SOCLIMPACT

# Downscaling climate impacts and decarbonisation pathways in EU islands, and enhancing socioeconomic and non-market evaluation of Climate Change for Europe, for 2050 and beyond

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# Work Package 3:
# Climate change vulnerability assessment framework and complex impact chains

## Deliverable 3.3. Report on selected indicators

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**Coastal and Maritime Tourism**

**Aquaculture**

**Marine Energy**

**Maritime transport**

| Version | Date | Author | Notes |
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# 1. Introduction

In this report a set of indicators is proposed for summarizing objectives and providing up-to-date information on the impacts of climate change, the state-of-the-environment and societal conditions of islands. These indicators are meant to support a practical description. They can be used for identifying policy goals, defining strategies, monitoring and evaluating implemented actions. They are also useful for communicating the environmental and societal conditions to a particular audience, such as local stakeholders, administrations, general public, policymakers from local to national levels. Finally, they provide a synthetic way to describe multiple aspects of the state of environment, natural resources assets and related human activities including socio-economic factors.

These indicators are based on environmental data, models, oceanographic and meteorological observations, and administrative archives. They are based on several parameters including physical, chemical or biological measures associated with environmental quality or natural resources, information on processes and interventions, economical values, members describing the composition and characteristics of societies and of their needs.
The indicators are focused on the four sectors addressed by SOCLIMPACT and strictly linked to the identified impact chains.

They allow:

- To compare conditions among islands
- To identify critical situations
- To identify trends and evolution of conditions leading to risks
- To monitor risks
- To monitor the results of management strategies

This deliverable consists of six sections (including this introduction, numbered as section 1) and an appendix consisting of a set of tables with a synthetic description of the indicators. In section 2 indicators are linked to the general goals of SOCLIMPACT. In section 3 the methodology used for defining indicators and the requirements to be satisfied are described. Section 4 lists all indicators, with a separation accruing to the type of indicator and the relevant impact chain. Section 5 presents tables summarising the indicators and identify those that are more commonly used and with cross sectorial relevance. Section 6 links the indicators to the impact chains.

# 2. Assessing vulnerability and risk within the Soclimpact project

## 2.1. Concepts and definitions

Vulnerability and risk assessment in the SOCLIMPACT project build upon the AR5 concept of risk, which relates to the interaction of climatic, environmental, and human factors that can lead to impacts and disasters. It also builds upon options for managing the risks posed by impacts and disasters, also highlighting the important role that non-climatic factors play in determining impacts. Key definitions for the risk assessment have undergone some changes during the last decades. The IPCC AR5 risk concept has been developed around the central term 'risk'. According to this concept, the risk is "the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. This deliverable adopts the IPCC approach and the term risk is used to refer to the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure".

Furthermore, risk is a result of the interaction of hazard, vulnerability, and exposure. Definitions and methodological approaches for the risk assessment within this report adopt the following definitions taken by the Glossary of the IPCC Fifth and Fourth Assessment Report (IPCC, 2014; IPCC, 2007):

**Hazard**

The hazard is the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

**Vulnerability**

Vulnerability refers to the propensity of exposed elements of a sector to suffer adverse effects. It is the degree to which a system is susceptible to (and unable to cope with) adverse effects of climate change, climate variability and extremes. Vulnerability is associated to a set of conditions that derive from the historical and prevailing cultural, social, environmental, political, technological, and economic contexts.

Two components of vulnerability are the **sensitivity** of a sector to changes in climate and its **adaptive capacity**. The first is the degree to which a system is affected, either adversely or beneficially, by climate variability or change: the second represents the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects

**Exposure**

Exposure is the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

## 2.2. The selected IC

This paragraph summarizes the selected impact chains (ICs) for the different Blue Growth sectors and the reasons underlying their selection (for more information, please refer to D3.2).

### 2.2.1. Coastal and Maritime Tourism

The ICs on the coastal and maritime tourism sector are based on the concept of *tourist experience value* (Prebensen et al., 2014), meaning that climate change, affecting the potential tourist destination, will influence and change the tourist perception. Thus, the impacts of climate change on the economy are analysed by looking at the interaction between demand and supply. The change in tourist perception will impact the demand-side. In some other cases, climate change could also affect the supply-side, since it is expected that policy actions should be taken to keep the demand curve unaffected.

