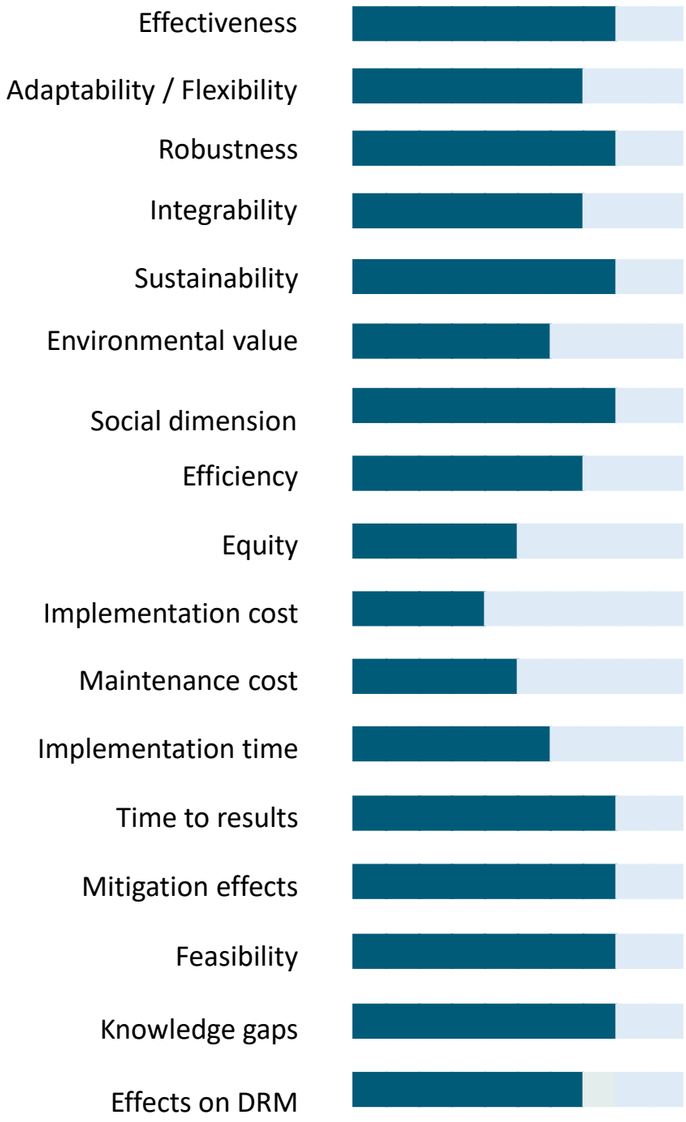
ECOSYSTEM SERVICES

SCALE OF ACTION

RISK / IMPACT ON THE TARGET



INDICATORS



Mar Bella Park, Barcelona (Manuel Ruisánchez and Xavier Vendrell. Source: Arquitecturacatalana.cat

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ADAPTA BLUES

SEA REGRESSION AREA

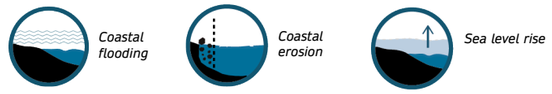
STRUCTURAL EbS

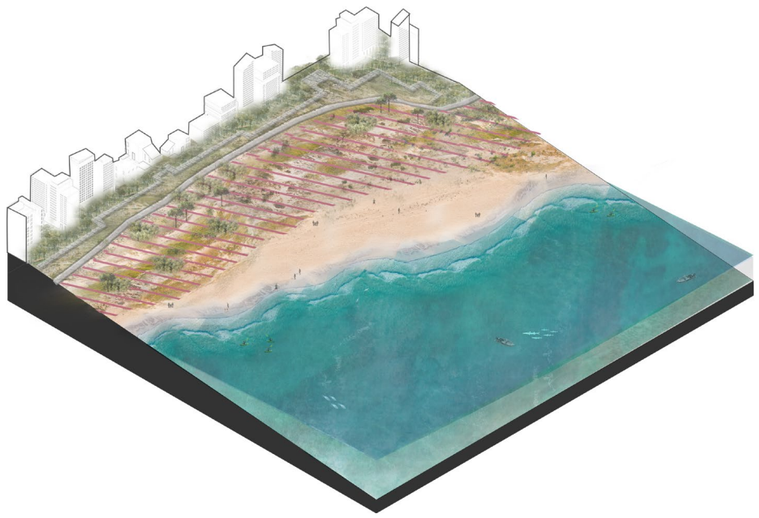
ACCOMMODATION SPONGING

Soil reserve that serves to absorb the coastal regression resulting from the gradual sea level rise and storm surges.

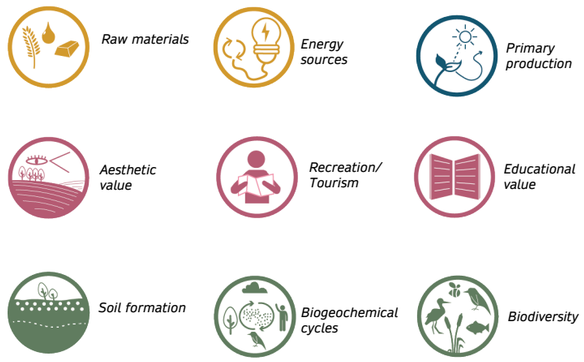
SCALE OF ACTION

RISK / IMPACT ON THE TARGET

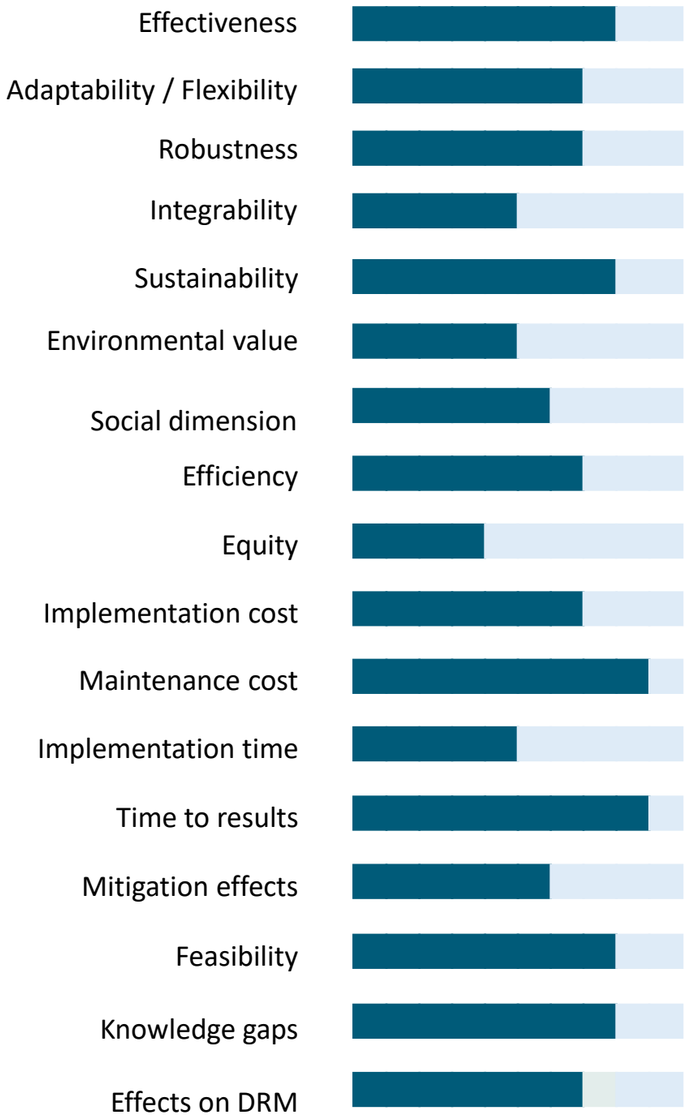




ECOSYSTEM SERVICES



INDICATORS



Mar Bella Park, Barcelona (Manuel Ruisánchez and Xavier Vendrell. Source: Arquitecturacatalana.cat

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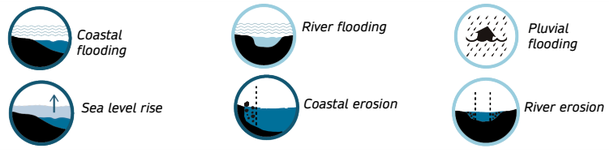
ADAPTA BLUES

FLOODING PROTECTION AREA | STRUCTURAL EbS | ACCOMMODATION SPONGING

Protected area, free of buildings, which serves to absorb the coastal regression resulting from the gradual sea level rise and storms.

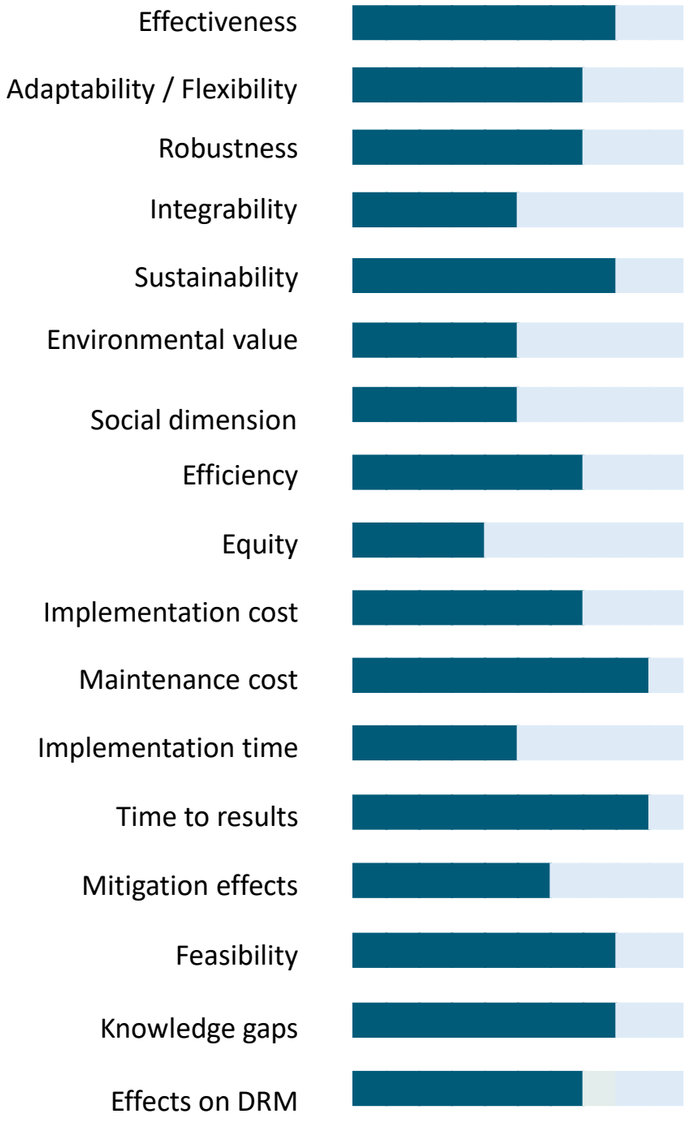
SCALE OF ACTION

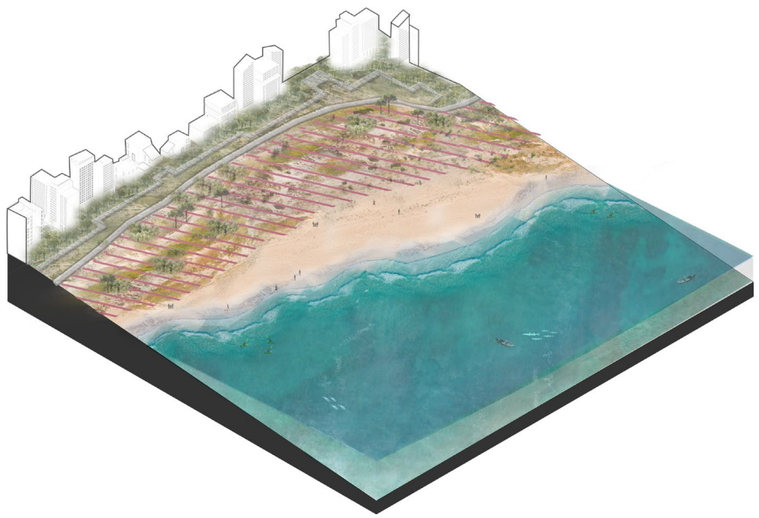
RISK / IMPACT ON THE TARGET



ECOSYSTEM SERVICES

INDICATORS





Corktown Common Park in Toronto. Source : MVVA

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https://www.wired.com/2014/08/a-gorgeous-park-designed-with-a-double-purpose-flood-protection/

STRATEGICAL INTERVENTIONS ON URBAN SERVICES | STRUCTURAL GREY | ACCOMMODATION SPONGING

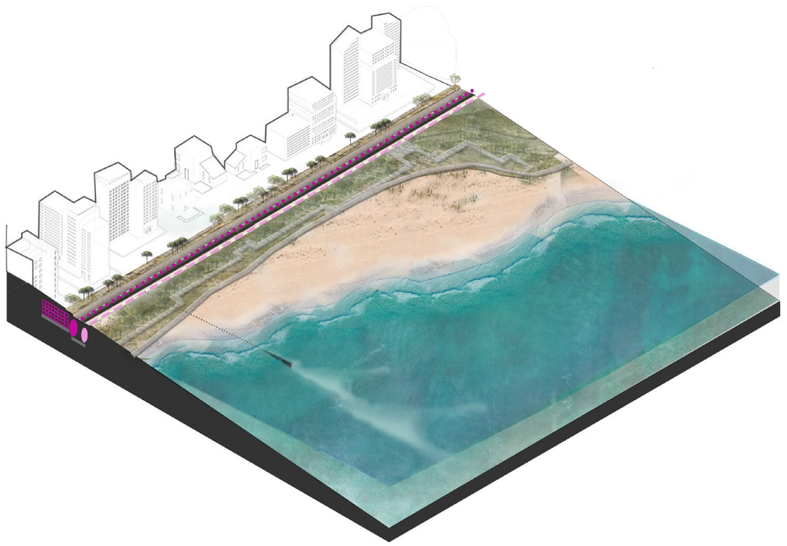
Stormwater management and urban planning techniques that aim to replicate hydrological processes in urban development, controlling runoff in the urban landscape. For instance, through the implementation of sustainable urban drainage systems (SUDS). Which, in addition to reducing the flow produced by rainfall, reduces the pollutants carried by runoff, minimizes the economic costs of stormwater management and improves the urban landscape.

SCALE OF ACTION

Local

RISK / IMPACT ON THE TARGET

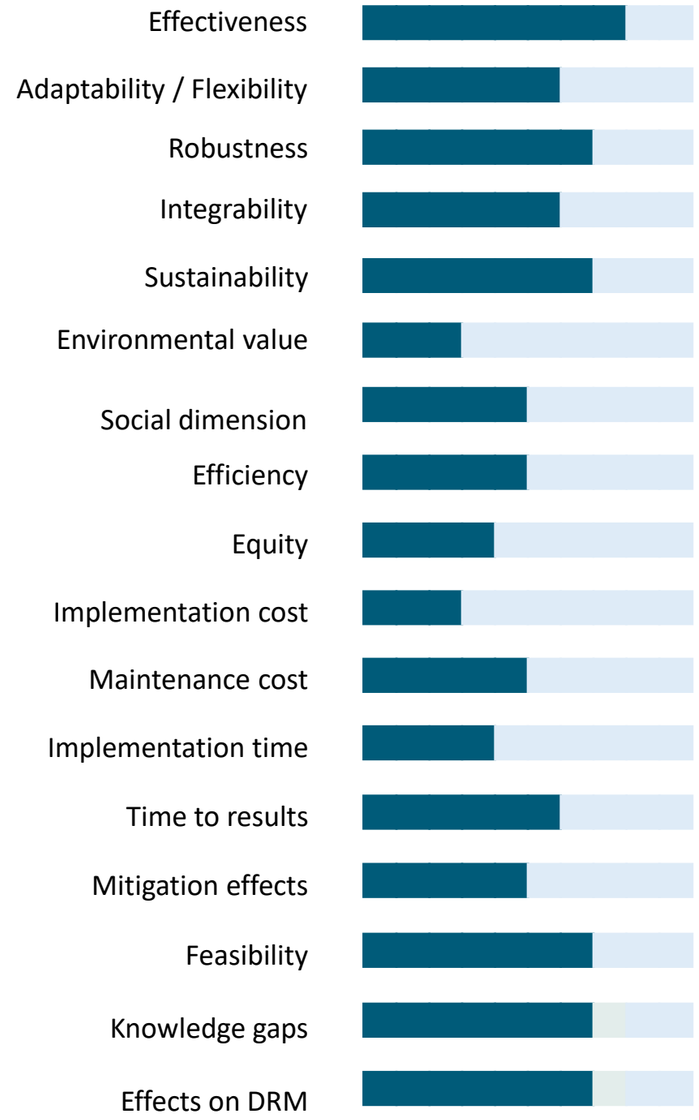
Pluvial flooding



ECOSYSTEM SERVICES

- Primary production
- Regulation of the water cycle
- Educational value
- Aesthetic value

INDICATORS



Garden-itinerary with built-in SUDS in Cehegín, Murcia, Spain. Source: How to Create Stories.

