

**Interreg**  
**Sudoe**



EUROPEAN UNION



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Desarrollo de herramientas para prevenir y gestionar los riesgos en la costa ligados al cambio climático

## **Actividad E.6.4.1. LISTADO DE INDICADORES AMBIENTALES SIGNIFICATIVOS**

**Informe del GT6: Medidas naturales de rehabilitación y preventivas de adaptación al cambio climático**

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## 1. INTRODUCCIÓN.

El Grupo de Trabajo 6 (GT6), del proyecto RISKCOAST, centra su actividad en elaborar propuestas reales de medidas de rehabilitación de medidas adaptadas a los cambios climáticos de origen fundamentalmente de tipo naturales, tanto de tipo mitigadoras como de tipo rehabilitadoras. El principal objetivo será el de fomentar el uso de este tipo de medidas y promover un cambio de mentalidad hacia medidas de rehabilitación y prevención más naturales, duraderas, menos costosas y en definitiva y por lo tanto más sostenibles.

La Actividad 6.4.1, centra sus objetivos en la elaboración de un sistema de indicadores significativos para la caracterización y seguimiento del riesgo climático en zonas costeras, que pueda servir de base para un monitoreo continuo en las zonas de costa.

El diseño del sistema de indicadores ha contado con la participación de todos los test sites del proyecto con la finalidad de evaluar de manera conjunta tanto la importancia de cada uno de los indicadores para el seguimiento del riesgo climático en zonas costeras como la facilidad de implementación y de cálculo.

El sistema de indicadores se ha basado en sistemas de indicadores ya establecidos, divididos por temáticas y clasificándolos dentro del marco de indicadores DPSIR.

El modelo DPSIR [del inglés, drivers (D)-pressure (P)-state (S)-impact (I)-response (R)], desarrollado por la Agencia Europea de Medio Ambiente (EEA, 1999). Las relaciones casuales en este modelo se podrían sintetizar a través de los vínculos mostrado en la Figura 1.



Modelo DPSIR estándar Fuente: Adaptado de la Agencia Europea de Medio Ambiente (EEA, 1999).

Como puede apreciarse, las relaciones causales que postula este modelo no se limitan a meras relaciones secuenciales del tipo Fuerzas motrices → Presión → Estado → Impacto → Respuesta considerando también relaciones causales recíprocas (entre los impactos y las respuestas), y la influencia de las respuestas no sólo sobre las fuerzas motrices, sino también sobre las presiones y sobre el estado del medio ambiente. Niemeijer y de Groot (2008) apuntan la necesidad de establecer una clara distinción entre el estado del medio ambiente y el impacto ejercido sobre el mismo. Estos autores señalan que un cambio en el estado ambiental puede tener un impacto totalmente diferente dependiendo del tipo de ecosistema (el impacto no será el mismo, por ejemplo, en tierras de cultivo que en espacios naturales protegidos). También reconocen la utilidad de establecer una diferenciación entre fuerzas motrices y presiones, ya que unas mismas fuerzas motrices (como un crecimiento poblacional o un incremento de ingresos) ejercen presiones diferentes y variables sobre el medio ambiente dependiendo del conjunto global de fuerzas motrices y de la forma en que la sociedad gestione estos cambios en dichas fuerzas. Además, un cambio en las fuerzas motrices no tiene por qué conducir necesariamente a un incremento de determinadas presiones, e incluso podría ser la causa de la reducción de otras presiones completas.

## 2. METODOLOGÍA

Las recopilaciones bibliográficas se han convertido en un instrumento muy útil para organizar todo el conocimiento científico que se ha generado en relación a una temática concreta o un lugar determinado. La realización de una recopilación bibliográfica debe de seguir unos principios de documentación, trazabilidad y reproducibilidad que permitan caracterizar correctamente el estudio llevado a cabo. El análisis de la bibliografía ha seguido los aspectos conceptuales y metodológicos de la declaración Prisma [1], para definir y explicitar los pasos sucesivos de la revisión sistemática realizada. La declaración Prisma ha adoptado las definiciones y enfoque de la Colaboración Cochrane [2] que implementa una guía que facilita a los autores de revisiones bibliográficas realizarlas de una manera sistemática y explícita de cara a la evaluación y reproducibilidad de la misma, de manera externa. En este contexto, se ha llevado a cabo un análisis bibliométrico de la producción científica publicada en la base de datos de la colección principal de Web Of Science (WoS) utilizando su API de consulta TS=(climate AND change AND adaptation AND environmental indicator\* AND coast\*). Se han obtenido un total de 125 registros.

El estudio ha permitido caracterizar los indicadores de impacto climático ligado a costas que han sido la base de la encuesta de valoración por parte de los integrantes del proyecto.