In order to embrace and summarize all the interactions that the tourist can experience in the destinations, three main categories of ICs have been considered for this sector:

- *loss of tourist experience value in the destination due to changes in environmental attributes;*
- *loss of tourist experience value in the destination due to changes in human being comfort (or health);*
- *loss of tourist experience value in the destination due to the quality of infrastructure and facilities.*

The three main IC categories have been divided into eight subcategories, defined *general* if affecting different islands in similar ways or *specific* if impacting on particular ecosystems and species, landscapes or activities:

*General IC*

- *Loss of comfort due to beach surface reduction.*
- *Loss of attractiveness due to climate discomfort*
- *Decrease of available domestic water for the tourism industry*
- *Increase of damages to infrastructures and facilities due to sea-level rise and storms.*

*Specific IC*

- *Loss of attractiveness of touristic marine environments.*
- *Loss of attractiveness due to increased danger of forest fire in touristic areas.*
- *Loss of attractiveness of touristic land environments.*
- *Loss of attractiveness due to loss of cultural and patrimonial heritage.*

### 2.2.2. Aquaculture

Although this sector is characterized by a great level of human control that mitigates features and consequences of climate change (De Silva and Soto, 2009), aquaculture activities are exposed to climate change impacts in direct and indirect ways. In particular, the risk of aquaculture-based communities is primarily a function of their exposure to extreme weather events, as well as the impact of climate change on physical and chemical parameters of the ecosystems, including temperature, salinity, acidity, and water levels and flows, which in turn will influence productivity.

Indeed, marine aquaculture is very susceptible to storms, which are predicted to occur with greater frequency in the future. Aquaculture facilities and infrastructures could be damaged, and the stock lost, thus affecting an increase in restoring costs for farmers and possible loss of income. Further, escapees could either have a negative impact on the local biodiversity and food chain as well as increase the risk of disease and parasitic infestation of wild stock. Further,

aquaculture activities can be heavily affected by climate change, because the increase of sea water temperature affects fish growth.

Thus, two main ICs affecting the aquaculture sector under climate change have been selected:

- *Increased fragility of the aquaculture activity due to extreme events*
- *Change in production due to changes in temperature*

### 2.2.3. Marine Energy

Marine energy may be susceptible to changes on climate, such as on wind patterns and wave regime. As suggested by Harrison and Wallace (2005) "where the resource is constrained, production and economic performance could suffer; on the other hand, stormier climates may create survival issues". Also, other renewable sources, such as hydropower and wind share this risk with marine technologies (e.g. Harrison and Whittington, 2002; Breslow and Sailor, 2002).
The used approach to identify the effects of climate change on marine energy as well as island energy system firstly take into account the main three elements of the energy value chain: generation, transmission, consumption.
The ICs on the energy sector include thus on-land power generation by RES (Renewable Energy Sources) and conventional fossil systems. Further, the protection of on-land electrical infrastructures is fundamental to assure that the produced marine energy is used. Finally, climate change will also have important impacts on the energy demand: on one hand, the maintenance of comfort conditions (especially in islands with high tourist activity) will require higher air-conditioning demand; on the other hand, higher water demand and competition from a number of sectors (residential, touristic, agriculture, etc.) will increase the demand from water desalination systems.
Thus, the proposed ICs:

- *Risk of changes in power generation due to long term climate change and variability*
- *Risk of damages to transmission grids due to extreme events*
- *Risk of changes in energy demand due to changes in precipitations and temperatures*

### 2.2.4. Maritime Transport

Within this sector it is well recognised that sea level rise and the increase of extreme weather events will affect infrastructures and equipment of the ports. Previous events occurred in the past have caused floods and agitation in the ports and, consequently, their temporary closure. Furthermore, extreme events already caused losses to ships. In particular, the routes and the nature of the transport are elements exposed to these damages, as some islands are part of important transoceanic routes. At the end, in case of extreme weather events, the population of some of the selected islands would be at risk of isolation.
Thus, three main risks affecting the maritime transport sector under climate change have been selected:

- *Risk of damages to ports' infrastructures and equipment due to floods and waves*
- *Risk of damages to ships on route (open water and near coast) due to extreme weather events*
- *Risk of isolation due to transport disruption*