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USA, New York, 2014, Gowanus Sponge Canal, DLANDstudio

TH, Bangkok, 2014, Siam Cement Group HQ, LAB studio

CAN, Vancouver, 2009 Community Catalyst by Garon Sebastien

UK, Edinburgh, 2005, Forth Stormwater park, Hyland Edgar Driver studio

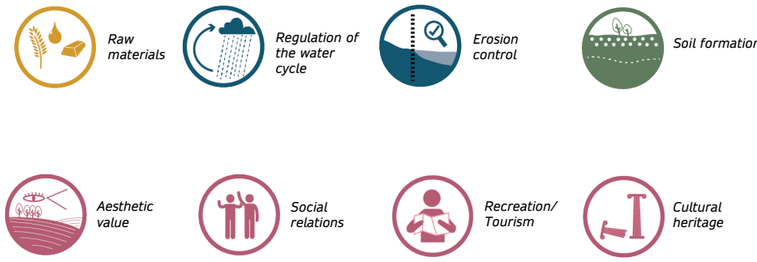
ARTIFICIAL BEACH

STRUCTURAL EbS

ACCOMMODATION ELEVATION

Sand area (or other materials), arranged on an elevated surface above the effects of flooding, with recreational uses similar to those of natural beaches.

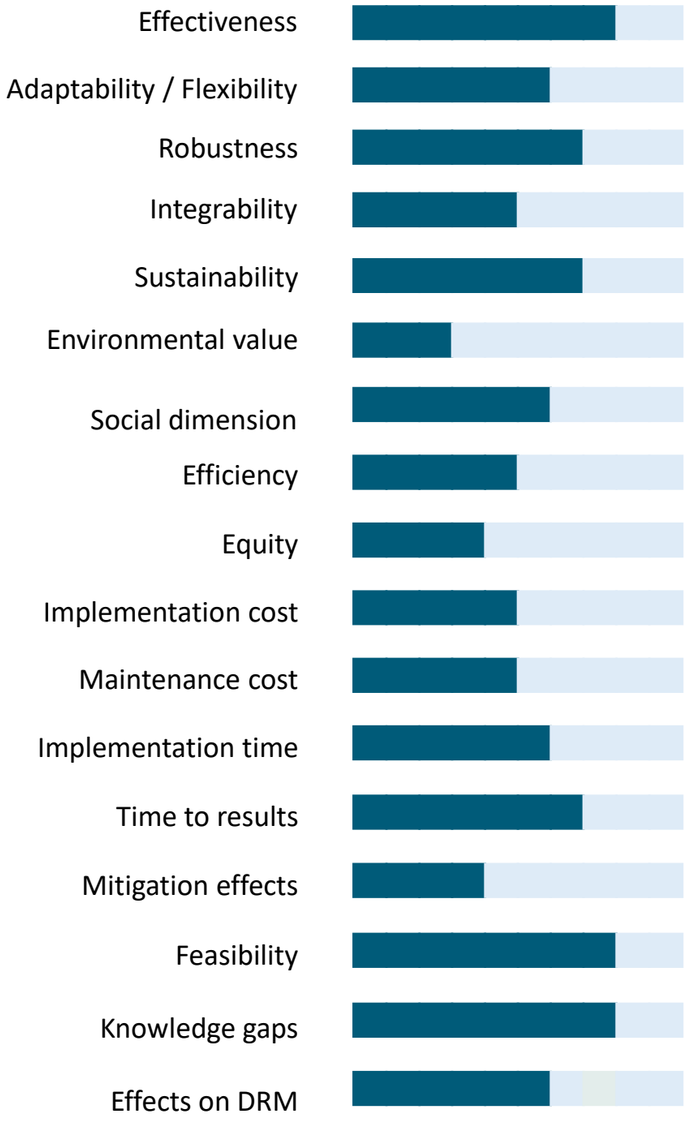
ECOSYSTEM SERVICES

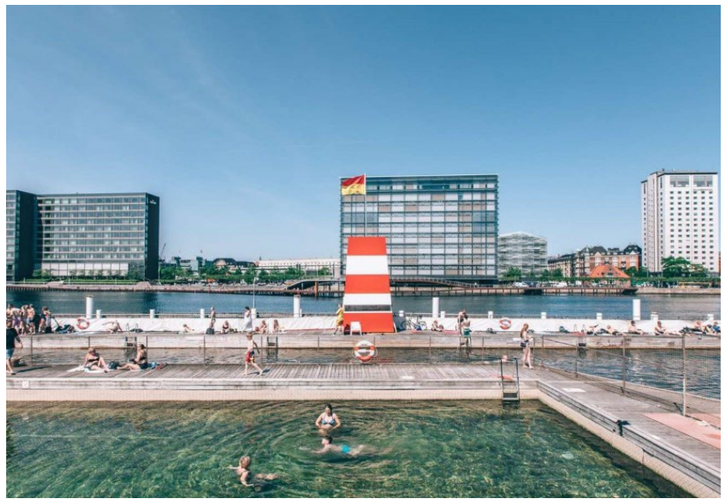


SCALE OF ACTION

RISK / IMPACT ON THE TARGET

INDICATORS





Islands Brygge artificial beach, Copenhagen. Source: Visit Copenhagen.

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ADAPTA BLUES

FLOODGATES

STRUCTURAL GREY

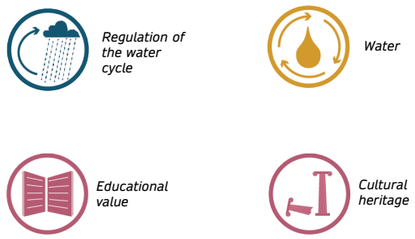
ACCOMMODATION RIVERS AND ESTUARIES

Floodgates are fixed installations that allow the flow of water under normal conditions and have structures that can be closed in the event of tidal surges, extreme meteorological tides or to regulate the flow in river discharges. They prevent flooding in urban settlements and infrastructure.

SCALE OF ACTION

RISK / IMPACT ON THE TARGET

ECOSYSTEM SERVICES



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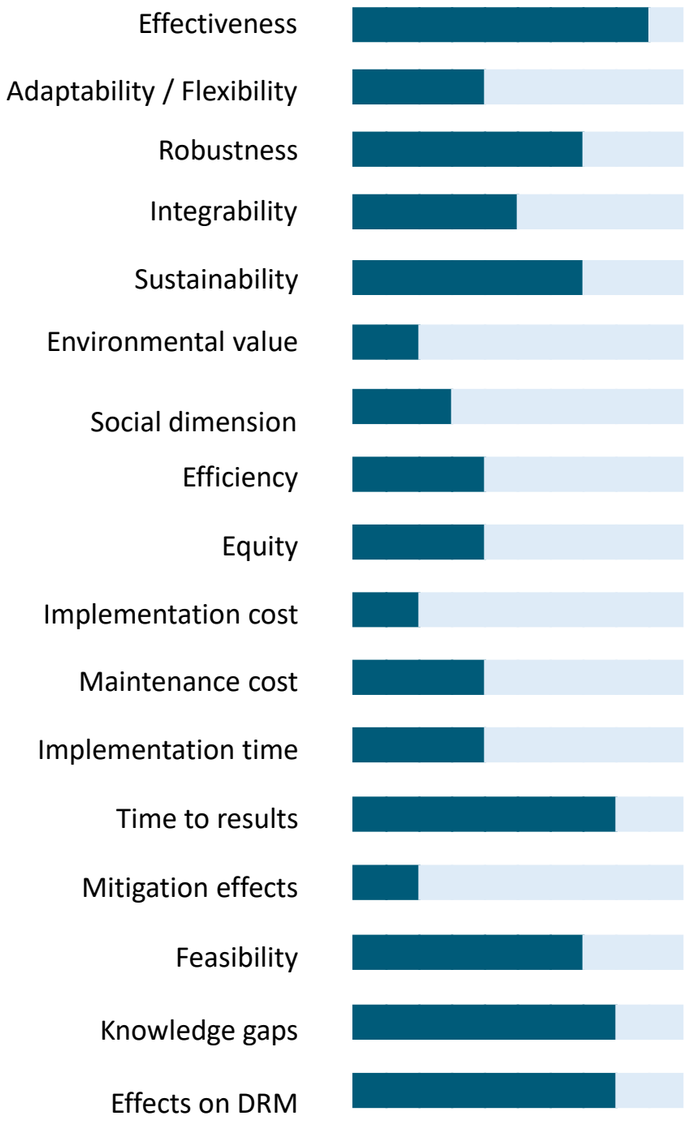

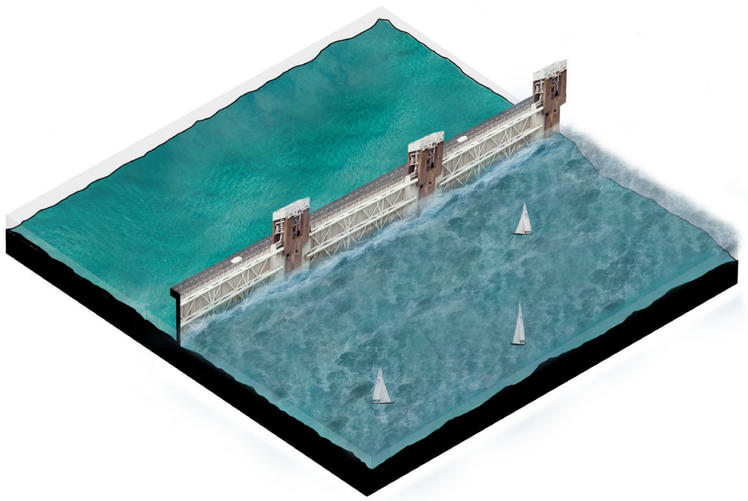

Gates at Bekhamste, UK. Source: River Trust.org

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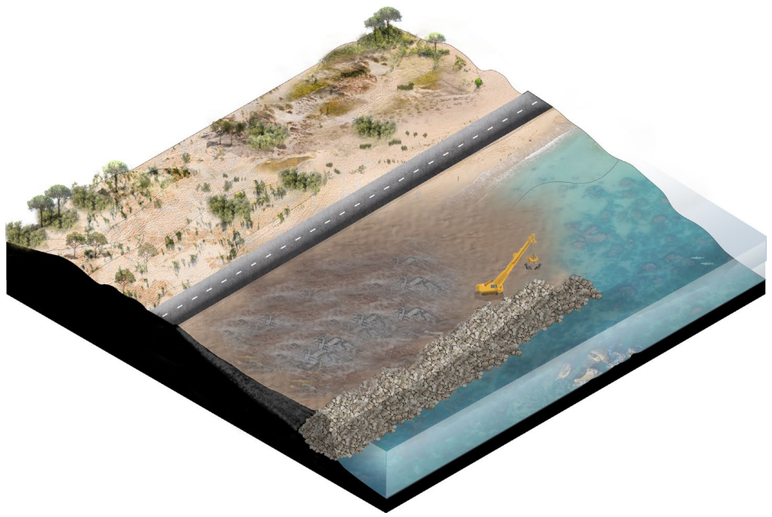
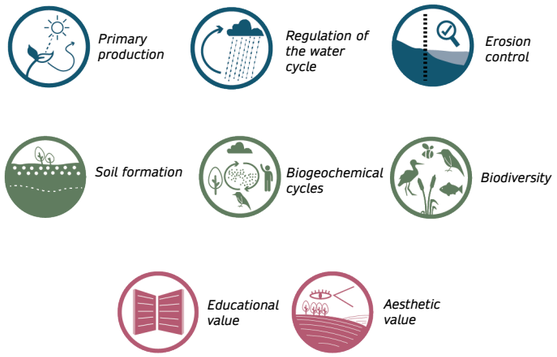
UK, Berkhhamste, 2018. New gates by Canals - River trust org

LANDCLAIM REOVERY | STRUCTURAL EbS | ACCOMMODATION RIVERS AND ESTUARIES

Removal of fill material in intertidal areas to restore the shoreline and increase the tidal prism in estuarine systems. The increase of the tidal prism allows the attenuation of current speeds and decreases flooding in estuarine areas.



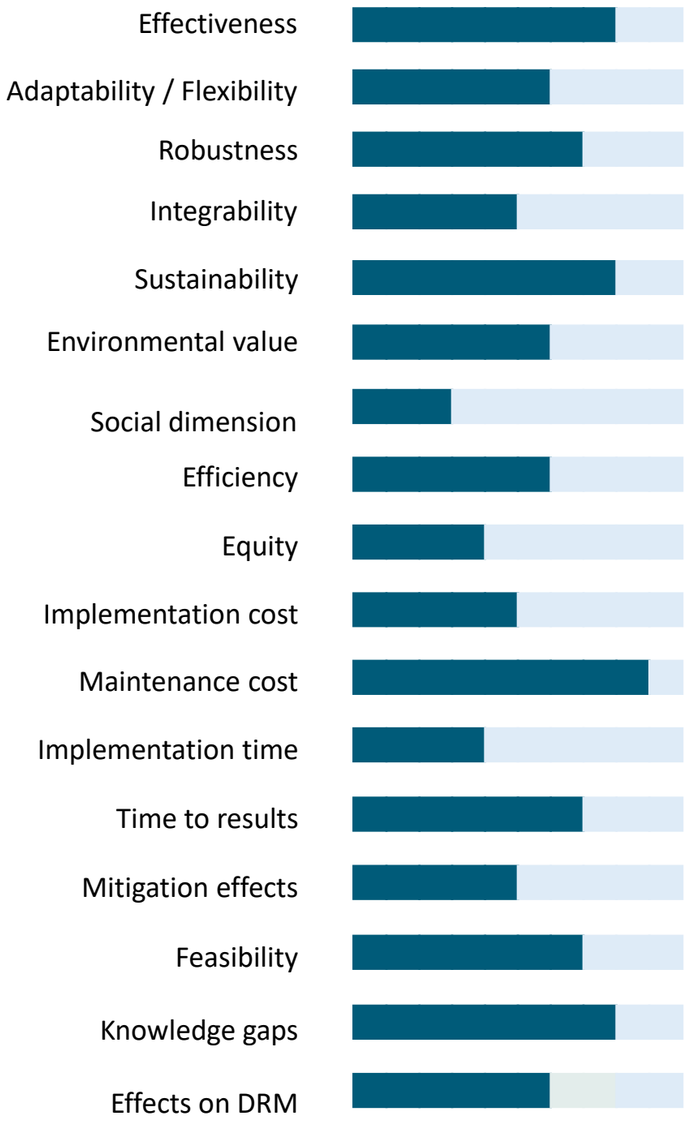
ECOSYSTEM SERVICES



SCALE OF ACTION

RISK / IMPACT ON THE TARGET

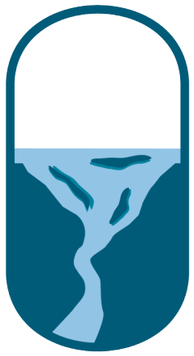
INDICATORS



Marsh restoration in Cantabria. Source: SEOBirdlife (https://seo.org/2016/10/21/restaurar-marismas-en-cantabria/)

REFERENCES

https://seo.org/2016/10/21/restaurar-marismas-en-cantabria/



MOUTH REGENERATION

STRUCTURAL EbS

ACCOMMODATION RIVERS AND ESTUARIES

Restore the natural rivers channels at their mouths to recover old riverbeds and generate flood zones.