Posteriormente se llevó a cabo una selección de indicadores, basada en dos criterios:

- Relevancia del indicador
- Facilidad para su cálculo e implementación

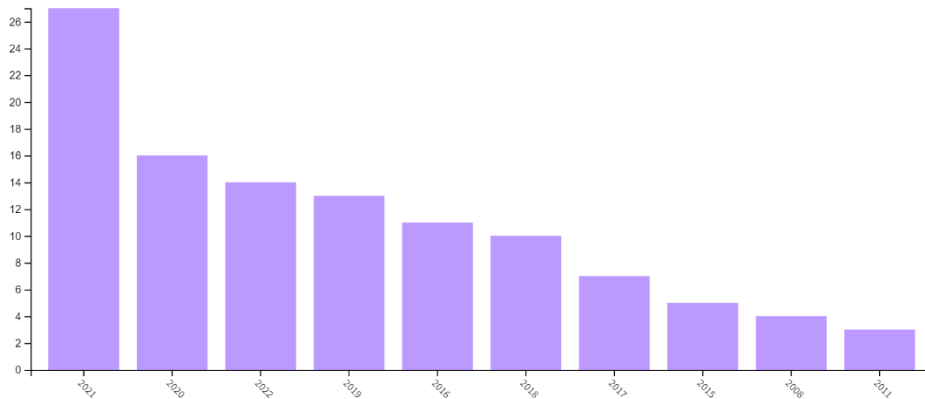
Para ello se realizó una encuesta de valoración que fue enviada a todos los miembros del proyecto, tanto investigadores como stakeholders. En esta encuesta se les solicitaba la valoración en una escala Likert de siete puntos de estos dos criterios para el conjunto de indicadores.

Basándonos en esta evaluación se llevó a cabo la selección de ítems, formando parte del sistema de indicadores aquellos relevantes que tenían una alta facilidad de cálculo e implementación.

### 3. RESULTADOS DE LA BÚSQUEDA BIBLIOGRÁFICA.

Los registros rescatados se caracterizan por las diferentes características de las publicaciones:

#### Evolución temporal de publicaciones relacionadas con indicadores de impacto climático en costas



Como se puede observar en la gráfica, el número de publicaciones y estudios relacionados con estos indicadores ha ido aumentando paulatinamente entre la comunidad científica, lo que indica que es una temática que cada vez despierta más interés en el ámbito científico.

#### Tipo de publicaciones

La gran mayoría de publicaciones se realizan bajo la modalidad de artículos científicos, aunque hay un porcentaje significativo de artículos de revisión que han sido consultados en profundidad para extraer los indicadores que más se podían ajustar a la temática de los test sites del proyecto.



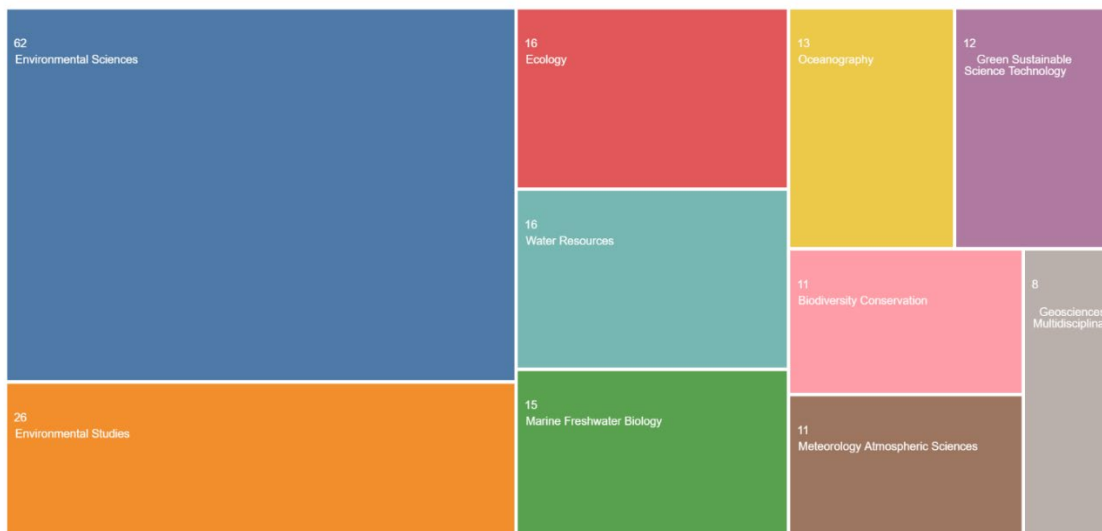
### Origen de las publicaciones

Respecto a los países que más investigan en este ámbito destacan Estados Unidos con 36 aportaciones y Australia con 19. Le siguen Inglaterra, Italia y España como líderes en la investigación en indicadores de impacto del cambio climático en costas.



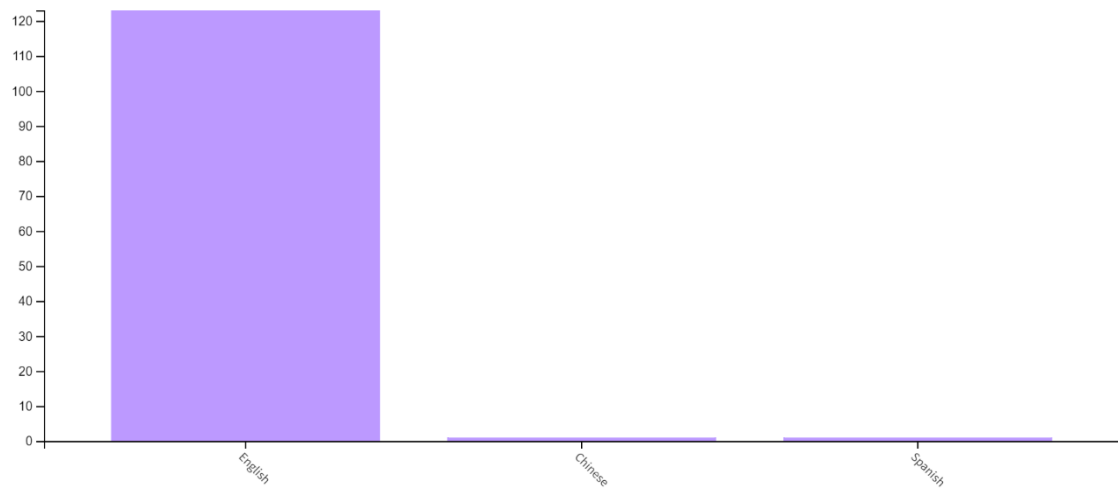
### Categorías científicas

Las categorías científicas que mas estudian estos indicadores son las ciencias ambientales, la ecología, así como los recursos hídricos y la investigación de la biología de agua dulce y marina.