# 3. Identifying and selecting indicators

Risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems. Thus, in order to assess risks, it is necessary to identify and select the indicators for each element of risk in the various impact chains. Indicators are parameters which provide information about specific states or conditions. They are extensively used in assessing vulnerability and risk in socio-ecological systems in the context of climate change. They are meant to provide quantified information, which is used to compare against critical thresholds or previous conditions.
A set of indicators along the impact chains allow the quantitative assessment of changes in the climate characteristics, changes in ecosystem services, and changes in the Blue Economy activities and in the whole economy of European islands.
CCIs (Climate Change Indicators) for marine and coastal ecosystems refer to units of measurement to evaluate the consequences in the marine and coastal environment experiences as a result of Climate Change (sea-level, composition, dynamics, .etc. ...). Practically, in the context of this study, hazards are associated with CCIs. ESIs (Environmental Services Indicators) refer to units of measurement to evaluate the consequences in Environmental Services of marine and coastal ecosystems that directly affect activities of the Blue Economy, such as changes in available beach surface, composition of sediment, reproductive and species growth, vulnerability of coastal infrastructures, waste assimilation capacity, etc.. EVIs (Environmental Value Indicators) refer to units of measurement to evaluate the economic value of changes in the Blue Economy activities of Environmental Services provided by marine-coastal ecosystems due to Climate Change. In this context, exposure indicators are either EVIs or ESIs.

## 3.1. Indicator characteristics

Selecting indicators is an iterative process whereby a list of ideal choices is slowly thinned out, with indicators rejected where they are unfeasible or – in particular – where there are insufficient data to substantiate them.
An indicator is expected to satisfy the following characteristics:

- It is valid and relevant, i.e., it represents well the factor you want to assess
- It is reliable and credible and also allows for data acquisition in the future
- It has a precise meaning, i.e. stakeholders agree on what the indicator is measuring in the context of the risk assessment
- It is clear in its direction, an increase in value is unambiguously positive or negative with relation to the factor and risk component
- It is practical and affordable, i.e., it comes from an accessible data source
- It is appropriate, i.e., the temporal and spatial resolution of the indicator is right for the risk assessment

In general, any list of indicators cannot be exhaustive and other indicators could be added. To exhaustive is particularly problematic for the "adaptive capacity" indicators. The present list shows (after an internal discussion) indicators that "practical and affordable" and that come "from an accessible data source". These lists cannot and should not be considered definitive and they might be revised in the continuation of the project. A short paragraph has been added to section 3.1 to clarify this.

## 3.2. How to identify the indicators

Starting from the outcomes of relevant literature (e.g. IPCC, 2014; GIZ and EURAC 2017, 2017), a methodological approach has been defined and four main steps have been identified.

*Selecting indicators for hazard*

In this report, as suggested by the GIZ methodology, hazard indicators were phrased so that they refer to a critical state or threshold. Frequencies, numbers etc. are used to describe the potential occurrence of a hazard and indicate the direction toward a defined event. For the hazard factor 'heavy rain', for instance, this could be 'number of days with more than 50mm precipitation'.

*Selecting indicators for vulnerability*

As said, vulnerability encompasses a variety of concepts and elements including *sensitivity* or susceptibility to harm and lack of *capacity* to cope and *adapt*.

Sensitivity may include physical attributes of a system (e.g. building material of houses, type of soil on agriculture fields), social, economic and cultural attributes (e.g. age structure, income structure). In order to identify the most appropriate indicators we propose guiding questions as the following (Fritzsche et al., 2014):

- *what are the characteristics of the system which make it susceptible to adverse effects of the changing signal(s) identified in the previous step?*
- *how do these climate conditions affect these systems?*

Capacity refers to the ability of societies and communities to prepare for and respond to current and future climate impacts. According to Giordano et al. (2013), "sensitivity and adaptive capacity could be sometimes confused. Adaptive capacity includes the intrinsic quality of a system that makes it more or less capable to adapt, but can also reflect the abilities to collect and analyse information, communicate, plan, and implement adaptation strategies that ultimately reduce vulnerability to climate change impacts".

For this extent, the key question to select indicators for adaptive capacity focus on the *capacities and resources within the system allowing to address climate change impacts*. In particular, the GIZ (2017) methodology proposes the following guiding question for the different dimension of adaptive capacity:

- ***Knowledge**: is there knowledge or expertise which might aid adaptation?*
- ***Technology**: are there technical options available and affordable which could enhance adaptive capacity?*
- ***Institutions**: how does the institutional environment contribute to adaptive capacity?*
- ***Economy**: which economic and financial resources are available for enhancing adaptive capacity or implementing adaption measures?*

*Selecting indicators for exposure*

The selection of exposure indicators is related to specific exposed elements (or elements at risk), which are the presence of people, livelihoods, species or ecosystems, etc. ..., in places that could be adversely affected by climate change. The degree of exposure can be expressed by absolute numbers, densities or proportions etc. of the elements at risk (e.g. population density in an area affected by drought).