SCALE OF ACTION


Watershed


City


Local

RISK / IMPACT ON THE TARGET


Coastal flooding


River flooding


Alteration of ecosystems

ECOSYSTEM SERVICES

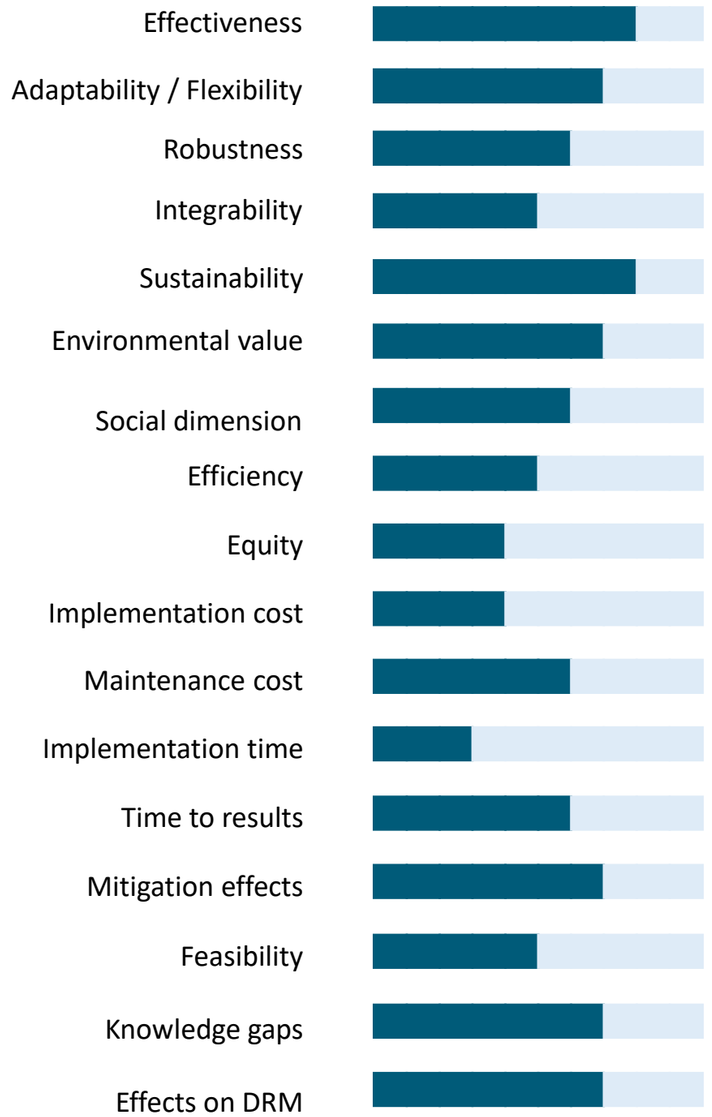

Erosion control

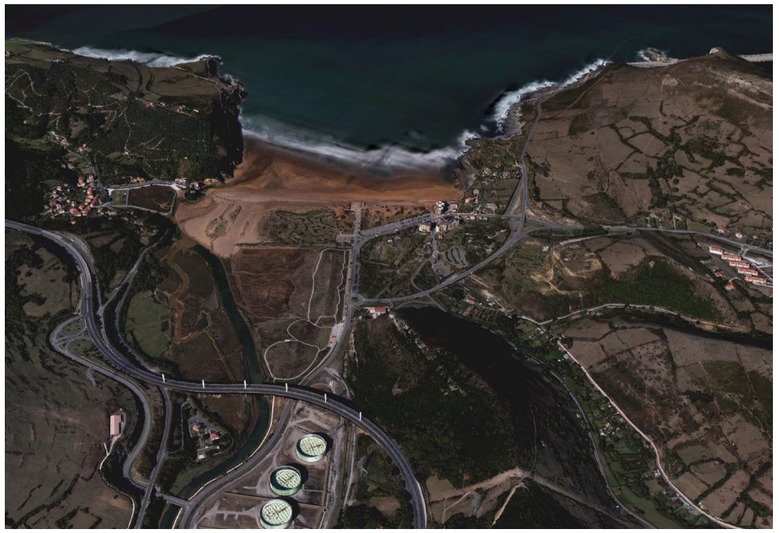

Erosion control


Educational value


Aesthetic value

INDICATORS





Reclamation of the mouth of the Barbadun, where there was once an oil industry. Source: GoogleEarth

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ADAPTA BLUES

SALTMARSH RESTORATION

STRUCTURAL EbS

ACCOMMODATION OF FLORA AND FAUNA

Active restoration of estuarine ecosystems and improvement of their functionality through the regeneration of the marsh communities characteristic of the study area. The restoration of the structural plant communities will favour the restoration and/or improvement of the fauna communities associated with the system.

SCALE OF ACTION

Watershed · City · Local

RISK / IMPACT ON THE TARGET

Coastal flooding · Coastal erosion · Sea level rise · Alteration of ecosystems

ECOSYSTEM SERVICES

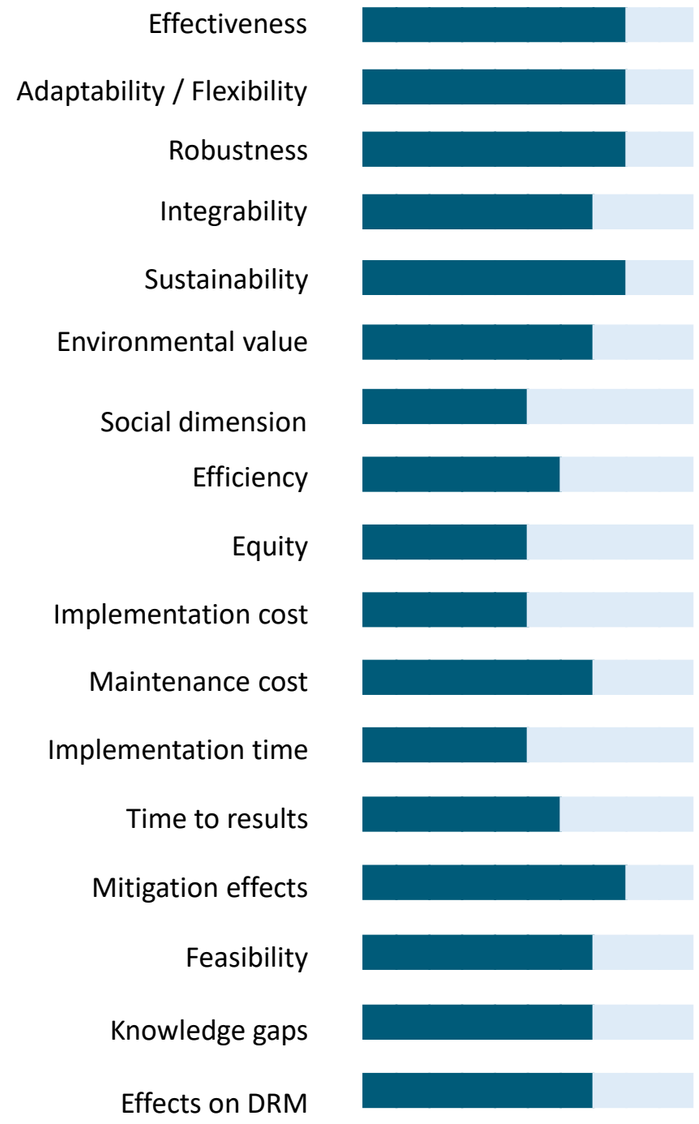
Raw materials · Energy sources · Air quality · Erosion control

Purification/improvement of water quality · Biological control · Pollinisation · Regulation of the water cycle

Educational value · Aesthetic value · Recreation/ Tourism · Cultural heritage

Soil formation · Biogeochemical cycles · Biodiversity

INDICATORS



Hydrodynamic restoration project of the marshes in the Ria del Capitan (Cantabria). Source: ConviveLife

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ADAPTA BLUES

WETLAND REGENERATION

STRUCTURAL EbS

ACCOMMODATION OF FLORA AND FAUNA

Wetland regeneration consists of restoring the physical, chemical or biological characteristics of an altered or degraded wetland in order to return it to its natural functions. These terrestrial and coastal wetland ecosystems are fundamental in the adaptation and mitigation of climate change.

SCALE OF ACTION

Watershed

City

Local

RISK / IMPACT ON THE TARGET

Coastal flooding

River flooding

Pluvial flooding

Alteration of ecosystems

ECOSYSTEM SERVICES

Raw materials

Energy sources

Water

Climate regulation

Air quality

Erosion control

Purification/improvement of water quality

Biological control

Pollinisation

Regulation of the water cycle

Primary production

Aesthetic value

Recreation/ Tourism

Cultural heritage

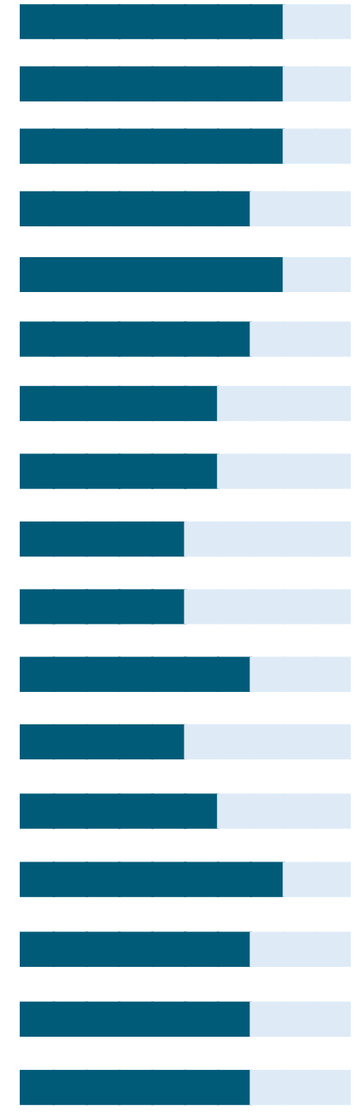
Educational value

Soil formation

Biogeochemical cycles

Biodiversity

INDICATORS



Harbin Cultural Center Wetland Park, China. Source: Turenscape.

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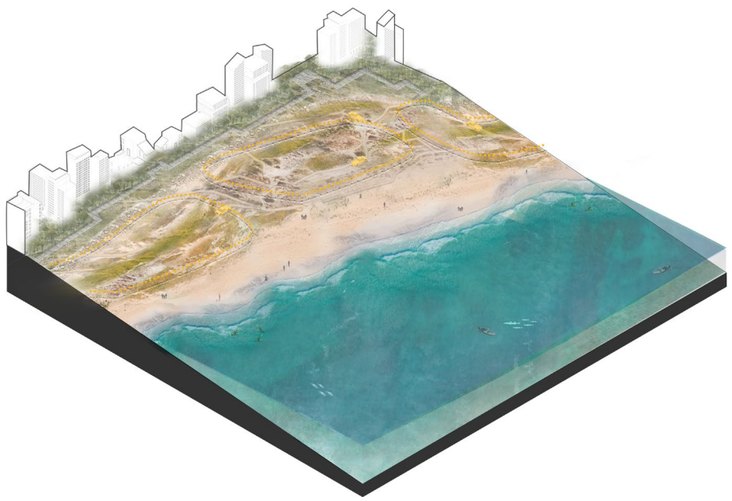
ADAPTA BLUES

FLORA AND FAUNA CONSERVATION

STRUCTURAL EbS

ACCOMMODATION OF FLORA AND FAUNA

Programs focused on the conservation of habitats that regulate the effects of climate change (erosion, flooding, saline intrusion, etc.).



ECOSYSTEM SERVICES

- Raw materials
- Energy sources
- Air quality
- Erosion control
- Purification/improvement of water quality
- Biological control
- Pollinisation
- Regulation of the water cycle
- Climate regulation
- Valor educativo
- Recreation/ Tourism
- Cultural heritage
- Educational value
- Aesthetic value
- Biogeochemical cycles
- Biodiversity
- Soil formation

Maintenance work in Barcelona's parks and gardens. Source: Parcs i Jardins de Barcelona

REFERENCES

SCALE OF ACTION

Local

RISK / IMPACT ON THE TARGET

- Coastal flooding
- Coastal erosion
- Aumento del nivel del mar
- Atmospheric pollution
- River flooding
- Erosión costera
- Alteration of ecosystems
- Contaminación acuática

INDICATORS

- Effectiveness
- Adaptability / Flexibility
- Robustness
- Integrability
- Sustainability
- Environmental value
- Social dimension
- Efficiency
- Equity
- Implementation cost
- Maintenance cost
- Implementation time
- Time to results
- Mitigation effects
- Feasibility
- Knowledge gaps
- Effects on DRM

RETREAT MEASURES

ADAPTA BLUES

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

NAME

descripción

CLIMATE CHANGE ADAPTATION STRATEGIES

AVANCE
Seawards

PROTECCIÓN
Protection

ACOMODACIÓN
Consolidating

RETROCESO
Inland

CLASSIFICATION ACCORDING THE STRUCTURE OF EACH COMPONENT

Strategy and management

Natural component

Nature-based component

Structural component

Non-structural component

PROTECTION

The coastal ecosystem has its own natural methods to protect itself from the water-earth border effects. Due to antropization, ecological weakening, and the growing climate change adaptation threat, it is necessary to reinforce these protections or to generate new ones in when they are completely extinct.

REINFORCEMENT
Those components are the ones that adhere to an existing protection, which is in damaged or has become insufficient.

LIVING SHORELINES
Breakwater designed to allow the settlement of a biological community, incorporating co-benefits such as carbon storage, increased biodiversity and reinforcement of the structure through bioprotection.

TERRACED EDGE
Relatively flat and sloping surface in contact with the sea, which reduces wave activity.

DUNE SYSTEM
Deposits of sand and gravel shaped by wind and waves on the shoreline. It is a flexible natural protection against erosion and flooding.

BERM
Nearly horizontal shore parallel ridge formed on the beach due to the landward transport of the coarsest fraction of the beach material by the wave uprush.

REINFORCED BANK
Whole or part of bank artificially strengthened for bank protection purposes.

REINFORCED BANK
Whole or part of a river or estuarine bank strengthened with natural materials for bank protection purposes.

REINFORCED CLIFFS
Whole or part of a coastal cliff strengthened with natural materials for bank protection purposes.

TIDE POOLS
An isolated pocket of seawater found in the ocean's intertidal zone.

BARRIER
Structures that protect the continent, lagoons, wetlands and marshlands from the wind, waves adn tidal energy.

DIKE
Manmade structure designed to protect low-lying areas from flooding from the sea or ocean.

SEAWALL
A wall or embankment erected to prevent the sea encroaching on or eroding an area of land.

OYSTER REEFS
Dense aggregations of oysters that form large colonial communities. They function as a natural filter and improve water overloaded with nutrients while acting as a barrier to reduce wave energy, prevent erosion, and fortify wetlands.

EMBANKMENT
An artificial earthen wall, often meant to prevent flooding of the hinterland.

SEAWARDS

This strategy mainly fights against the risk of erosion on the coastline. To face this threat, the coastline is advanced in order to stabilize its profile. Beyond facing danger, the benefit of this strategy is the increase of public space. It is usually used in situations where there is a lack of it.

ADVANCE THE LINE WITH SEDIMENT
Seawards components, mainly with sand or clay, through nourishing or catchment.

SEDIMENT TRAPS
Small ponds placed between the inlet and the main wetland to promote sedimentation of coarse particles before water is distributed through the wetland.

SAND NOURISHMENT
Sand addition to the coastal system to mitigate the consequences of previous erosion.

CHANGES IN GRANULOMETRIC COMPOSITION
Replacement of sands with gravels, pebbles or other sands of larger diameter to increase beach stability.