### Lenguas utilizadas

Casi el 100% de las publicaciones se realizan en inglés, siendo el chino y el castellano lenguajes testimoniales.





#### 4. SISTEMA DE INDICADORES INICIAL

Tras el análisis bibliográfico se obtuvieron una serie de indicadores que se clasificaron según las temáticas que se definieron para el sistema de indicadores:

<b>Ecological Risk</b>	Geology / Water /Soil
	Climate
	Ecosystems
	Agriculture, Fisheries, Tourism, Coastal related activities
<b>Financial Risk</b>	Economics
	Industries
	Infraestructures
<b>Political Risk</b>	Social / Demographic
	Governance

De esta manera, se presentan por categorías los indicadores obtenidos.

<b>Ecological risk</b>
<b>Geology / Water /Soil</b>
Percent of Metro Area at Risk of Flooding
Percent of Landscape that is Arable Land
Degree of Soil Salinity in Arable Land
Projected Change in Sea-Level Rise
Rate of Coastal Erosion
Degree of Saltwater Intrusion in Coastal Acquifers
Percent of Bodies of Water with High Quality
Level of Geophysical Risk of Landslides
Total Number of Flood Events
Area of coastal municipalities subject to considerable danger
Coastal erosion
Recession of beaches and cliffs
Sediment deficit
Presence of dams on the main rivers
Hillside movements (landslides)
Overflows of watercourses
Rock falls
Flooding: Peak Flow
Flooding: Peak Volume
River flows
River floods

<b>Ecological risk</b>
<b>Geology / Water /Soil</b>
Shoreline displacement
Longshore sediment transport rate
Runoff quantity
Runoff seasonality

<b>Ecological risk</b>
<b>Climate</b>
Total Number of Extreme Heat Events
Total Number of Droughts
Number of People Affected by Extreme Weather
Change in Sea Surface Temperature
Total Number of torrential rains
Total Number of intense winds
Total Number of severe swells
Total Number of unusual tides
Drought Risk Resilience: Standardized Precipitation Index (SPI)
Drought Risk Resilience: Effective Drought Index (EDI)
Present average January maximum temperature
Present average January minimum temperature
Present Days >30 °C
Present average annual rainfall

<b>Ecological risk</b>
<b>Ecosystems</b>
Urban land growth rate
Beaches and dunes damaged
Degradation of aquifer recharge
Impact of coastal erosion on natural areas (wetlands, dunes, ...)
Ecological capital at risk
Erosion hotspots: impact on ecologic value (protected areas, habitats, biodiversity)
Potential Areas Exposed to Risks: Natural Areas, Site of Community Importance (SCI), Special Protection Areas (SPA)
Area without vegetation

<b>Financial Risk</b>
<b>Economics</b>
Cost of restoration of eroded beaches
Economic capital at risk
Erosion hotspots: impact on economic value
Cost of flood defence

<b>Financial Risk</b>
<b>Economics</b>
Cost of erosion defence
Cost of restoration of flooded land

<b>Financial Risk</b>
<b>Industries</b>
Percent of Economy Based in Agriculture
Percent of Economy in Nearshore Fishing Industry
Percent of Economy Based in Offshore Fisheries
Percent of Economy Based in Tourism Industry
Percent of Economy Based in Port and Shipping Industries
Diversity of Lodging Types

<b>Financial Risk</b>
<b>Infraestructures</b>
Percent of Low-Income Housing in Relation to Flood Zones
Percent of People Living Less than 5 Meters Above Sea Level
Level of Commercial Infrastructure Damage from Extreme Weather Events
Level of Housing Damage from Extreme Weather Events
Level of Shoreline Development
Presence of ineffective or even counterproductive coastal defence infrastructures
Urbanised and recreational areas affected
Road network affected
Agricultural areas affected
Coastal infrastructure (ports and harbours) affected
Potential Infrastructures Exposed to Risks: roads
Potential Infrastructures Exposed to Risks: Railways
Potential Infrastructures Exposed to Risks: Lifelines (Water main, Sewerage, Pipeline)
Percent of urban area susceptible to flooding

<b>Political Risk</b>
<b>Social / Demographic</b>
Urban Population
Percent of Urban Population Below 30 Years of Age
Urbanization Rate
Urban Population Density
Dependency Ratio
Human capital at risk
Potential Population Exposed to Risks: Inhabitants

<b>Political Risk</b>
<b>Social / Demographic</b>
Potential Population Exposed to Risks: Other People (Workers, Tourists, Homeless)
Potential Population Exposed to Risks: Elderly, children, disabled
% population > 65 years
Population density

<b>Political Risk</b>
<b>Governance</b>
Level of Civil Society Engagement
Climate Adaptation Plans
Capacity of Current Disaster Response
Investment in Climate Resilient Development Projects
Main existing (public and private) and mobilisable resources
Structure of operational emergency response means
Protection of coast against erosion by artificial works
Protection of coast against erosion by integrated management
Investments on coastal protection
Investment amount for structural measures
Investment amount for non-structural measures
Sea-level rise projection