*Check indicator's specificity*

Once the first draft of indicators is compiled, it is suggested to check indicator's specificity in order to verify if the indicator is formulated towards the risk approach and to assess whether they are explicit and self-explicative, mainly in two regards:

- validity and relevance – the selected indicator needs to represent well the factor included in the impact chain;
- computation methods – this aspect embraces data availability and quality, a frequent pitfall in indicator selection if underestimated

## 3.3. The factsheet to identify and select indicators

With the aim to support the identification and selection of the indicators per factor in the impact chains developed in D.3.2, a template indicator factsheet has been prepared that records all potential indicators with any relevant additional information. The factsheet is presented in Tab. 1 and it is accompanied by a text that guides in its compilation. In principal, the factsheet requires a brief description of the indicator, the unit of measurement, potential data sources, a brief explanation outlining the reason for selecting it.

*Tab. 1 – template of the fact sheet to be provided to describe each indicator*

| | |
|---|---|
| **Sector** | Select the sector affected from the menu "Coastal and Maritime Tourism", "Aquaculture", "Maritime Transport", "Marine Energy" |
| **Impact chain** | Name of the impact chain where the indicator is present |
| **Indicator type** | *Which risk component is described by the indicator?* Select from the menu "Hazard", "Sensitivity", "Adaptive Capacity", "Exposure" |
| **Reference factor** | The factor (producing the risk in the impact chain) to be described by the indicator |
| **Indicator: Name, abbreviation, short description** | Indicator name with short name used to denote the indicator and a short description on its meaning and computation |
| **Unit** | Definition of the unit used in the expression of the indicator |
| **Indicator classification** | Select from the menu "Climate Change indicators", "Environmental services indicators", "Environmental value indicators" |
| **Sources of information** | Describe, in general terms, which types of sources (models, administrative data, geomorphological data, satellites, observations, platforms,…) of information on the indicator are available |
| **Supplementary Information** | Add useful information and reference on the indicator and its computation |

## 4. Results: full list of indicators

The fact-sheets of all indicators are provided in the Appendix 1. Here only the abbreviation used and their general meaning is described. The summary table at the end of this section lists all indicators that have been proposed.

Abbreviations are assigned with some common criterion. Indicators initiating with N are numbers, with P are percentages, with B are Boolean ("YES" or "NO") variables, with L are assessments on a Lickert scale, n (lower case) for negation "NO". The presence of X in the abbreviation denotes the use of maximum in the definition, Tot of the Total and AVE of the average. Here are some examples of adopted abbreviations:

- **Air** Air
- **Apt** Airports
- **Cho** Choice
- **Coast** coastal and coast
- **Cr** Crops
- **Empl** Employees
- **Frs** Forest
- **Le** Length
- **P** Precipitation
- **Pax** Passengers
- **pH** potential of Hydrogen
- **Pa** Path
- **Pla** Plan
- **Po** port(s)
- **Poll** Pollution
- **Sa** Sand
- **Sh** Ship(s)
- **Sp** Species
- **SS** Sea Surface
- **SWH** Significant Wave Height
- **T** temperature
- **Tr** Training
- **Trt** Treatment
- **Tou** Tourists
- **Wa** Walking
- **Wi** Wind
- **Wtr** Water

The indicators in the following lists of indicators (considered separately for each sector) to allow for the operationalization of the Impact Chains, have been selected from the sources described above with the following criteria:

1. Indicators are proper for measuring the particular aspect they focus on;

2. Indicators are functional either inside the factor they form part at first instance (hazard, exposure, sensitivity, adaptive capacity) or to dialogue with indicators belonging to other factors in order to facilitate the assessment of multifactorial relationships having place in each sector.

3. Most indicators are homogeneous and comparable with those integrated in the more widely recognised and used indicator systems in the global and European institutional framework.

## 4.1. Coastal and Maritime Tourism

Although the movement of developing environmental and sustainability indicators starts with OECD systems in 1990 and gives place to a big framework containing a wide range of indicator systems (environmental indicators, decoupling indicators, sustainable development indicators…), tourism becomes incorporated to this trend a bit later by the hand of UNWTO. Since 1994 this multilateral organization has been developing a set of indicators to assess the sustainable development of tourism able to properly respond to the specificities of that complex and multi-sectoral industry, that has been updated several times (see UNWTO Conference Manila 2018).

Also the World Travel and Tourism Council has developed indicator systems to assess those aspects of tourism industry development that mostly focus on tourism firms and organizations, thus complementing the vision launched by UNWTO. Their global and country analysis give a big amount of information reported as serial indicators, mainly in the field of economic dimension of tourism sustainable development.