ADVANCE THE LINE WITH FLORA AND FAUNA
To advance the coastline with new ecosystems or strenghten the existing ones.

MARINE ANGIOSPERMS
Angiosperm communities that increase the available sediment for organism and attenuate water velocity associated with currents and waves

KELP FORESTS
Underwater areas with a high density of brown algae that favor attenuation of current velocity.

ADVANCE THE LINE WITH STRUCTURES
Engineering works into the sea and change coastal dyanmics.

GROYNE
A low wall or sturdy barrier built out into the sea from a beach to check erosion and drifting.

ACCOMMODATION

Through this strategy, the confrontation between land and sea is not so much sought, as the adaptation of this environment to the continuous contact between the different ecosystems. The different measures focus on generating a transition zone on the shoreline where appropriate exchanges can take place and, in this way, improve the resilience of the whole.

LAND SPONGE
Set of measures to increase the filtering capacity of the land near the coast.

COASTAL PARK
Public park designed as a protection area against maritime flooding with recreational and educational uses.

SEA REGRESSION AREA
Land reserve to mitigate the coastal regression caused by the sea level rise and storms.

FLOODING PROTECTION AREA
Protected area, free of infrastructures, designed to mitigate the coastal regression caused by sea level rise and storms.

STRATEGICAL INTERVENTIONS ON URBAN SERVICES
Water management and urban planning techniques that aim to imitate hydrological processes in urban development by controlling runoff in the urban landscape.

RISING
Components intended to raise elements and areas of the coast that need to be protected from flooding.

ARTIFICIAL BEACH
A man-made beach designed as a sand surface on an elevated area free of the effects of flooding.

RIVERS AND ESTUARIES
Works on fluvial areas near the coast to improve its interaction with the sea.

FLOOD GATES
Control of water flows in channels by hydraulic mechanical devices.

LANDCLAIM RECOVERY
Removal of fill material to restore the shoreline and coastal habitats.

MOUTH REGENERATION
Removal of channelizations at river mouths to recover floodplains.

SALTMARSH REGENERATION
Restoration of coastal wetlands by saltmarsh communities to improve the ecosystem services of flood control and filter water.

WETLAND REGENERATION
Restoration of wetlands dominated by herbaceous communities, that form a transition between aquatic and terrestrial ecosystems.

FLORA AND FAUNA CONSERVATION
Conservation programs to protect habitats that act as regulators of the effects of climate change (erosion, flooding, saline intrusion, etc.)

RETREAT

Measures, mainly urban and territorial planning, that seek to create a safe space for flooding and protect assets by reducing exposure by setting them back.

RIVERS AND ESTUARIES
Works on fluvial areas near the coast to improve its interaction with the sea.

ASSET RELOCATION
Relocation of existing infrastructure, assets and/or real estate to a new place that is not currently at risk.

PLANNED REALIGNMENT
Procedures for creating a new position for the coastline through engineering.

NON-STRUCTURAL

They consist of a series of physical and programmatic policies designed according to the needs of a community and the level of risk to which it is exposed. Their main goal is minimizing it and improving coastal resilience. These types of programs seek to avoid unconscious development and help the population prepare against floods.

EARLY WARNING SYSTEMS
A warning system that can be implemented as a chain of information communication systems and comprises event detection and decision subsystems for early identification of hazards (in time to minimize the effects of the event)

RISK TRANSFER MESAURES
Development of communication tools about the risk on the coastal area

MEDIA TRAINING
Development of training programs in communication about the status and actions on the coast.

RESEARCH ON COASTAL RESILIENCE
Support for projects that investigate new adaptation mechanisms or the improvement of existing ones.

EDUCATION PROGRAMS IN RESILIENCE
Transfer of "know-how" on coastal adaptation in educational programs from kindergartan to university.

REGULATORY

Regulation measures that complement, complete, or partially replace the structural ones include modifications in public policies, management practices, regulatory policies, and tax collection policies.

COASTAL PROTECTION PLAN
Development of a protection plan to preserve the goods and services of the littoral areas.

INSTITUTIONAL AND MANAGEMENT MESAURES
A set of measures to promote coordinated and coherent action in climate change adaptation and risk management on the coast.

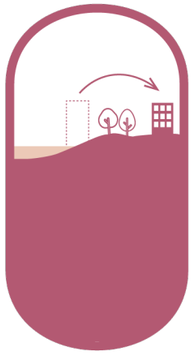
MOBILITY MANAGEMENT
Development of an optimal public transportation network to reduce the need for private vehicles. It also includes changes in the mobility of the area.

STRATEGIC RETREAT POLICIES
Management of human settlements and infrastructures to delay their position to safety areas.

SPECIFIC PLANNING SYSTEMS
Development of coastal planning for climate change adaptation and risk prevention.

WATER MANAGEMENT POLICIES
Water cycle planning and management system, both for the water supply and wastewater systems. It includes plans, projects and actions.

LANDLAB

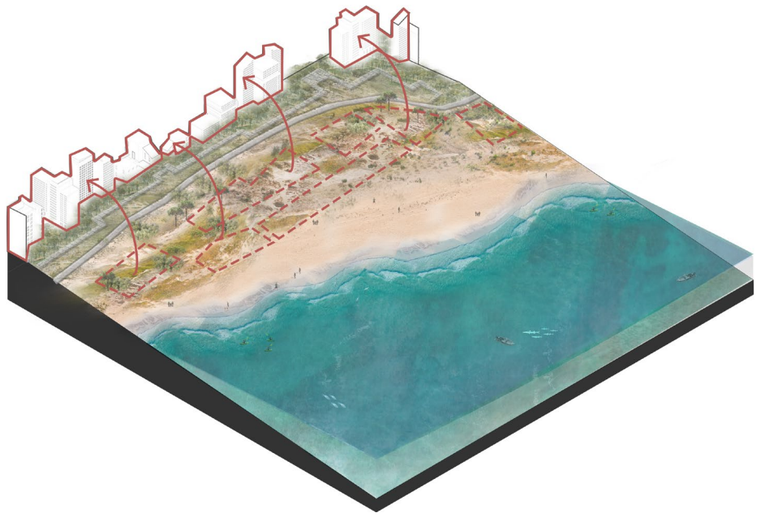


ASSET RELOCATION

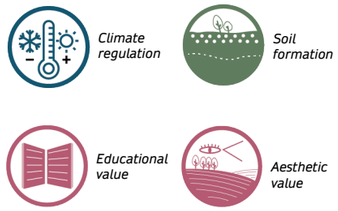
STRUCTURAL GREY

RETREAT

Relocation of existing infrastructure, assets and/or real estate from their current placement to a non-risk location at the present time, reducing the capital exposed to the hazards foreseen by the climate change and therefore reducing the risk associated with such events.

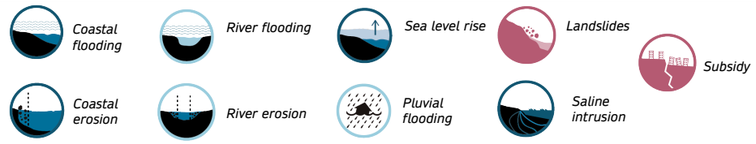


ECOSYSTEM SERVICES

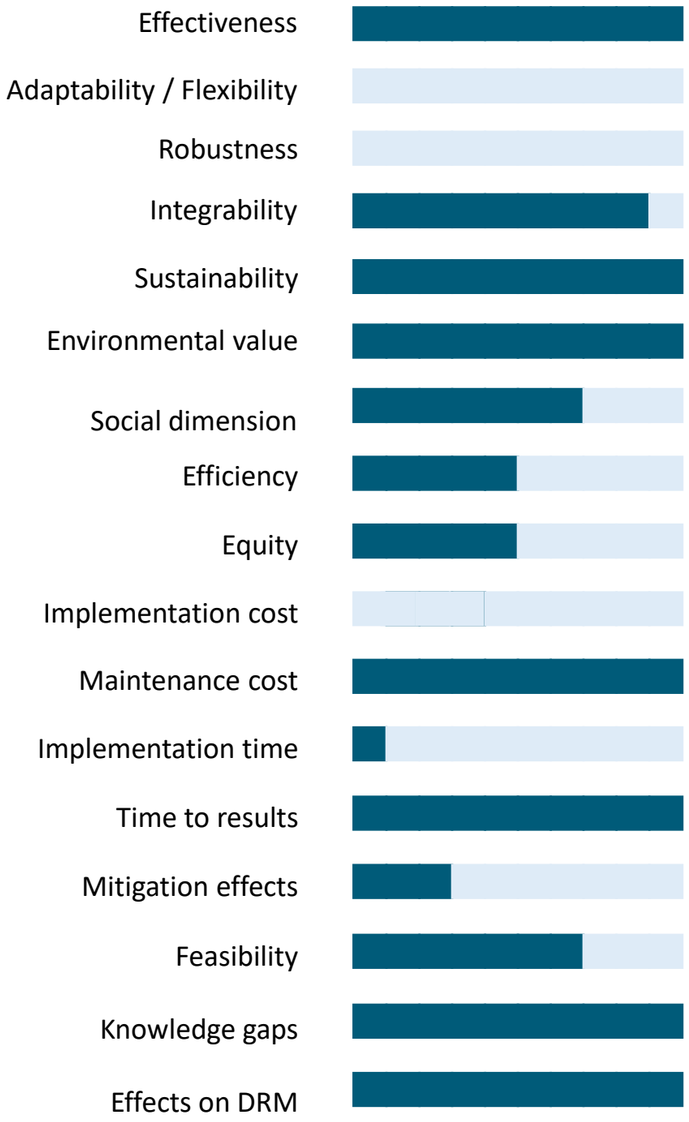


SCALE OF ACTION

RISK / IMPACT ON THE TARGET



INDICATORS



Properties on a cliff in Mallorca. Source: Última Hora.

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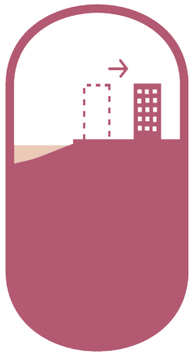
https://www.ultimahora.es/noticias/local/2022/11/08/1824935/expertos-avisan-mallorca-debe-retranquear-100-metros-blindar-acantilados.html

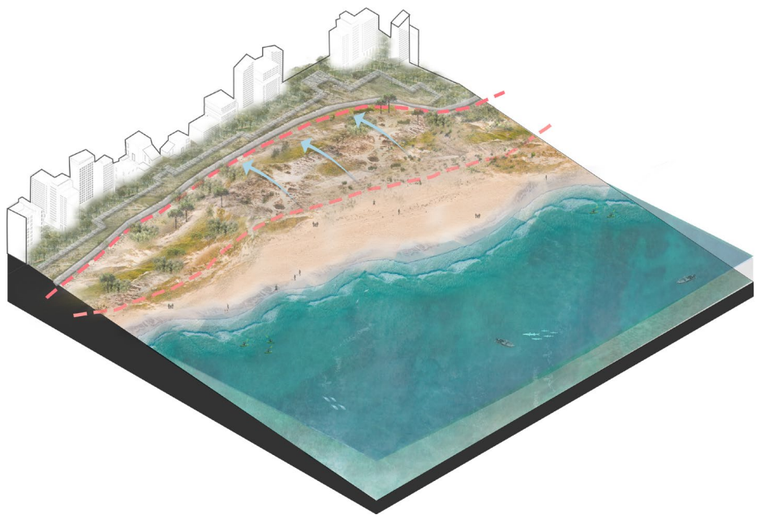


PLANNED REALIGMENT

STRUCTURAL GREY

RIVER AND ESTUARY ACCOMMODATION

Management of the necessary expropriations and affectations to carry out the setback with respect to the coast.

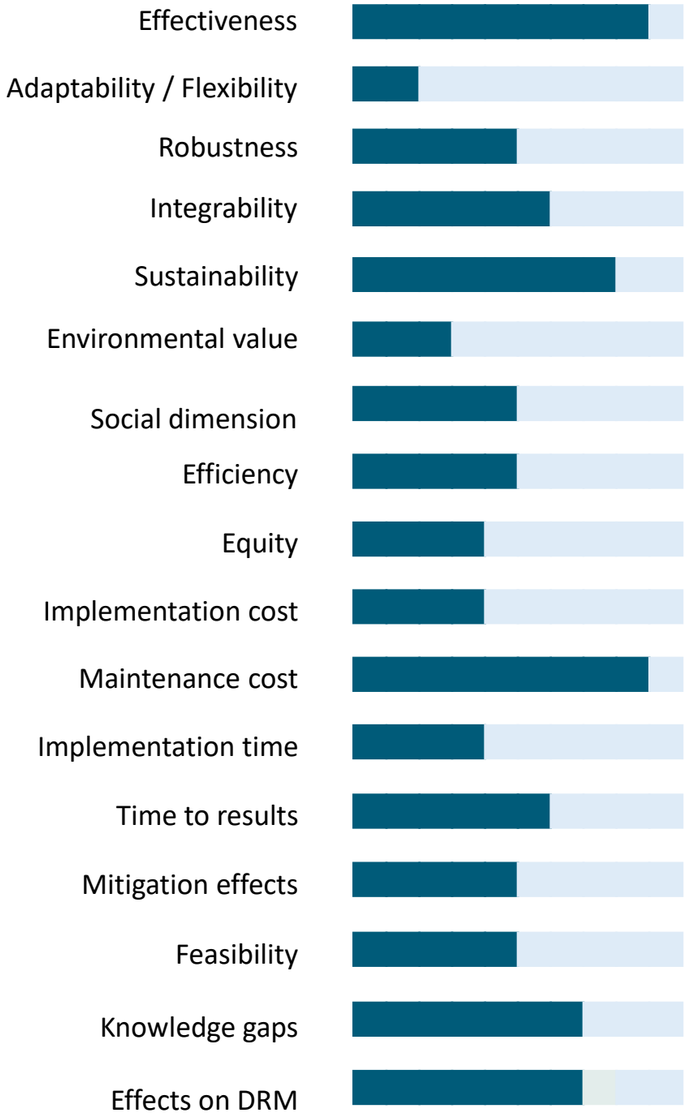


ECOSYSTEM SERVICES

SCALE OF ACTION

RISK / IMPACT ON THE TARGET

INDICATORS



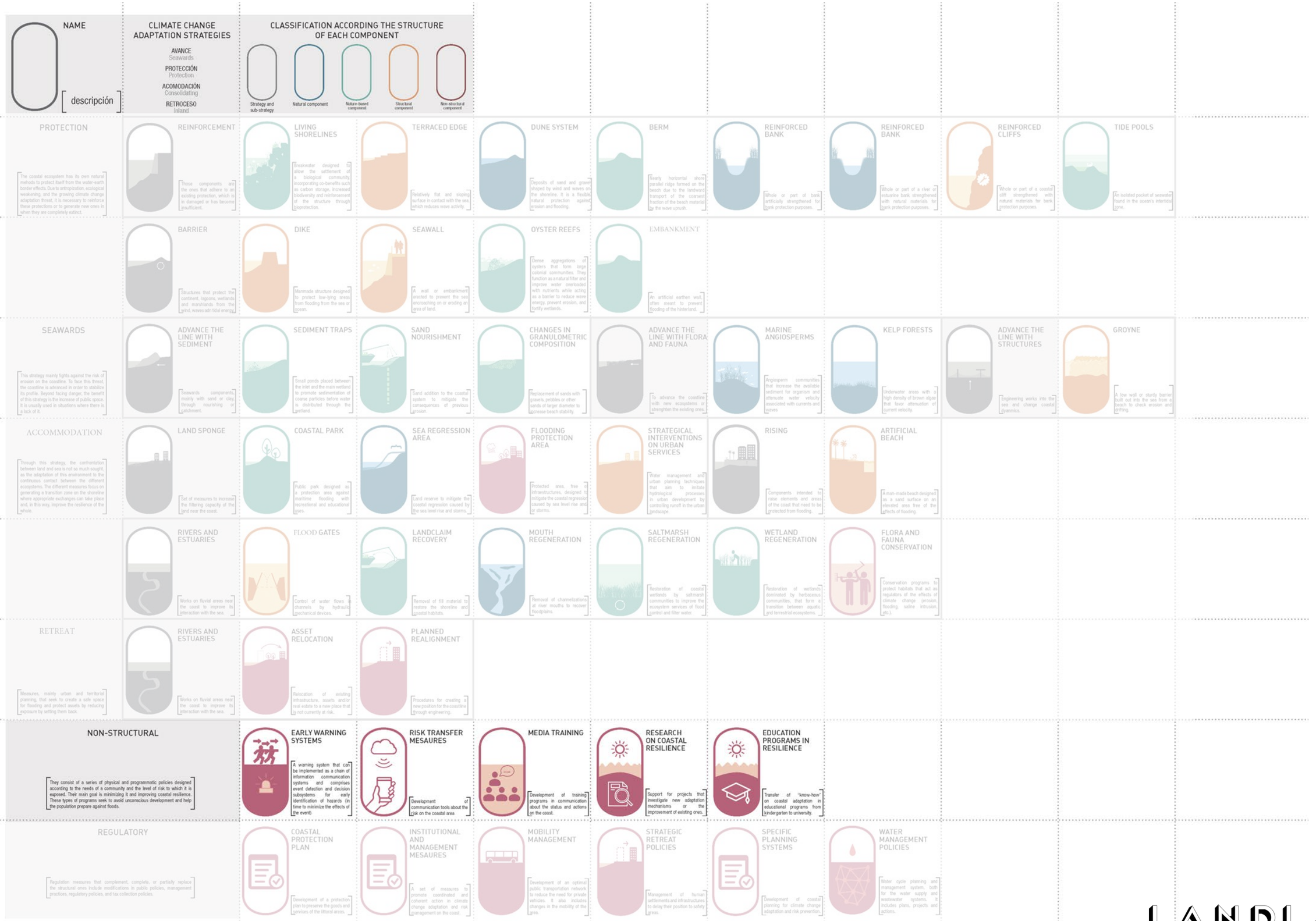
Landscape recovery of the Tudela-Culip site at Cap de Creus, former holiday resort, Spain.Source: Estudi Martí Franch.