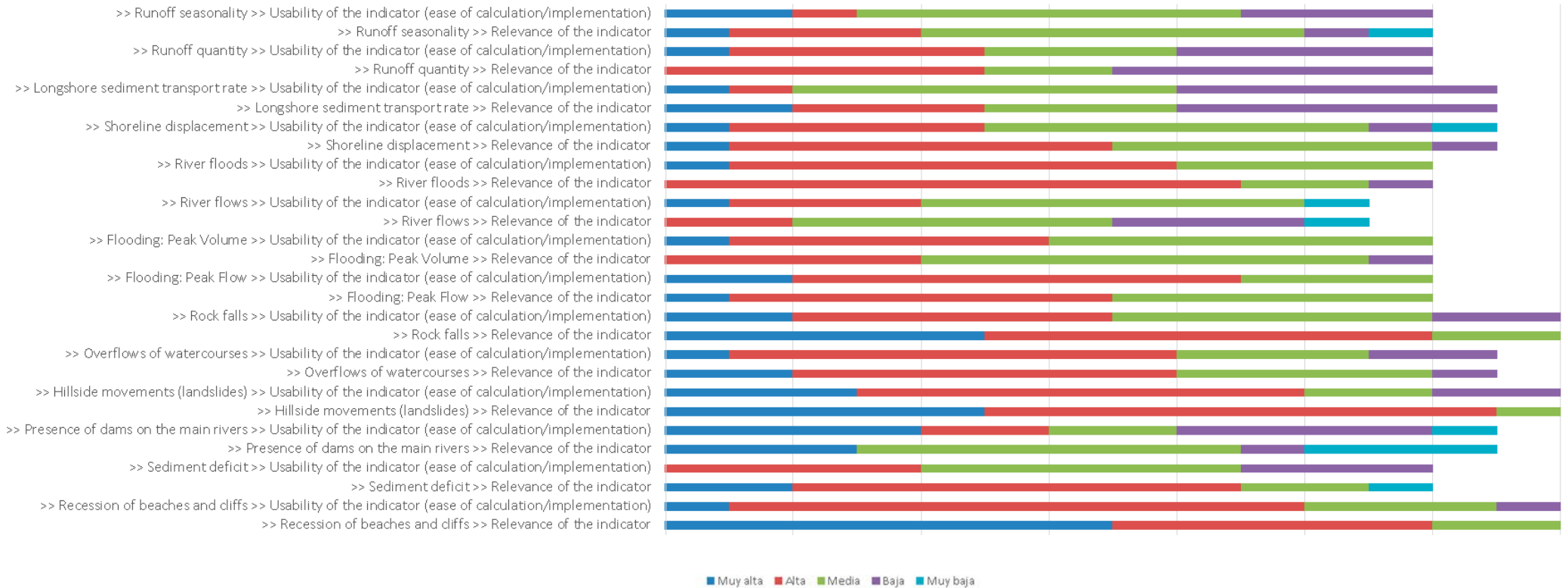
## 5. VALORACIÓN DEL SET INICIAL DE INDICADORES

A continuación, se presentan los resultados de la valoración de indicadores.

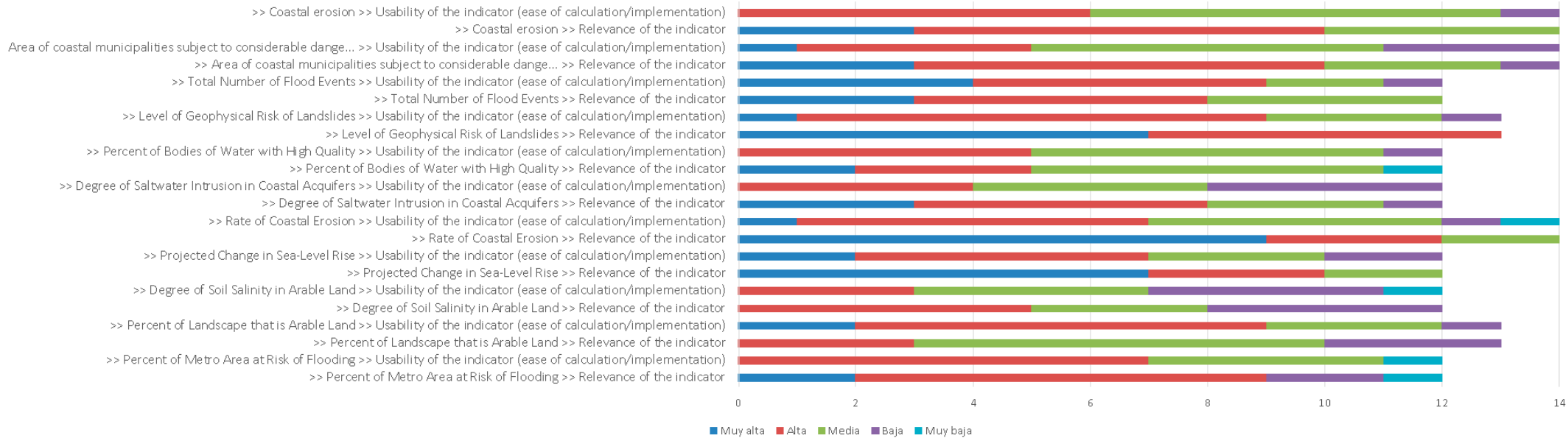
Para ello, se muestra un gráfico por cada área y subárea que se definieron para el sistema de indicadores:

<b>Ecological Risk</b>	Geology / Water /Soil
	Climate
	Ecosystems
	Agriculture, Fisheries, Tourism, Coastal related activities
<b>Financial Risk</b>	Economics
	Industries
	Infraestructures
<b>Political Risk</b>	Social / Demographic
	Governance

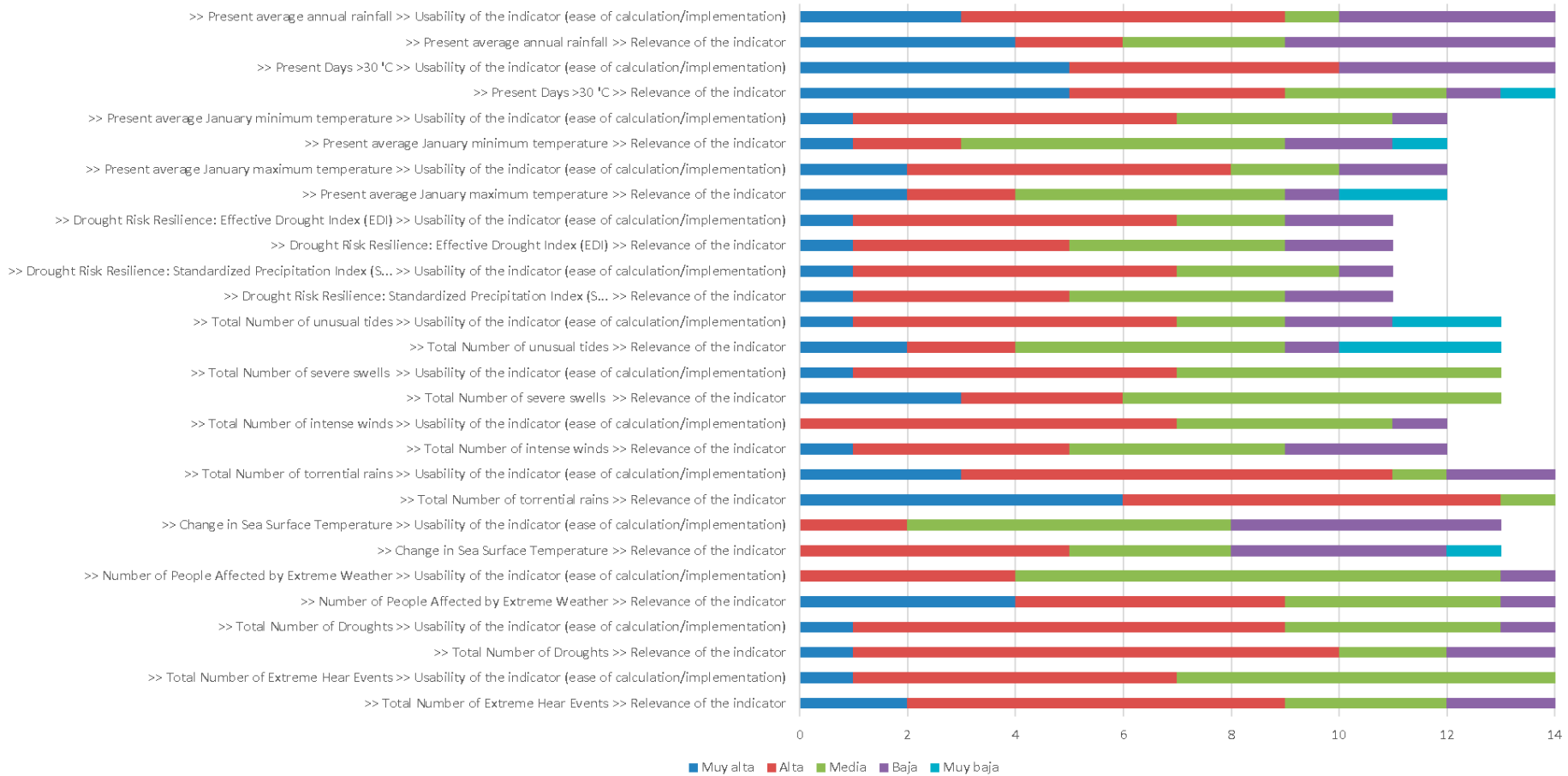
### Ecological risk Geology / Water /Soil



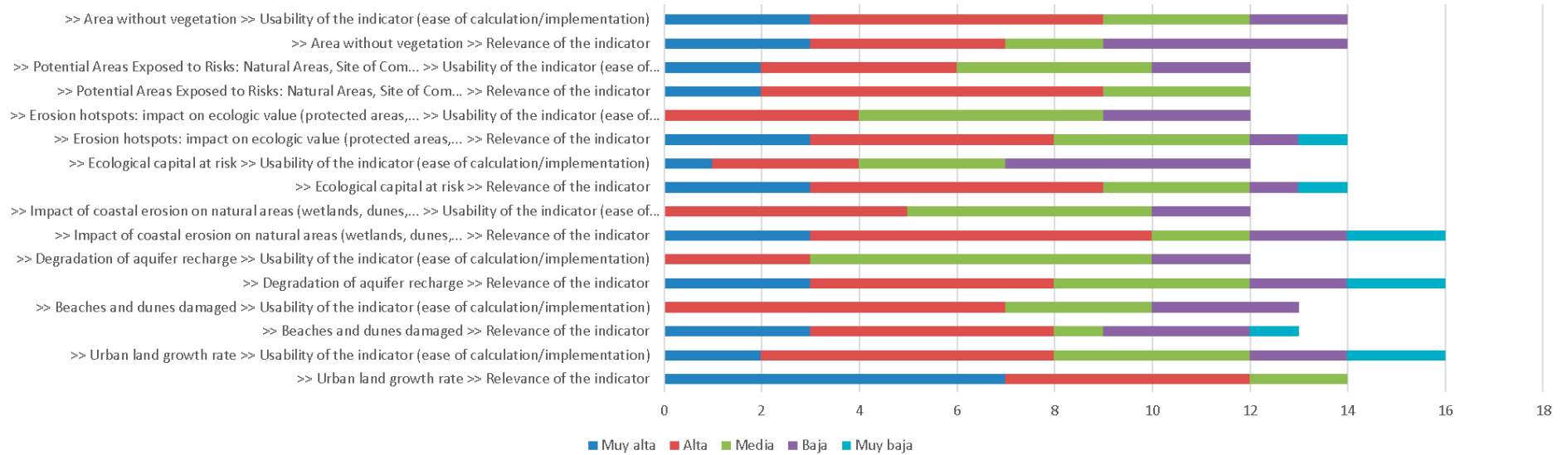
**Ecological risk  
 Geology / Water / Soil**