Finally, The European Tourism Indicator System (ETIS) (see at file:///C:/Users/Usuario/Downloads/ETIS%20toolkit%202016%20150316%20(1).pdf ) provided since 2013 an extraordinarily well structures corpus of sustainable development of tourism that holds 27 core indicators and 40 optional indicators, subdivided into four categories: i) destination management; ii) social and cultural impact, iii) economic value; and iv) environmental impact.

Most of indicators developed to sustain the operationalization of coastal and marine Impact Chains come from these sources so they are completely tested and widely used globally. Yet, some others that are specific of the developed Impact Chains has been developed working on the indicators provided by the European Environment Agency, mainly, Eurostat and the European Centre for Disease Prevention, for the case of the impact chain related to infectious diseases and climate change.

Indicators of socioeconomic performance of tourism in Soclimpact islands area available from de decades of sixties and seventies of last century, when the first national and regional statistics systems in Europe open space to collect and classify relevant information from tourism activity, at that time exploiting as global economic and cultural phenomena.

An important set of environmental indicators for tourism in the islands has been developed since the beginning of nineties, following the guidelines from OECD and UNWTO, later incorporated to the European Eurostat system.

Many indicators can be obtained from homogenised European sources, mainly Eurostat and the European Environment Agency. Also, regional statistic systems provide quite part of the required information. In this case, most of statistic systems follow a common framework to collect and organise tourist information, including the units of measurement. In some cases, could be needed adjusting primary information to guarantee comparability.

### *4.1.1 Hazard*

Risk: **Loss of attractiveness of touristic marine environments**

- **SSTAVE** - Monthly Average Sea Surface Temperature
- **SST_2-98** – Annual Sea Surface Temperature range (*difference between the annual values of the 2nd and 98th percentile the daily sea surface temperature*)
- **SSpHAVE** - Monthly Average Sea Surface pH
- **SSpH_2-98** - Annual sea surface pH range (*difference between the annual values of the 2nd and 98th percentile the daily sea surface pH values*)

Risk: **Loss of attractiveness due to increased danger of forest fire in touristic areas**

- **SPI** - Standardised Precipitation Index (*precipitation represented as standardized departure from a selected probability distribution function that models the precipitation data. SPI can be interpreted as the number of standard deviations by which the observed anomaly deviates from the long-term mean*)
- **NSPI** - Number of months per year in which the Standardized Precipitation Index is lower or equal to -1
- **FWI** - Fire Weather Index (*Represents the potential fire intensity, combining: temperature, relative humidity, wind speed and 24-hour rainfall*)
- **CDD** - Consecutive Dry Days (*annual Maximum number of consecutive dry days when PR<1.0mm, also referred to as 'longest dry spell'*)
- **HWM** - Heat Wave Magnitude (*maximum magnitude of the heat waves in a year, where heat wave is the period ≥ 3 consecutive days with maximum temperature above the 90th percentile of daily maxima in the suitable reference period)*
- **NWi20** - Number of days with Wind blowing >20 km/h

Risk: **Loss of attractiveness of touristic land environments**

- **NTX90p** - Number of days per year in which Temperature is above than 90th percentile of maximum daily temperature
- **Ptot** - Annual Total Precipitation
- **HWM** - Heat Wave Magnitude (*maximum magnitude of the heat waves in a year, where heat wave is the period ≥ 3 consecutive days with maximum temperature above the 90th percentile of daily maxima in the suitable reference period)*
- **NSPI**- Number of months per year in which the Standardized Precipitation Index (SPI) is lower or equal to -1
- **FI** - Flood Intensity (Components: -Peak flow; -Peak level; -Maximum 24-h flood volume; -Maximum 72-h flood volume; -Tidal flood volume)

- **NWiX98p** - Number of days with extreme Wind speed (*maximum value above the 98th percentile of daily maximum wind speed*)

Risk: **Loss of attractiveness and comfort due to beach availability reduction**

- **MSLAVE** – annual Mean Sea Level
- **NSWHX98p** - Number of days per year with SWH maximum above the 98 percentile of the daily maximum
- **NSLX98p** - Number of days per year with SL maximum above the 98 percentile of the daily sea level maximum

Risk: **Loss of attractiveness due to climate discomfort**

- **HWM** - Heat Wave Magnitude (*maximum magnitude of the heat waves in a year, where heat wave is the period ≥ 3 consecutive days with maximum temperature above the 90th percentile of daily maxima in the suitable reference period)*
- **NTX90p** - Number of days per year in which Temperature maximum is above than 90th percentile of maximum daily temperature
- **TN_HD** - Annual number of combined Tropical Nights and Hot Days (*Number of days when minimum temperature >20ºC and maximum temperature >30ºC occur in sequence*)
- **NEWC** - Number (or percentage) of days under Extreme Weather Conditions (wind, storm surges and floods).