REFERENCES

NON-STRUCTURAL MEASURES

ADAPTA BLUES

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA



LANDLAB

ADAPTA BLUES

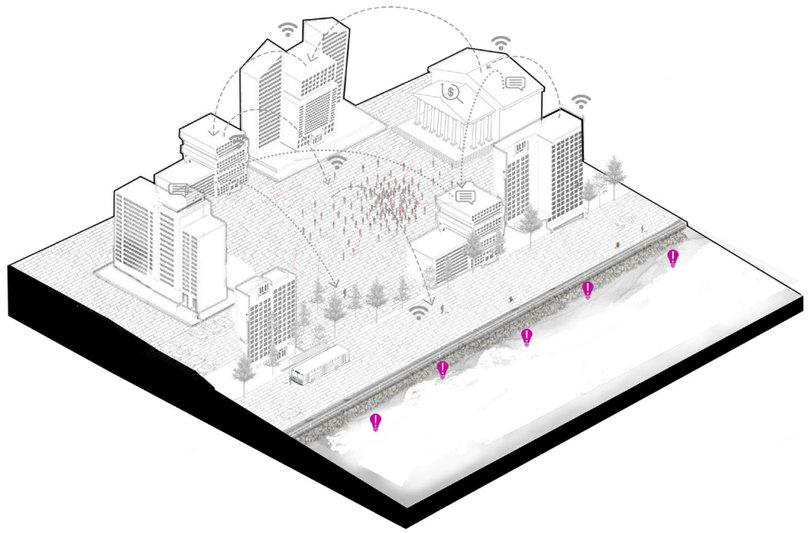
EARLY WARNING SYSTEMS

SOCIAL

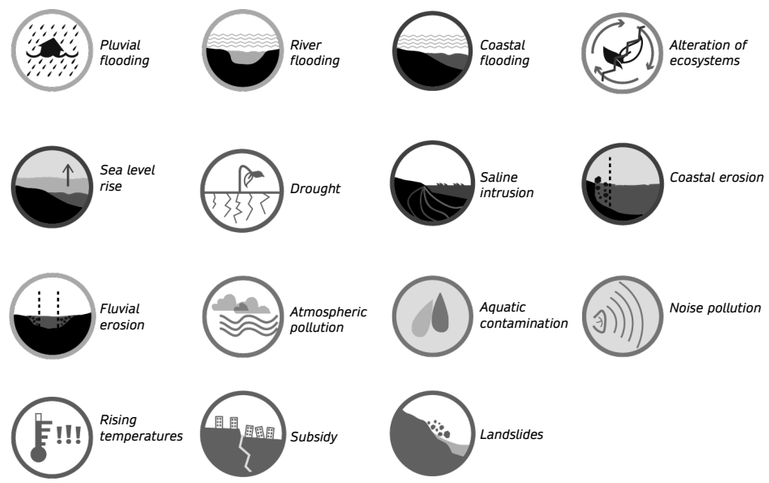
NON-STRUCTURAL

Early warning systems are a set of systems and processes for monitoring, hazard forecasting and prediction, disaster risk assessment, communication and preparatory activities that enable individuals, communities, governments, businesses and other actors to take timely action to reduce the risk of disasters before hazardous events occur.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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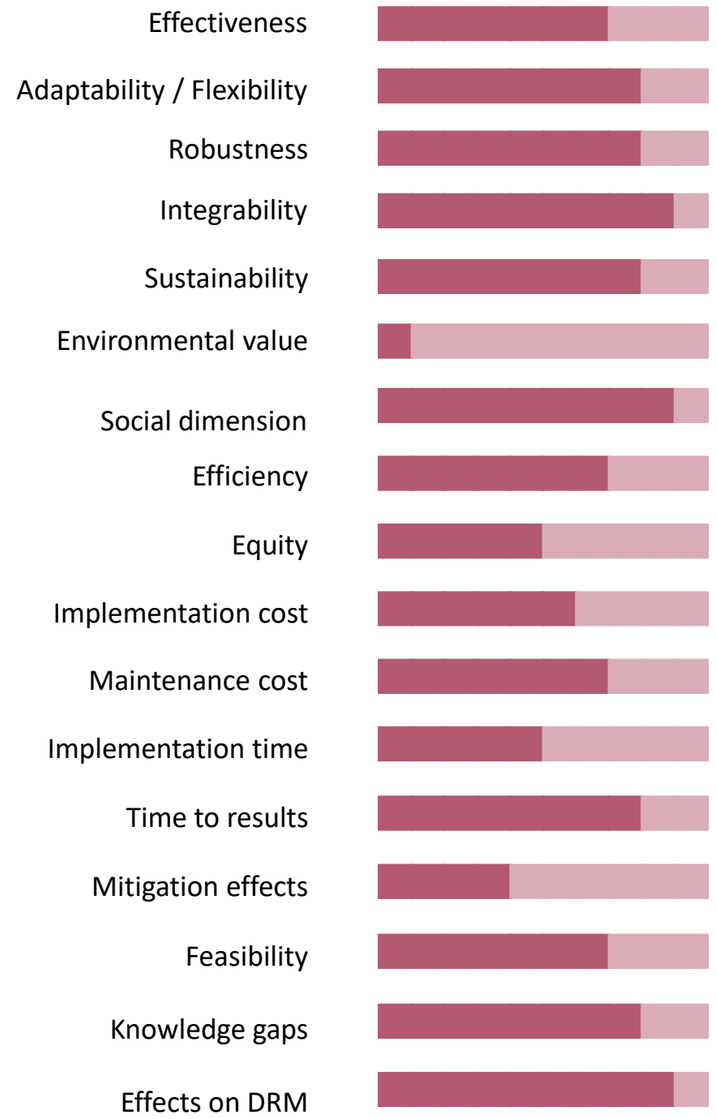


Coastal flooding episode. Source: Logan Abassi.

REFERENCES

https://www.un.org/es/climate-change/climate-solutions/early-warning-systems

ADAPTA BLUES

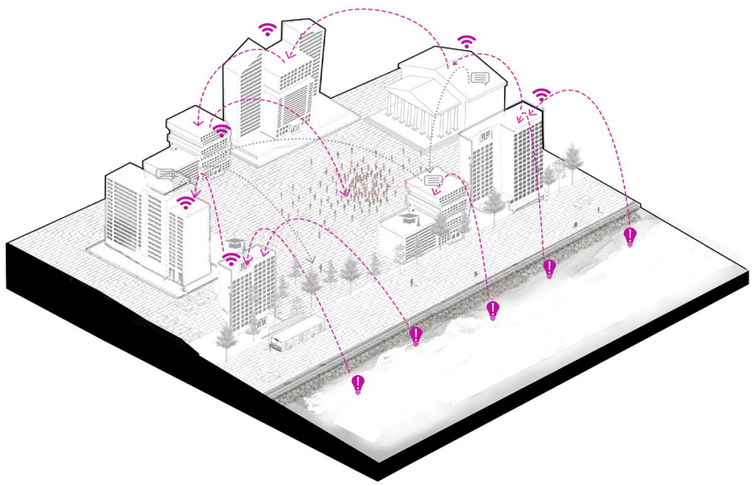
RISK TRANSFER MEASURES

SOCIAL

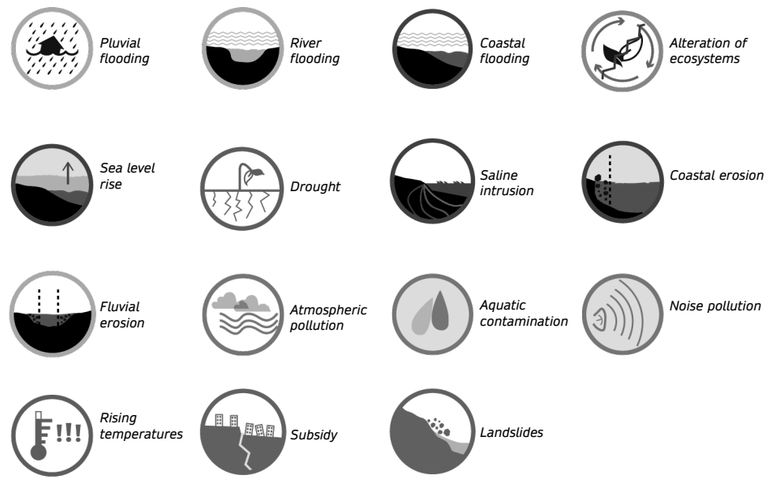
NON-STRUCTURAL

Risk transfer measures include a wide variety of activities focused on different audiences and implemented by different actors, such as media (radio, television, newspapers), public bulletins, permanent exhibits (memorials, museums, watermarks), commemorative activities, conferences, and signs in low-lying areas. Activities whose goals are to improve public and political awareness of the hazards related to the analyzed threat.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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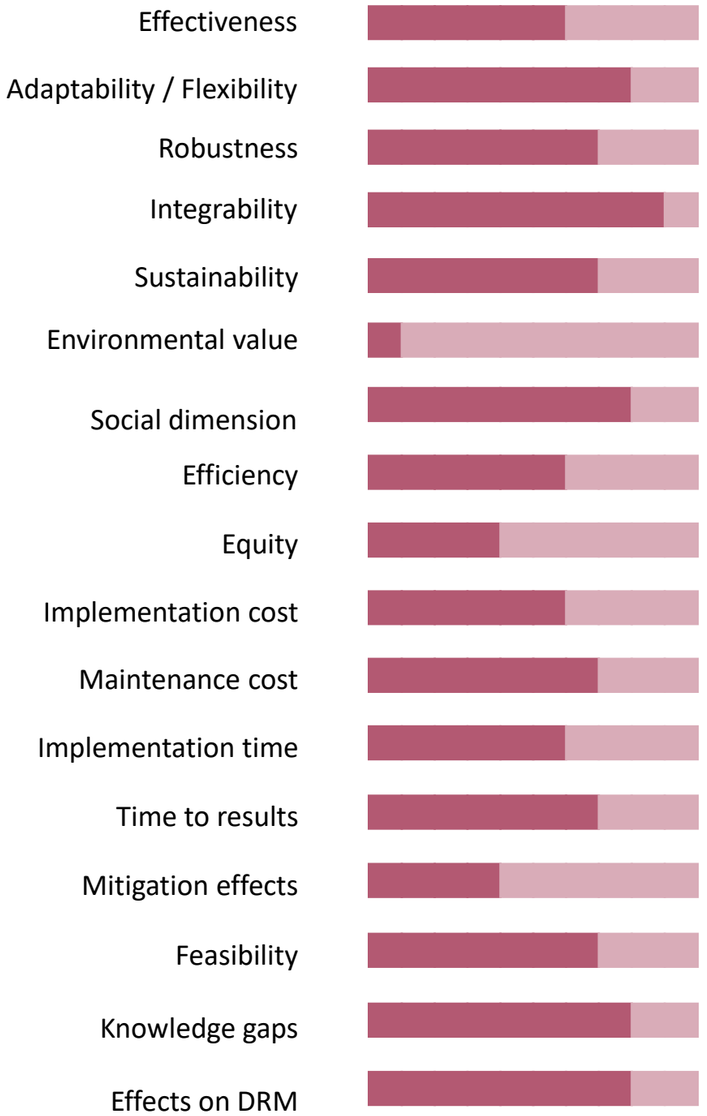

Coastal flooding episode. Source: Logan Abassi.

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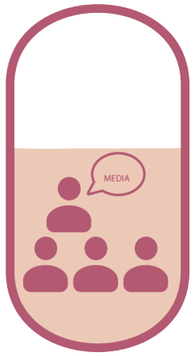