### Ecological risk / Climate

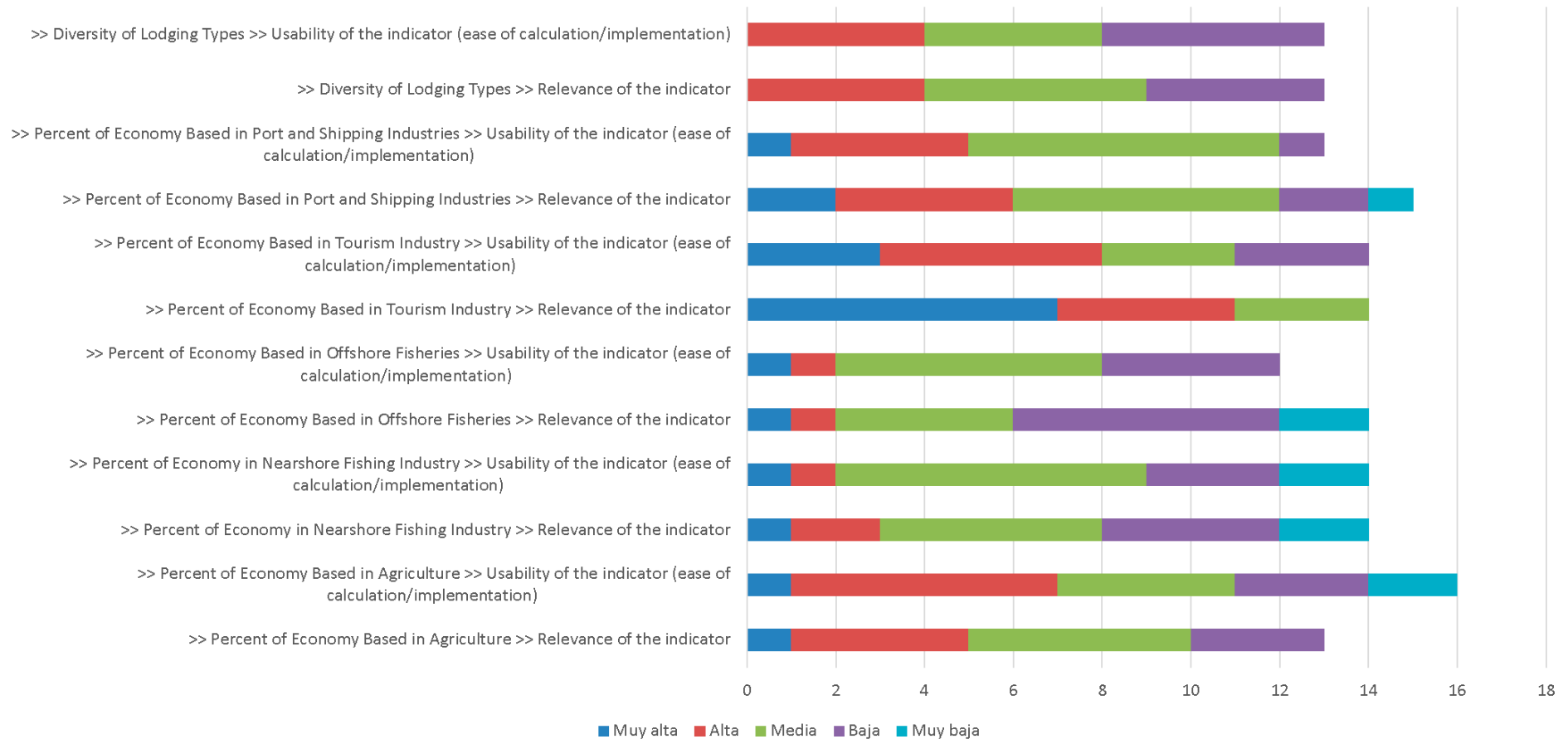


### Ecological risk / Ecosystems

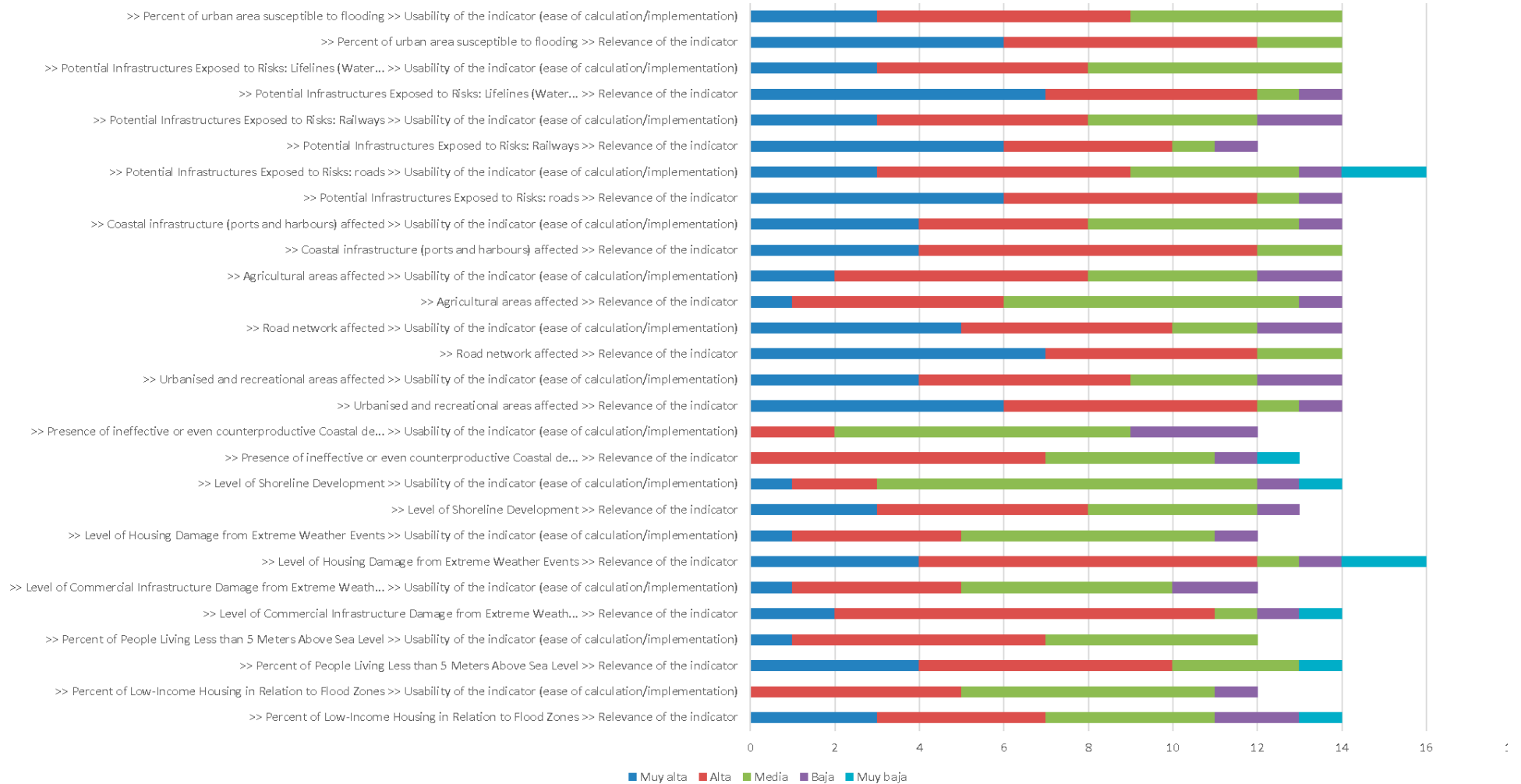




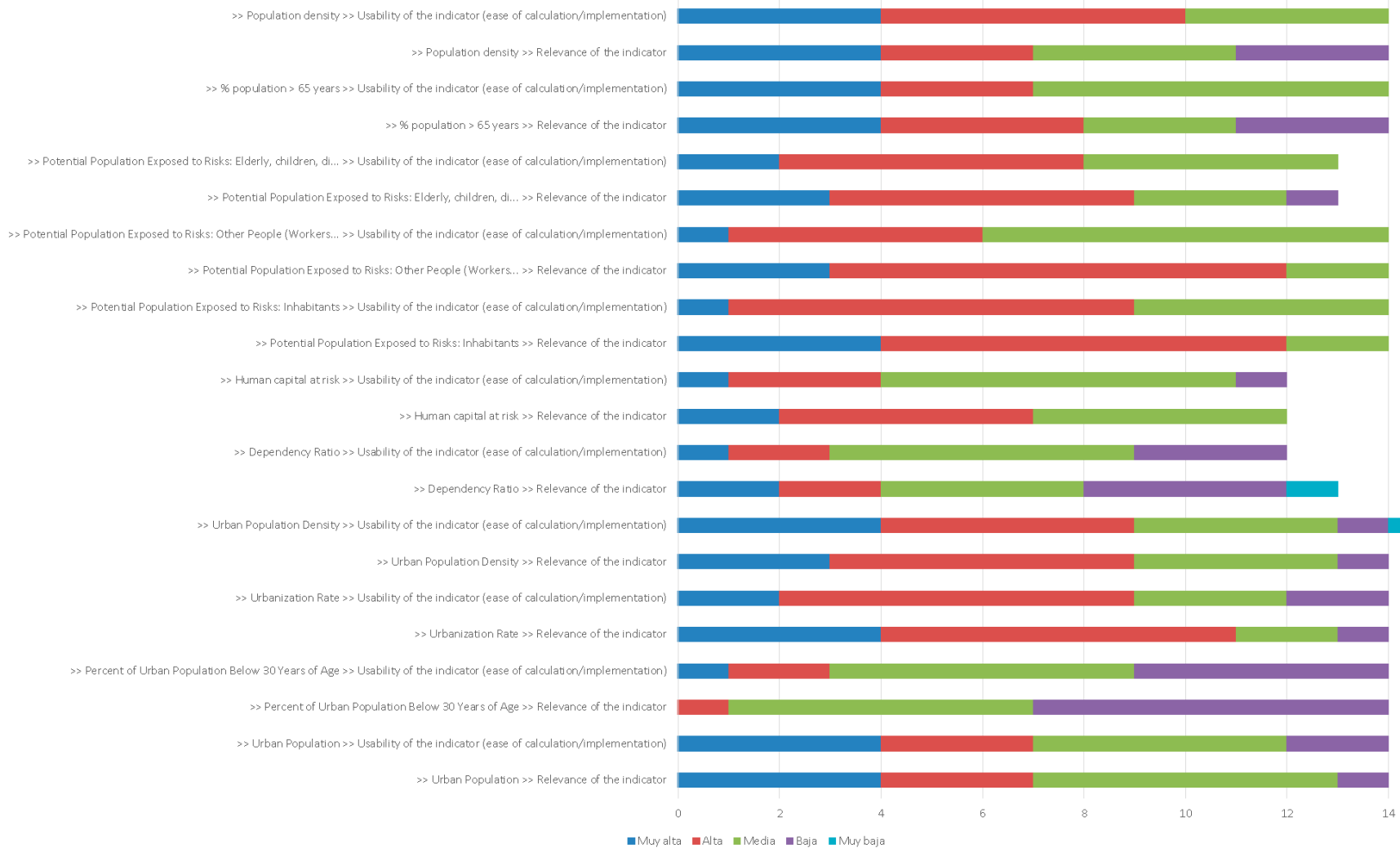
## Financial Risk / Economics



### Financial Risk / Infraestructures



**Political Risk / Social - Demographic**



**Political Risk / Governance**



## 6. SELECCIÓN FINAL DE INDICADORES Y CLASIFICACIÓN D.P.S.I.R.

Una vez evaluados los indicadores, se han seleccionado para cada área y subárea aquellos que han obtenido una valoración positiva tanto en relevancia del indicador como en su facilidad para el cálculo e implementación.

Igualmente, se han clasificado como indicadores de tipo: drivers (D), pressure (P), state (S), impact (I) or response (R).

<b>Ecological risk</b>	<b>D.P.S.I.R.</b>
<b>Geology / Water /Soil</b>	
Percent of Metro Area at Risk of Flooding	I
Projected Change in Sea-Level Rise	P
Rate of Coastal Erosion	I
Level of Geophysical Risk of Landslides	I
Total Number of Flood Events	P
Coastal erosion	S
Recession of beaches and cliffs	S
Hillside movements (landslides)	P
Overflows of watercourses	P
Rock falls	I
Flooding: Peak Flow	P