Risk: **Decrease of available domestic water for the tourism industry**

- **NTX90p** - Number of days per year in which temperature is above than 90th percentile of maximum daily temperature (*During these days an extra water demand for irrigation and refreshing purposes will take place*)
- **Ptot** - Annual total precipitation
- **NSPI** - Number of months per year in which the Standardized Precipitation Index (SPI) is lower or equal to -1

Risk: **Increase of damages to infrastructure and facilities due to sea level rise and storms**

- **NSWHX98p** - Number of days per year with SWH maximum above the 98 percentile of the daily maximum
- **MSLAVE** - Mean Sea Level (*annual value*)
- **NWiX98p** - number of days per year with maximum wind speed maximum above the 98percentile of a reference baseline period
- **Rx5d** - Index for the maximum annual precipitation over five consecutive days

Risk: **Loss of attractiveness due to loss of cultural and patrimonial heritage**

- **NSWH98p** - Number of days per year with SWH above the 98 percentile of the daily maximum in the reference baseline period
- **MSLAVE** - Annual Mean Sea Level
- **NSLX98p** - Number of days per year with Sea Level maximum is above the 98$^{th}$ percentile of the daily sea level maximum in the reference baseline period

***4.1.2 Sensitivity***

Risk: **Loss of attractiveness of touristic marine environments**

- **FSpD** - Density of flagship species (*This indicator measures the density of a given flagship species in a given area in Kg/Ha*)
- **FSpS** - Average size of flagship species (*This indicator captures the average size of an individual of the species studied in cm)*
- **PSFSp** – percentage of surface occupied by foundation species with respect to the potential surface (*This indicator measures the amount space occupied by the species*)
- **PISp** - Integrity of the species (*This indicator is composed of three numbers representing the percentage well/moderately/badly preserved species at a given time*)
- **POFS** – percentage of overfished stocks (*This indicator measures the percentage of fish stocks that are overfished at a given time*)
- **PFFFS** – percentage of fully fished fish stocks (*This indicator measures the percentage of fish stocks that are fully fished at a given time*)
- **PHUP** - habitats considered under pressure/under threat
- **SeTD** - Sewage total discharges (
- **ChlC** - Chlorophyll-a concentrations in European seas
- **EcoliC** - E. coli concentration

Risk: **Loss of attractiveness due to increased danger of forest fire in touristic areas**

- **PALF -** Percentage of island area that is managed for agriculture, livestock and forestry purposes
- **NRAB** - Number of recreational areas with barbecue (public use)

Risk: **Loss of attractiveness of touristic land environments**

- **FP** - Fragmentation pressure of urban and transport infrastructure expansion (Number of meshes per 1000 square kilometres)
- **PHUP** – percentage of habitats considered under pressure/under threat **(**
- **API** - Releases of air pollutants from industry
- **EI** - Emission intensity of domestic sector
- **MSWV** - Waste volumes from manufacturing and services sector
- **MWV** - Municipal waste volumes
- **FSpD** - Density of flagship species (*This indicator measures the mass of a given flagship species in a given area*
- **FSpS** - Average size of flagship species

Risk: **Loss of attractiveness and comfort due to beach availability reduction**

- **NGro** - Number of groyne and breakwater-sort structures, including ports affecting sand
- **PTopSocks** - Percentage of days per year in which the beach registered the presence of algae topsocks on the beach
- **PJelly** - Percentage of days per year in which the beach registered the presence of jellyfish on sea bathing waters

- **PAlgae** - Percentage of days per year in which the beach registered the presence of big and dense amount of microalgas/cyanobacterias on sea bathing waters or visible area around.