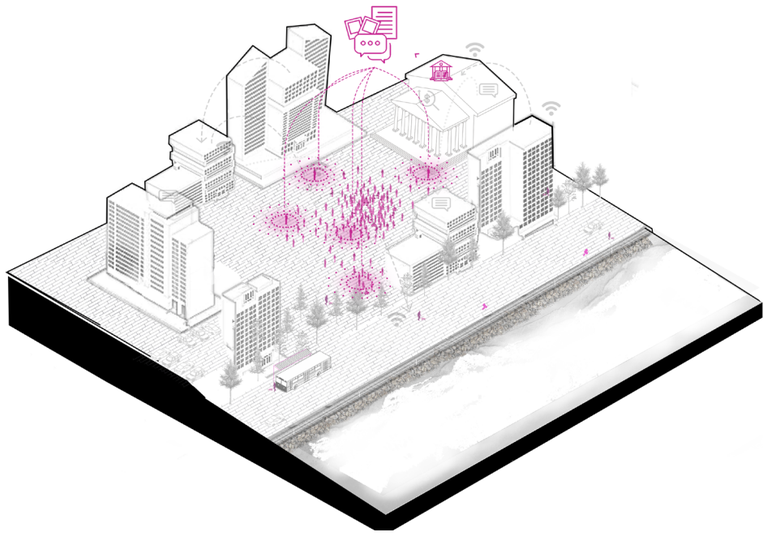
MEDIA TRAINING

SOCIAL

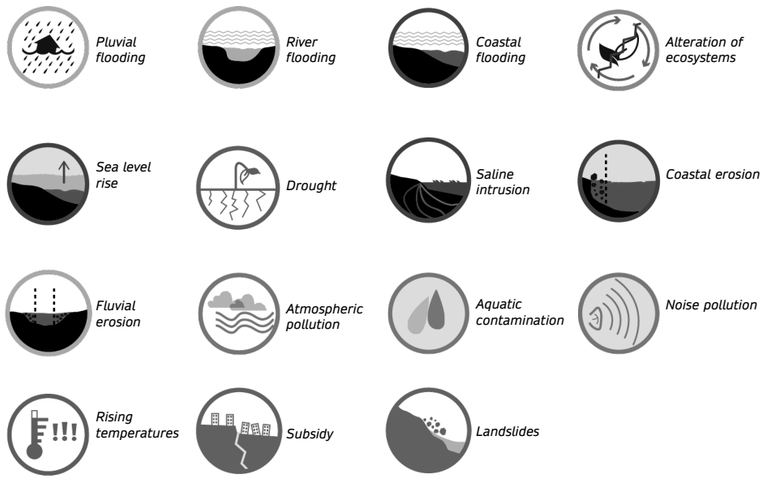
NON-STRUCTURAL

Development of training programs in communication with the state and actions of the coast.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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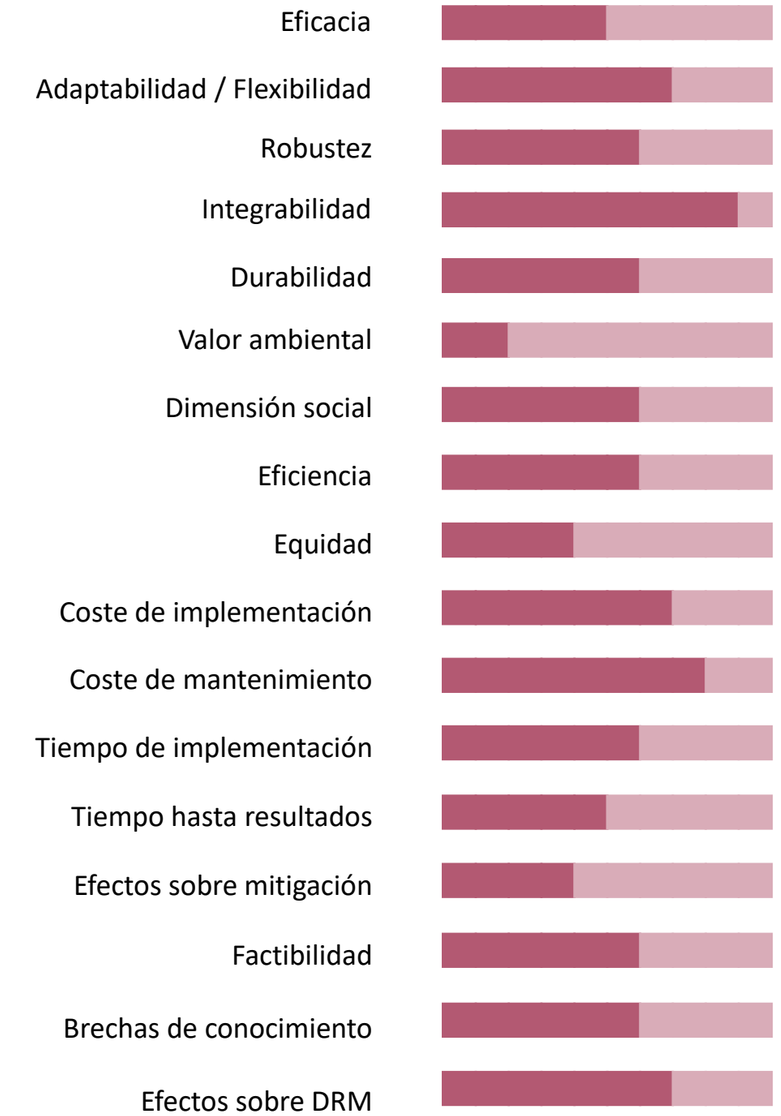


Coastal flooding episode. Source: Logan Abassi..

REFERENCES

ADAPTA BLUES

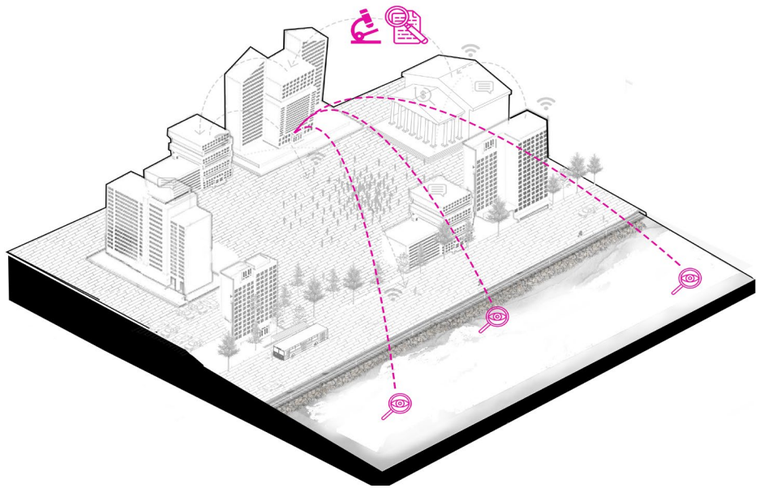
RESEARCH ON COASTAL RESILIENCE

INSTITUTIONAL

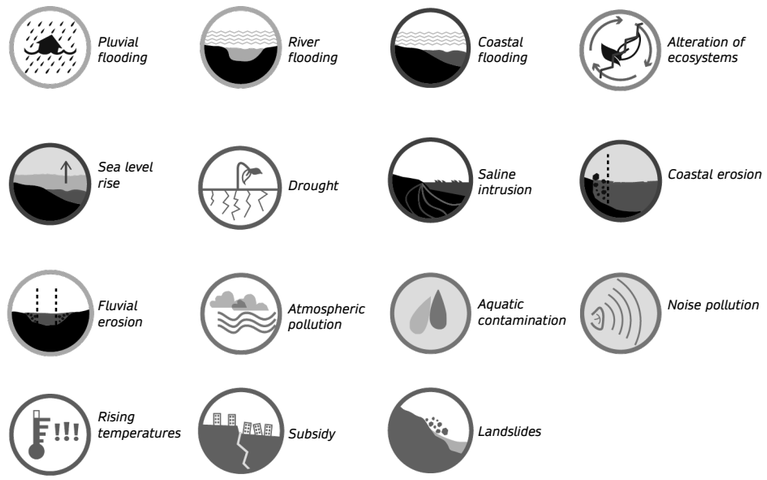
NON-STRUCTURAL

Funding for projects that research new mechanisms and tools to contribute to making countries and communities more resilient and improve their capacity to fight climate change.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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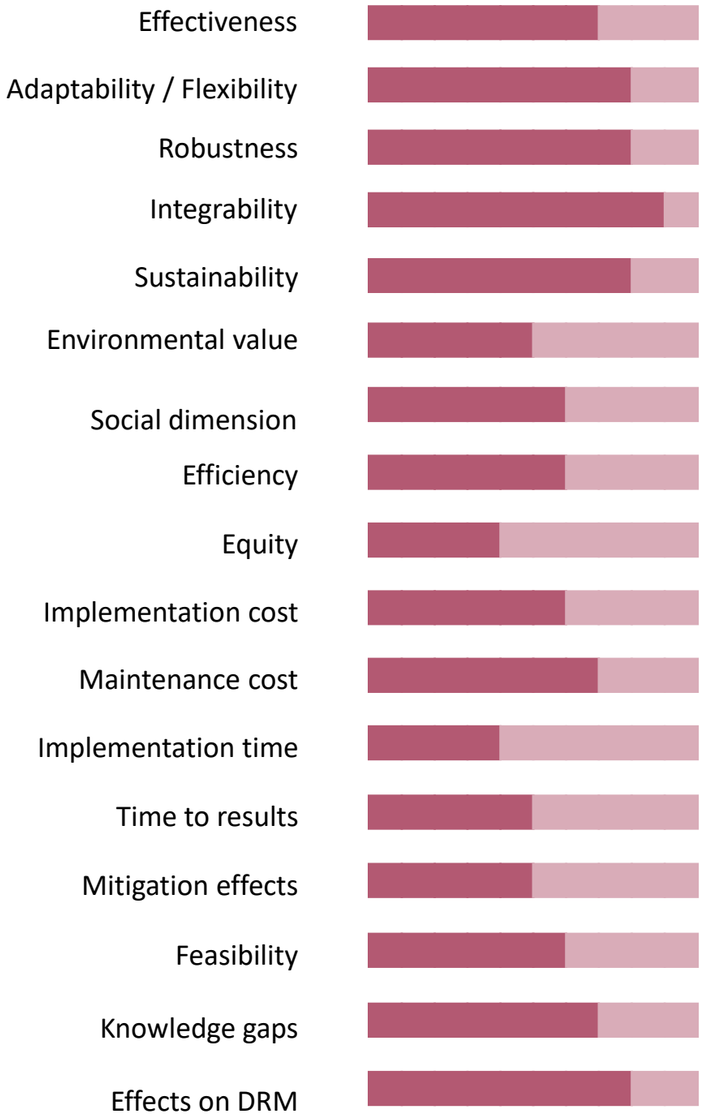


Participation and co-design process. Source: Paisaje Transversal.

REFERENCES

NL, Delft Institute, 2010, funded research programs

ADAPTA BLUES

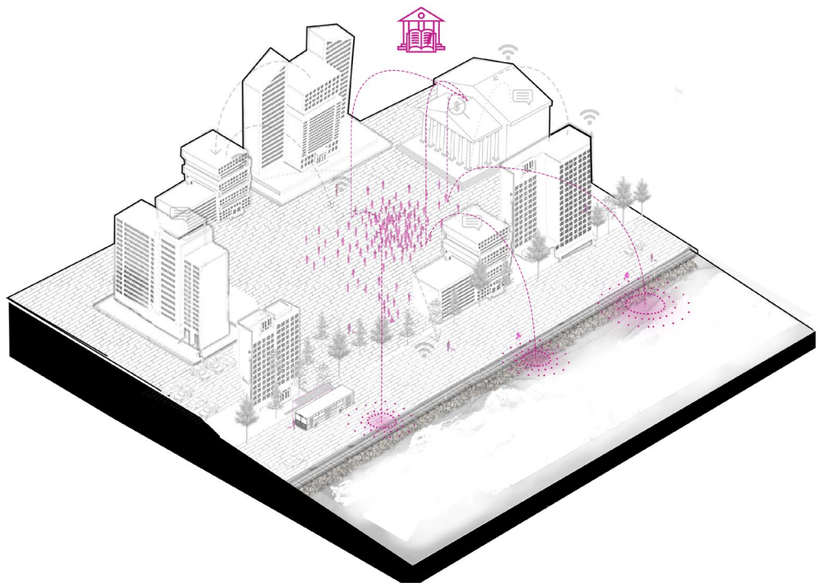
EDUCATION PROGRAMS IN RESILIENCE

INSTITUTIONAL

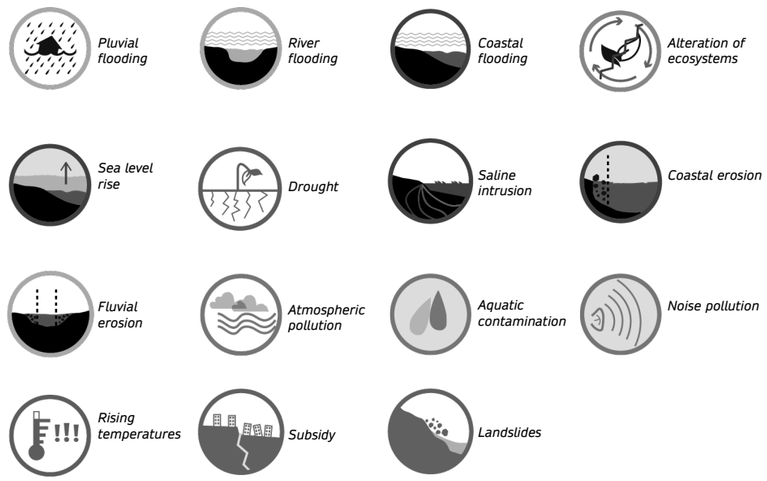
NON-STRUCTURAL

Development of training programs to contribute to making communities more resilient and improve their capacity to fight climate change

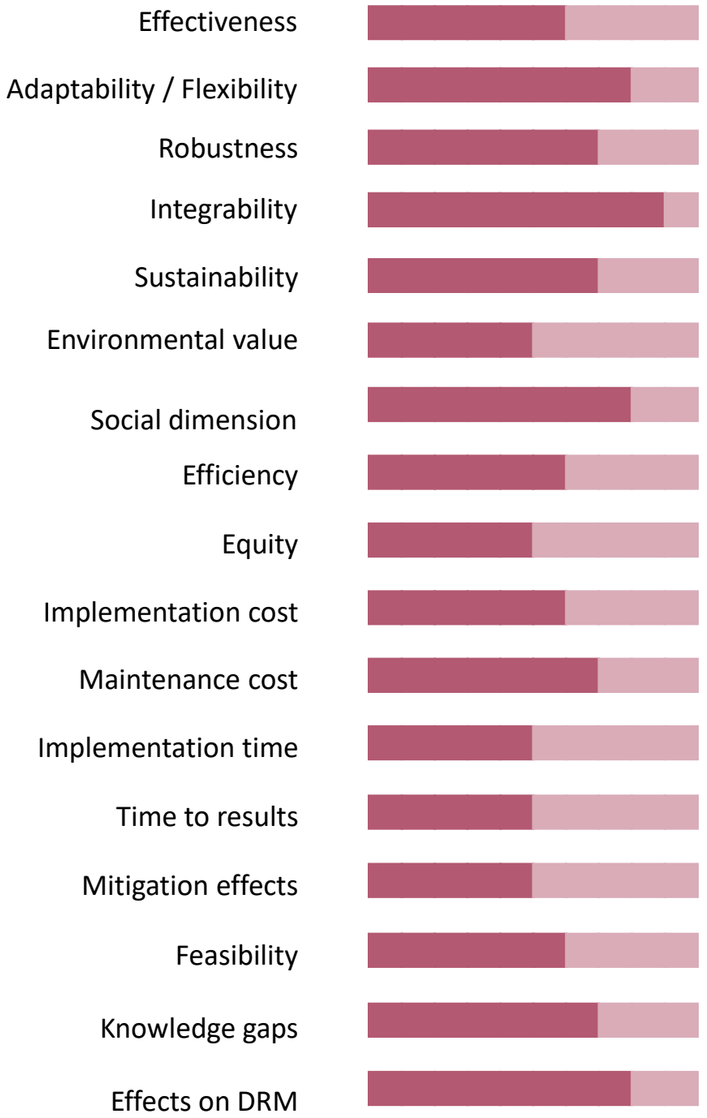
SCALE OF ACTION



RISK / IMPACT ON THE TARGET



INDICATORS



IHCantabria, a research and training centre. Source: IHCantabria.

REFERENCES

REGULATORY MEASURES

ADAPTA BLUES

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

NAME

descripción

CLIMATE CHANGE ADAPTATION STRATEGIES

AVANCE
Seawards

PROTECCIÓN
Protection

ACOMODACIÓN
Consolidating

RETROCESO
Inland

CLASSIFICATION ACCORDING THE STRUCTURE OF EACH COMPONENT

Strategy and sub-strategy | Natural component | Nature-based component | Structural component | Non-structural component

PROTECTION

The coastal ecosystem has its own natural methods to protect itself from the water-earth border effects. Due to antropization, ecological weakening, and the growing climate change adaptation threat, it is necessary to reinforce these protections or to generate new ones in when they are completely extinct.

- **REINFORCEMENT** — Those components are the ones that adhere to an existing protection, which is in damaged or has become insufficient.
- **LIVING SHORELINES** — Breakwater designed to allow the settlement of a biological community incorporating co-benefits such as carbon storage, increased biodiversity and reinforcement of the structure through bioprotection.
- **TERRACED EDGE** — Relatively flat and sloping surface in contact with the sea, which reduces wave activity.
- **DUNE SYSTEM** — Deposits of sand and gravel shaped by wind and waves on the shoreline. It is a flexible, natural protection against erosion and flooding.
- **BERM** — Nearly horizontal shore parallel ridge formed on the beach due to the landward transport of the coarsest fraction of the beach material by the wave uprush.
- **REINFORCED BANK** — Whole or part of bank artificially strengthened for bank protection purposes.
- **REINFORCED BANK** — Whole or part of a river or estuarine bank strengthened with natural materials for bank protection purposes.
- **REINFORCED CLIFFS** — Whole or part of a coastal cliff strengthened with natural materials for bank protection purposes.
- **TIDE POOLS** — An isolated pocket of seawater found in the ocean's intertidal zone.
- **BARRIER** — Structures that protect the continent, lagoons, wetlands and marshlands from the wind, waves adn tidal energy.
- **DIKE** — Manmade structure designed to protect low-lying areas from flooding from the sea or ocean.
- **SEAWALL** — A wall or embankment erected to prevent the sea encroaching on or eroding an area of land.
- **OYSTER REEFS** — Dense aggregations of oysters that form large colonial communities. They function as a natural filter and improve water overloaded with nutrients while acting as a barrier to reduce wave energy, prevent erosion, and fortify wetlands.
- **EMBANKMENT** — An artificial earthen wall often meant to prevent flooding of the hinterland.