River floods	S

<b>Ecological risk</b>	<b>D.P.S.I.R.</b>
<b>Climate</b>	
Total Number of Extreme Heat Events	S
Total Number of Droughts	S
Total Number of torrential rains	S
Total Number of severe swells	S
Present Days >30 °C	S
Present average annual rainfall	S

<b>Ecological risk</b>	<b>D.P.S.I.R.</b>
<b>Ecosystems</b>	
Urban land growth rate	D
Beaches and dunes damaged	I
Potential Areas Exposed to Risks: Natural Areas, Site of Community Importance (SCI), Special Protection Areas (SPA)	S
Area without vegetation	S

<b>Financial Risk</b>	<b>D.P.S.I.R.</b>
<b>Economics</b>	
Cost of restoration of eroded beaches	R
Economic capital at risk	S
Erosion hotspots: impact on economic value	P
Cost of flood defence	R
Cost of erosion defence	R
Cost of restoration of flooded land	R

<b>Financial Risk</b>	<b>D.P.S.I.R.</b>
<b>Industries</b>	
Percent of Economy Based in Agriculture	S
Percent of Economy Based in Tourism Industry	S
Percent of Economy Based in Port and Shipping Industries	S
Diversity of Lodging Types	S

<b>Financial Risk</b>	<b>D.P.S.I.R.</b>
<b>Infrastructures</b>	
Percent of People Living Less than 5 Meters Above Sea Level	S
Level of Housing Damage from Extreme Weather Events	I
Urbanised and recreational areas affected	I
Road network affected	I
Coastal infrastructure (ports and harbours) affected	I
Potential Infrastructures Exposed to Risks: roads	S
Potential Infrastructures Exposed to Risks: Railways	S
Potential Infrastructures Exposed to Risks: Lifelines (Water main, Sewerage, Pipeline)	S
Percent of urban area susceptible to flooding	S

<b>Political Risk</b>	<b>D.P.S.I.R.</b>
<b>Social / Demographic</b>	
Urban Population	S
Urbanization Rate	S
Urban Population Density	S
Potential Population Exposed to Risks: Inhabitants	S
Potential Population Exposed to Risks: Other People (Workers, Tourists, Homeless)	S
Potential Population Exposed to Risks: Elderly, children, disabled	S
% population > 65 years	S
Population density	S

<b>Political Risk</b>	<b>D.P.S.I.R.</b>
<b>Governance</b>	
Climate Adaptation Plans	R
Investment in Climate Resilient Development Projects	R
Protection of coast against erosion by integrated management	R
Investment amount for non-structural measures	R
Sea-level rise projection	R

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