Risk: **Loss of attractiveness due to climate discomfort**

- **NAirPOLL** - Number of days (per year) in which the concentration of pollutant particles, measured in $\mu g/m^3$ is over the European health-based standards
- **PTou6_65** – percentage of tourists over 65 years old and visitors under 6 years' old

Risk: **Decrease of available domestic water for the tourism industry**

- **TouWtrD** – Tourist Water Demad *(Annual daily average water consumption per overnight) (Quantity of water used in agriculture per 1000 euros of GAV)*
- **WtrDE** – Water Demand Efficiency *(Quantity of water used in agriculture per 1000 euros of GAV)*
- **DWtrC** – Domestic Water Consumption *(annual mean value of daily consumption of domestic water per capita)*
- **LGWtrA** – Expert assessment of groundwater quantitative and chemical status

Risk: **Increase of damages to infrastructure and facilities due to sea level rise and storms**

- **NDnSH** - Number of days per year in which the service (water, energy and telecommunications) was interrupted due to climate hazards
- **CDR**- Cost of repairing damages to infrastructures (related with the touristic activity such as promenades, marinas, etc.) related to climate hazards, per year

Risk: **Loss of attractiveness due to loss of cultural and patrimonial heritage**

- **LFVI** - Flood vulnerability index for coastal areas holding cultural and patrimonial heritage

### *4.1.3 Adaptive capacity*

Risk: **Loss of attractiveness of touristic marine environments**

- **PCWWtrt** – Percentage of pollution (chemicals) cleaned from wastewaters after treatment
- **TWtrt** - volume of treated water
- **PPopWWTrtT** – Percentage of Population with urban waste water treatment (*the percentages of the population connected to primary, secondary and tertiary urban waste water treatment facilities*)

Risk: **Loss of attractiveness due to increased danger of forest fire in touristic areas**

- **BWS** - Presence or absence of an efficient early warning system (*Boolean variable denoting presence or absence)*
- **FAWS** - Funds available for warning system
- **NEWS** - Number of employees in the warning system
- **NFF** - Number of firefighters
- **NFRPla** - Number of fire risk plans

- **NV** - Number of voluntary
- **PEL** - Percentage educational level

Risk: **Loss of attractiveness of touristic land environments**

- **APA** - Area of nationally designated Protected Areas
- **NPA** - Number of sites of nationally designated Protected Areas
- **POC** – Percentage of total Organic Crop out of total Utilised Agricultural Area
- **AHBD** - Area of sites designated under the EU Habitats and Birds Directives

Risk: **Loss of attractiveness and comfort due to beach availability reduction**

- **FACoastM** - Funds Available for Coast/beach Maintenance
- **LCoastPA** - Expert assessment of effectiveness of the Coastal Protection Actions on a Lickert scale

Risk: **Loss of attractiveness due to climate discomfort**

- **BWS** - Presence or absence of an efficient early warning system (*Boolean variable denoting presence or absence)*
- **FAWS** - Funds available for warning system
- **NEWS** - Number of employees in the warning system
- **PTouBC** – Percentage of tourism beds with cooling systems

Risk: **Decrease of available domestic water for the tourism industry**

- **XWtr** - Annual maximum amount of water that can be provided from non-conventional sources (e.g. desalination and sewage treatment plants)
- **BWtrM** - Presence of quality-labelled water monitoring and management system
- **FAWtrM** - Funds for water monitoring and management system
- **PWtrR25** - Percentage of days per year in which freshwater reserves are above 25%

Risk: **Increase of damages to infrastructure and facilities due to sea level rise and storms**

- **BWS** - Presence or absence of an efficient early warning system (*Boolean variable denoting presence or absence)*
- **FAWS** - Funds available for warning system
- **NEWS** - Number of employees in the warning system
- **FMMCoastI** - Funds allocated to monitoring and maintenance of coastal infrastructures and facilities per year

Risk: **Loss of attractiveness due to loss of cultural and patrimonial heritage**

- **FMCH** - Funds available for maintenance of cultural heritage
- **BWS** - Presence or absence of an efficient early warning system to protect cultural heritage sites from extreme weather

#### *4.1.4 Exposure*

Risk: **Loss of attractiveness of touristic marine environments**

- **LCoast** - Linear size of the coast (*This indicator measures the length of the coast exposed*)

- **ACoastSea** - Area of coastal sea (*This indicator measures the extension of the coastal sea exposed*)
- **PMPA** - Area covered by Marine Protected Areas in EU waters within 200 m (km2) (*This indicator measures the percentage of the marine protected area network coverage*)
- **NEco** - Number of ecosystems (*number of different ecosystems exposed*)
- **ER** - Indicator of ecosystem richness, weighting the relative surface occupied by different ecosystems (*This indicator measures the diversity of existing ecosystems, taking into account that different ecosystems are more or less spread in the space*)
- **NFSpecies** - Number of flag species (*number of different flag species that are present in the island*)
- **NTouP** - Number of tourist population (*total annual number of visitors reaching the island)*