SEAWARDS

This strategy mainly fights against the risk of erosion on the coastline. To face this threat, the coastline is advanced in order to stabilize its profile. Beyond facing danger, the benefit of this strategy is the increase of public space. It is usually used in situations where there is a lack of it.

- **ADVANCE THE LINE WITH SEDIMENT** — Seawards components mainly with sand or clay, through nourishing or catchment.
- **SEDIMENT TRAPS** — Small ponds placed between the inlet and the main wetland to promote sedimentation of coarse particles before water is distributed through the wetland.
- **SAND NOURISHMENT** — Sand addition to the coastal system to mitigate the consequences of previous erosion.
- **CHANGES IN GRANULOMETRIC COMPOSITION** — Replacement of sands with gravels, pebbles or other sands of larger diameter to increase beach stability.
- **ADVANCE THE LINE WITH FLORA AND FAUNA** — To advance the coastline with new ecosystems or strengthen the existing ones.
- **MARINE ANGIOSPERMS** — Angiosperm communities that increase the available sediment for organism and attenuate water velocity associated with currents and waves.
- **KELP FORESTS** — Underwater areas with a high density of brown algae that favor attenuation of current velocity.
- **ADVANCE THE LINE WITH STRUCTURES** — Engineering works into the sea and change coastal dynamics.
- **GROYNE** — A low wall or sturdy barrier built out into the sea from a beach to check erosion and drifting.

ACCOMMODATION

Through this strategy, the confrontation between land and sea is not so much sought, as the adaptation of this environment to the continuous contact between the different ecosystems. The different measures focus on generating a transition zone on the shoreline where appropriate exchanges can take place and, in this way, improve the resilience of the whole.

- **LAND SPONGE** — Set of measures to increase the filtering capacity of the land near the coast.
- **COASTAL PARK** — Public park designed as a protection area against maritime flooding with recreational and educational uses.
- **SEA REGRESSION AREA** — Land reserve to mitigate the coastal regression caused by the sea level rise and storms.
- **FLOODING PROTECTION AREA** — Protected area, free of infraestructures, designed to mitigate the coastal regression caused by sea level rise and/or storms.
- **STRATEGICAL INTERVENTIONS ON URBAN SERVICES** — Water management and urban planning techniques that aim to imitate hydrological processes in urban development by controlling runoff in the urban landscape.
- **RISING** — Components intended to raise elements and areas of the coast that need to be protected from flooding.
- **ARTIFICIAL BEACH** — A man-made beach designed as a sand surface on an elevated area free of the effects of flooding.
- **RIVERS AND ESTUARIES** — Works on fluvial areas near the coast to improve its interaction with the sea.
- **FLOOD GATES** — Control of water flows in channels by hydraulic mechanical devices.
- **LANDCLAIM RECOVERY** — Removal of fill material to restore the shoreline and coastal habitats.
- **MOUTH REGENERATION** — Removal of channelizations at river mouths to recover floodplains.
- **SALTMARSH REGENERATION** — Restoration of coastal wetlands by saltmarsh communities to improve the ecosystem services of flood control and filter water.
- **WETLAND REGENERATION** — Restoration of wetlands dominated by herbaceous communities, that form a transition between aquatic and terrestrial ecosystems.
- **FLORA AND FAUNA CONSERVATION** — Conservation programs to protect habitats that act as regulators of the effects of climate change (erosion, flooding, saline intrusion, etc.).

RETREAT

Measures, mainly urban and territorial planning, that seek to create a safe space for flooding and protect assets by reducing exposure by setting them back.

- **RIVERS AND ESTUARIES** — Works on fluvial areas near the coast to improve its interaction with the sea.
- **ASSET RELOCATION** — Relocation of existing infrastructure, assets and/or real estate to a new place that is not currently at risk.
- **PLANNED REALIGNMENT** — Procedures for creating a new position for the coastline through engineering.

NON-STRUCTURAL

They consist of a series of physical and programmatic policies designed according to the needs of a community and the level of risk to which it is exposed. Their main goal is minimizing it and improving coastal resilience. These types of programs seek to avoid unconscious development and help the population prepare against floods.

- **EARLY WARNING SYSTEMS** — A warning system that can be implemented as a chain of information: communication systems and comprises event detection and decision subsystems for early identification of hazards (in time to minimize the effects of the event).
- **RISK TRANSFER MESAURES** — Development of communication tools about the risk on the coastal area.
- **MEDIA TRAINING** — Development of training programs in communication about the status and actions on the coast.
- **RESEARCH ON COASTAL RESILIENCE** — Support for projects that investigate new adaptation mechanisms or the improvement of existing ones.
- **EDUCATION PROGRAMS IN RESILIENCE** — Transfer of "know-how" on coastal adaptation in educational programs from kindergarten to university.

REGULATORY

Regulation measures that complement, complete, or partially replace the structural ones include modifications in public policies, management practices, regulatory policies, and tax collection policies.

- **COASTAL PROTECTION PLAN** — Development of a protection plan to preserve the goods and services of the littoral areas.
- **INSTITUTIONAL AND MANAGEMENT MESAURES** — A set of measures to promote coordinated and coherent action in climate change adaptation and risk management on the coast.
- **MOBILITY MANAGEMENT** — Development of an optimal public transportation network to reduce the need for private vehicles. It also includes changes in the mobility of the area.
- **STRATEGIC RETREAT POLICIES** — Management of human settlements and infrastructures to delay their position to safety areas.
- **SPECIFIC PLANNING SYSTEMS** — Development of coastal planning for climate change adaptation and risk prevention.
- **WATER MANAGEMENT POLICIES** — Water cycle planning and management system, both for the water supply and wastewater systems. It includes plans, projects and actions.

LANDLAB

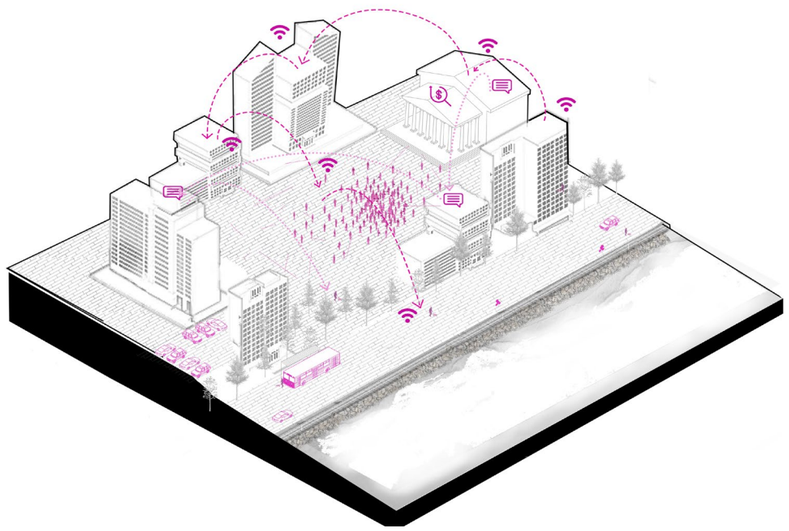
COASTAL PROTECTION PLAN

INSTITUTIONAL

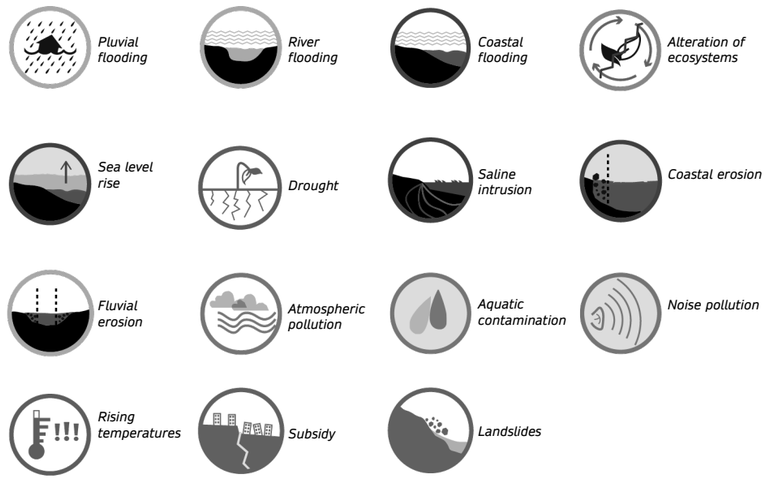
NON-STRUCTURAL

Document with legal and/or juridical value for the application of coastal protection measures, promoting the links between the different stakeholders and activities. Decisions for the development and protection of the coast are taken as part of a long-term, continuous and dynamic process between the different stakeholders and the relationships between physical processes and human activities.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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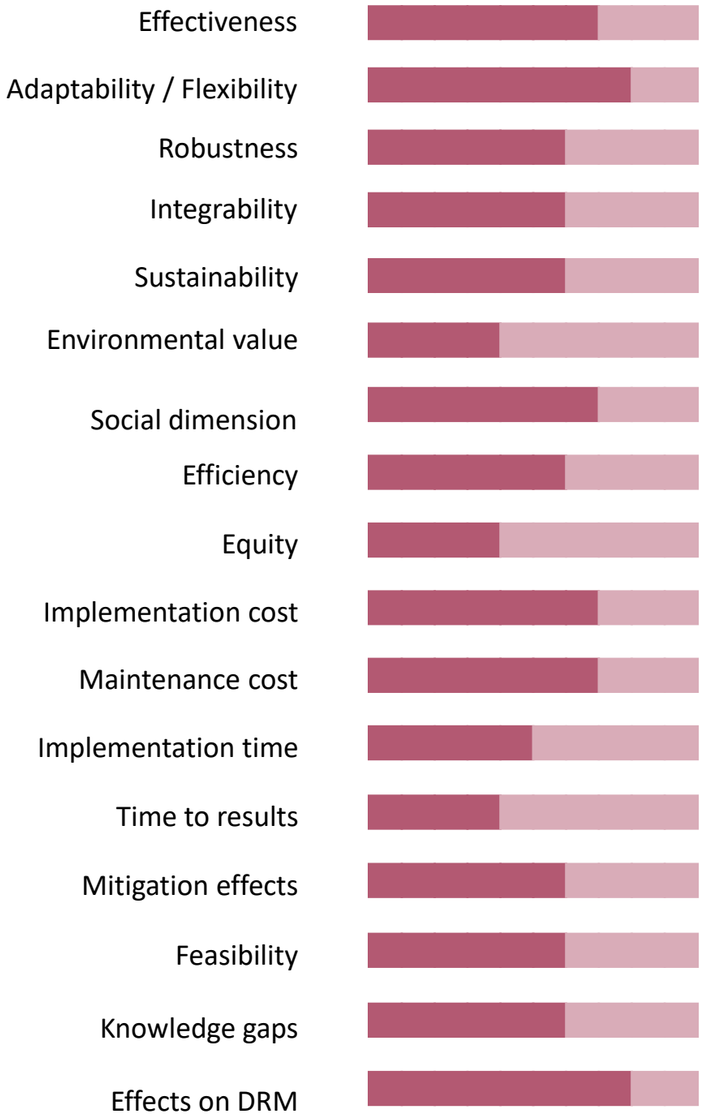

Vulnerability to climate change in the Region of Murcia. Source: own elaboration.

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https://protecccioncosteracartagena.co/
https://coastal.la.gov/our-plan/2023-coastal-master-plan/
https://www.pub.gov.sg/CoastalProtection

ADAPTA BLUES

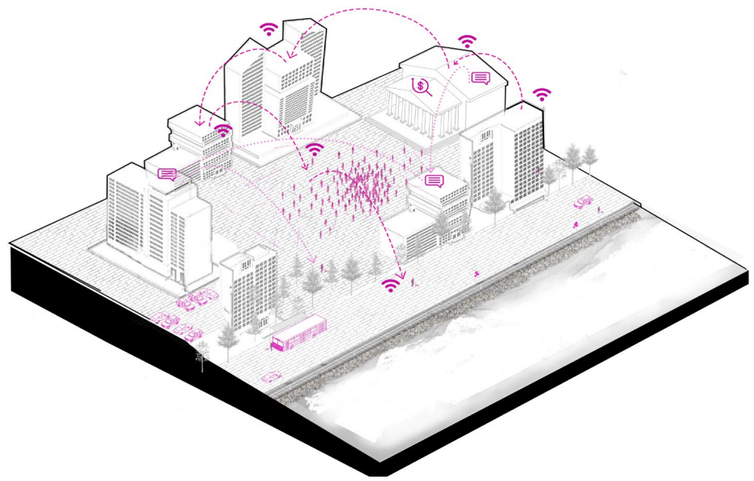
INSTITUTIONAL AND MANAGEMENT MEASURES

SOCIAL

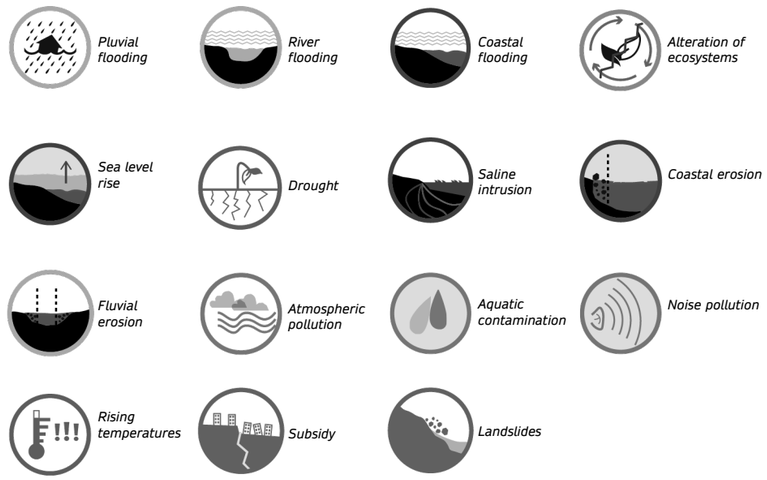
MANAGEMENT

Measures to promote a coordinated and coherent action of climate change adaptation and risk management.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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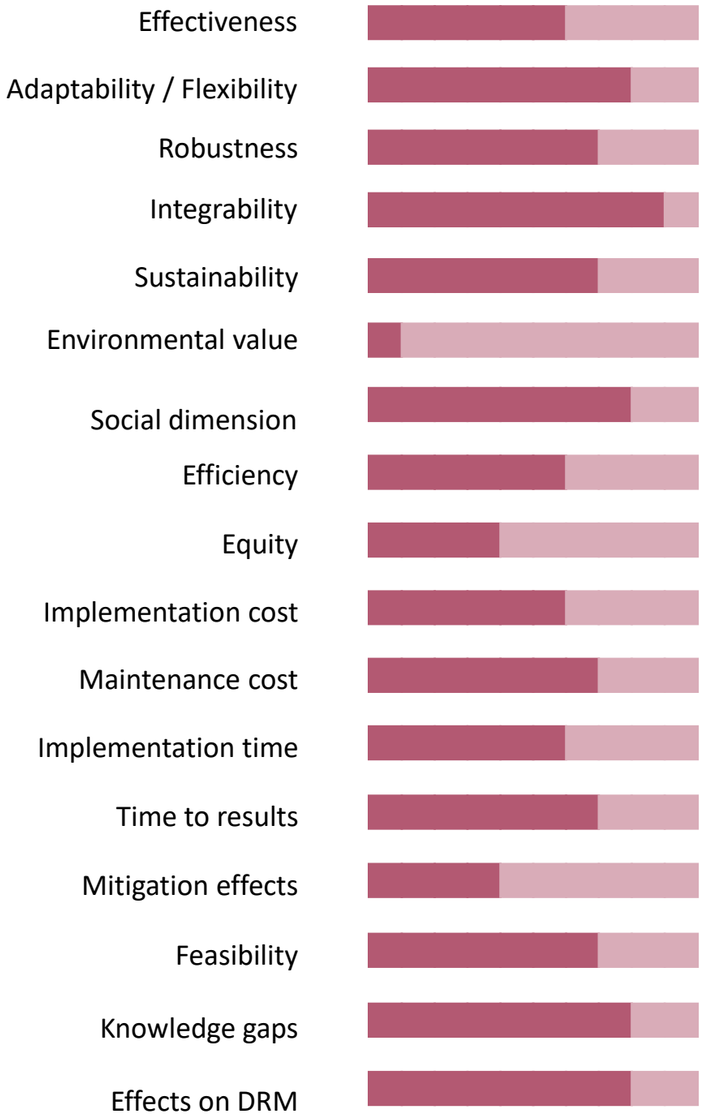


Participation and co-design process. Source: Transversal Landscape.

REFERENCES

MOBILITY MANAGEMENT

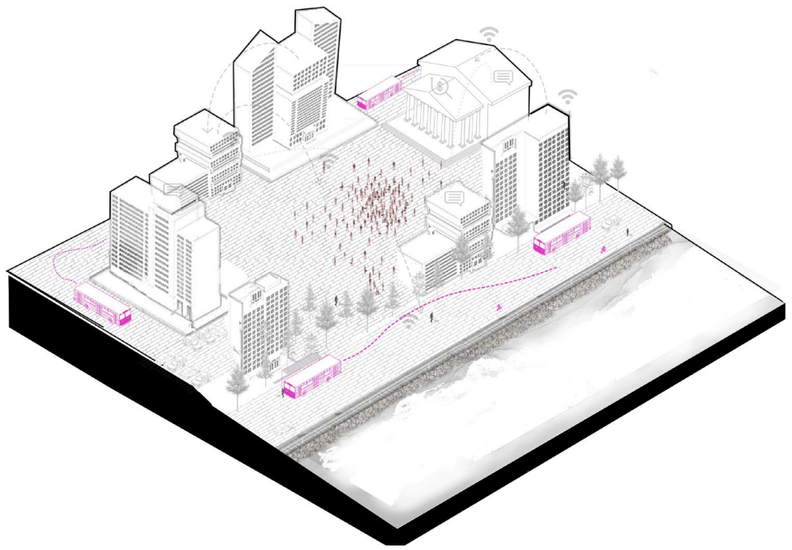
INSTITUTIONAL POLICIES AND PROGRAMMES

NON-STRUCTURAL

Development of an optimal public transport network to reduce the need for private vehicles, making the enjoyment of the coastline more inclusive. It also includes changes in the mobility of the area.

SCALE OF ACTION

Country · Region · Watershed · City · Local



RISK / IMPACT ON THE TARGET

Pluvial flooding · River flooding · Coastal flooding · Alteration of ecosystems

Sea level rise · Drought · Saline intrusion · Coastal erosion

Fluvial erosion · Atmospheric pollution · Aquatic contamination · Noise pollution

Rising temperatures · Subsidy · Landslides

INDICATORS

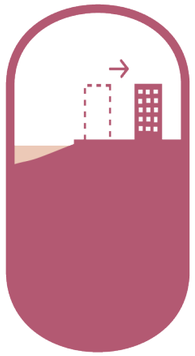
- Effectiveness
- Adaptability / Flexibility
- Robustness
- Integrability
- Sustainability
- Environmental value
- Social dimension
- Efficiency
- Equity
- Implementation cost
- Maintenance cost
- Implementation time
- Time to results
- Mitigation effects
- Feasibility
- Knowledge gaps
- Effects on DRM

Intermodal Station, Nørreport Station, Copenhagen. Source: ArchDaily.

REFERENCES

USA, Miami, 2017, West Palm Beach competition, Ecosistema Urbano

ADAPTA BLUES



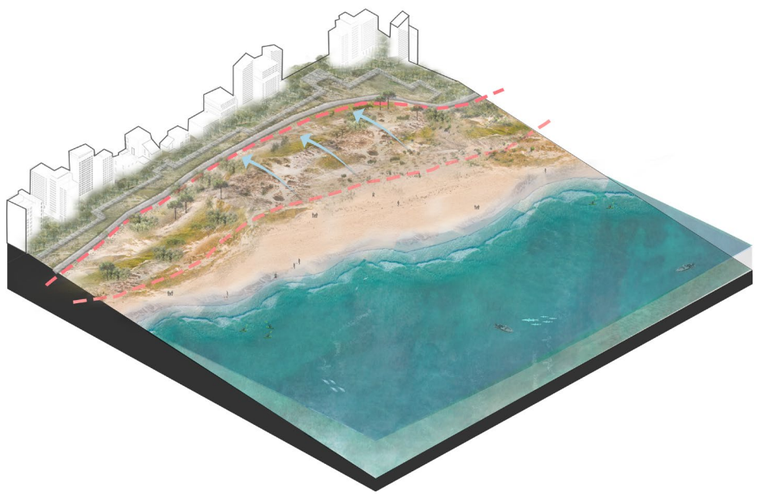
STRATEGIC RETREAT POLICIES

SOCIAL

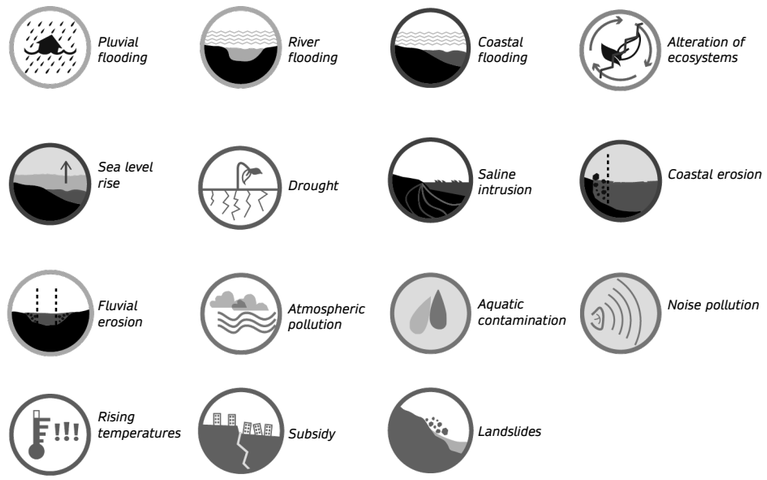
NON-STRUCTURAL

Management of human settlements and infrastructures to retreat their position to safty areas from coastal risks.

SCALE OF ACTION



RISK / IMPACT ON THE TARGET



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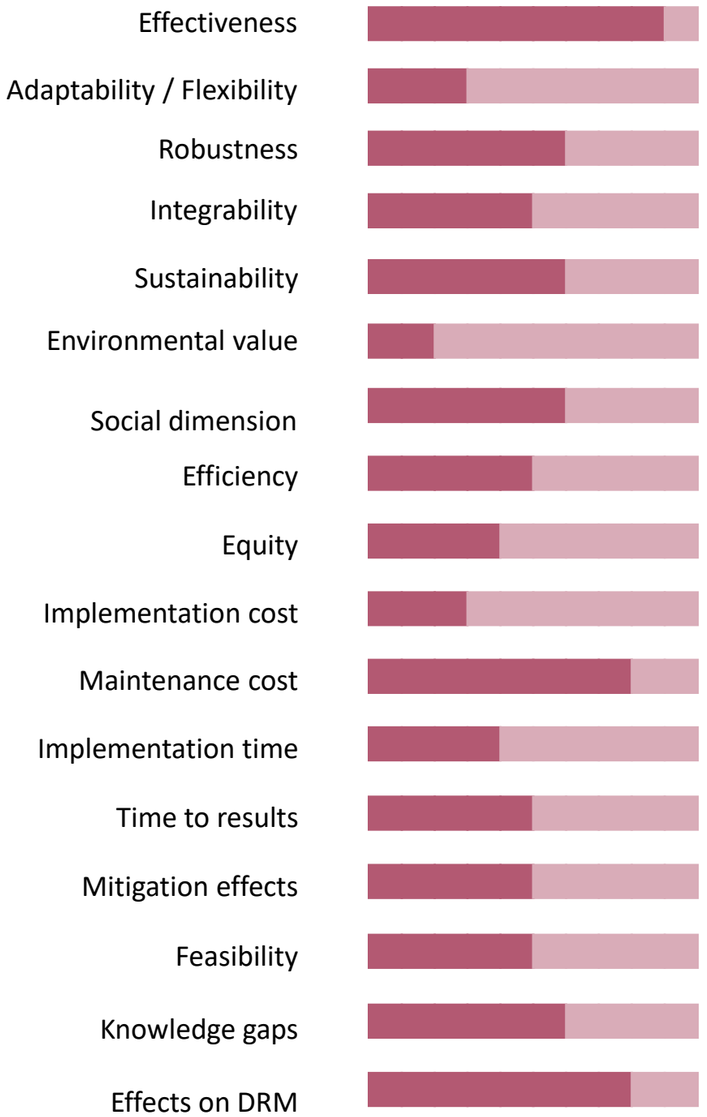


Coastal flooding episode. Source: Logan Abassi.

REFERENCES

ADAPTA BLUES

SPECIFIC PLANNING INSTRUMENTS

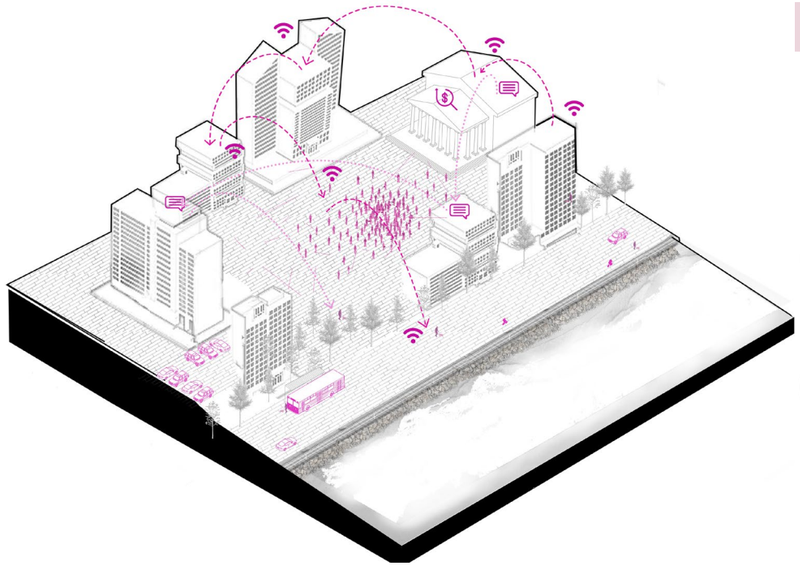
INSTITUTIONAL POLICIES AND PROGRAMMES

NON-STRUCTURAL

Planning, development and management instruments for the coastal environment aimed at adapting to climate change and risk prevention and management.

SCALE OF ACTION

Country · Region · Watershed · City · Local

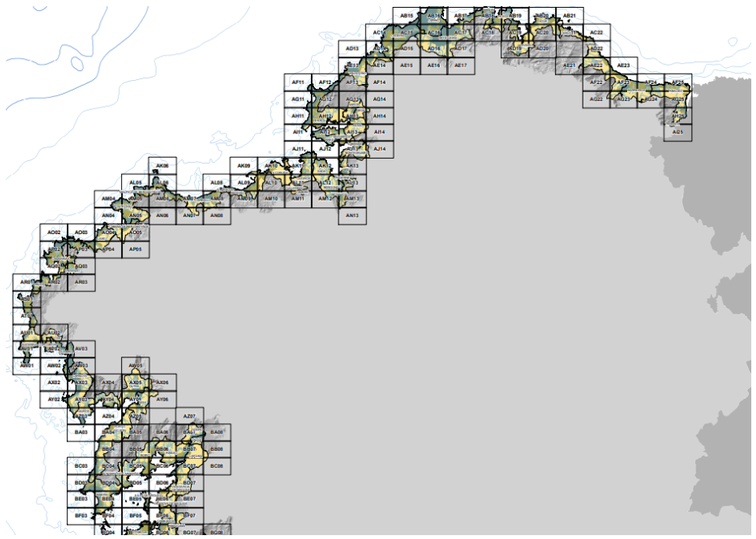


RISK / IMPACT ON THE TARGET

- Pluvial flooding
- River flooding
- Coastal flooding
- Alteration of ecosystems
- Sea level rise
- Drought
- Saline intrusion
- Coastal erosion
- Fluvial erosion
- Atmospheric pollution
- Aquatic contamination
- Noise pollution
- Rising temperatures
- Subsidy
- Landslides

INDICATORS

- Effectiveness
- Adaptability / Flexibility
- Robustness
- Integrability
- Sustainability
- Environmental value
- Social dimension
- Efficiency
- Equity
- Implementation cost
- Maintenance cost
- Implementation time
- Time to results
- Mitigation effects
- Feasibility
- Knowledge gaps
- Effects on DRM



Galician Coastal Management Plan, 2011. Source: POL Galicia.

REFERENCES

http://webpol.xunta.gal/web/index.php/introduccion/gl

https://www.territoriodecantabria.es/ordenacion-del-territorio/plan-de-ordenacion-del-litoral-pol

http://rijksoverheid.minienm.nl/nvk/NationalCoastalStrategy.pdf

WATER MANAGEMENT POLICIES

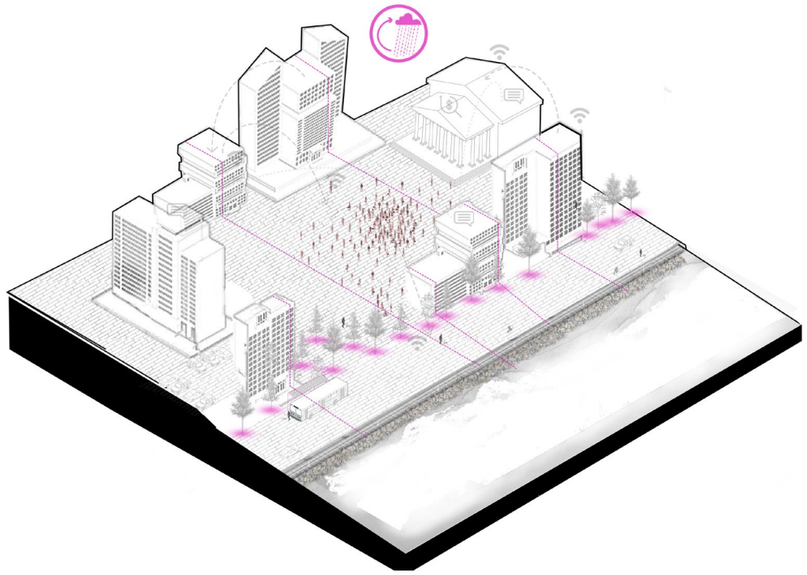
INSTITUTIONAL POLICIES AND PROGRAMMES

NON-STRUCTURAL

Water cycle planning and management system, both for the water supply and wastewater treatment. It includes plans, projects and actions.

SCALE OF ACTION

Country · Region · Watershed · City · Local



Plan Le Paris Pluie, to reuse rainwater in the city of Paris. Source: Paris.fr

RISK / IMPACT ON THE TARGET

- Pluvial flooding
- River flooding
- Coastal flooding
- Alteration of ecosystems
- Sea level rise
- Drought
- Saline intrusion
- Coastal erosion
- Fluvial erosion
- Atmospheric pollution
- Aquatic contamination
- Noise pollution
- Rising temperatures
- Subsidy
- Landslides

INDICATORS

- Effectiveness
- Adaptability / Flexibility
- Robustness
- Integrability
- Sustainability
- Environmental value
- Social dimension
- Efficiency
- Equity
- Implementation cost
- Maintenance cost
- Implementation time
- Time to results
- Mitigation effects
- Feasibility
- Knowledge gaps
- Effects on DRM

REFERENCES

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ADAPTA BLUES

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