Risk: **Loss of attractiveness due to increased danger of forest fire in touristic areas**

- **NTotP** – Total population of the Island (*Inhabitants in the island, both permanent residents, and tourist equivalent*)
- **P6-65P** – Percentage of population younger than 6 years and older than 65 years
- **Acrops** - cultivated area
- **Afrs** - forest area
- **Pfrs** – Percentage of island area that is occupied by forests
- **PfrsPA** - Percentage of forest that belongs to protected area
- **NFSpecies** - Number of flagship land species and birds
- **NTouP** - Number of tourist population (*total annual number of visitors reaching the island)*
- **LWaPa** - Length of walking paths

Risk: **Loss of attractiveness of touristic land environments**

- **AS** - Size of area of study
- **ALCCE** - Land cover change for ecosystems
- **NSpecies** - Number of species per ecosystem
- **NFSpecies** - Number of flagship land species and birds
- **NTouP** - Number of tourists

Risk: **Loss of attractiveness and comfort due to beach availability reduction**

- **ASaB** - Area of sand beaches
- **NSaB** - Number of sand beaches
- **NTouBP** - Number of beach tourists per year

Risk: **Loss of attractiveness due to climate discomfort**

- **NTouP** - Number of tourist population (*total annual number of visitors reaching the island)*
- **NTouP_JJAS** - Number of tourists between June and September (both included)

Risk: **Decrease of available domestic water for the tourism industry**

- **PLWtrPe** - Percentage of land susceptible of water percolation
- **NTouP_JJAS** - Number of tourists between June and September (Dry season in Mediterranean Islands)

Risk: **Increase of damages to infrastructure and facilities due to sea level rise and storms**

- **LeCoastTou** – length of coastal with touristic infrastructures
- **LeCoastF** - length of coastal main facilities (water, electricity and telecommunications)

Risk: **Loss of attractiveness due to loss of cultural and patrimonial heritage**

- **NTouP_CuHe** - Number of tourists that visit cultural and patrimonial heritage sites per year
- **NCuHe** - Number and relevance of cultural and patrimonial heritage sites

## 4.2. Aquaculture

### *4.2.1 Hazard*

Aquaculture is directly exposed to extreme meteorological events. This requires to define a set of indicators capable of describing the intensity of storms, mainly wins and waves. Availability depends on in situ instrumentation close to the facility, which particularly for waves is problematic, and in most cases has to be replaced by hind casts and model data. The other critical physical factor is water temperature, because of physiological characteristics of the farmed species, and to which similar considerations apply concerning availability of long time series.

Computation of indicators of sensitivity, adaptation capacity and exposure relies of the record collected at the farming facilities. Often they are not public and their use would rely on the cooperation of consortia and farmers. They are problematic in terms on regular availability in time and homogeneity to compare different locations and islands. Expert judgement will be a key ingredient for reaching a consistent evaluation of risks.

Risk: **Increased fragility of the aquaculture activity due to extreme events**

- **NWiX98p** - Frequency of storms (*number of days with Wind speed maximum above the 98$^{th}$ percentile of a reference baseline period*)
- **SLX98p** – Extreme storm surge height (*annual value of 98$^{th}$ percentile of the daily Sea Level maximum*
- **SWHX98p** – Extreme significant wave height (*annual value of the 98$^{th}$ percentile of the daily Significant Wave Height maximum)*

Risk: **Change in production due to changes in temperature**

- **NSSTX** - Sea water heat waves (*number of days with average SST above maximum temperature for the fish species*)

### *4.2.2. Sensitivity*

Risk: **Increased fragility of the aquaculture activity due to extreme events**

- **PCRep** – Annual Percentage Cost of Repairing (*amount spend on repair per year as percentage of total asset value)*
- **MRt** - Average Mortality Rate of the stock

Risk: **Change in production due to changes in temperature**

- **MRt** - *Average Mortality Rate of the stock*
- **SGR** -Specific Growth Rate (*decrease in growth rate as function of increase in temperature*)

#### *4.2.3 Adaptive capacity*

Risk: **Increased fragility of the aquaculture activity due to extreme events**

- **STD** - Stocking Density (*Number of animals per m3*)
- **BWS** - Existence and efficiency of an early coastal Warning System (*Boolean variable denoting presence or absence of active oceanographic stations)*
- **WCR** - Working Capital Ratio (*liquidity ratio that measures a firm's ability to pay off its current liabilities with current assets*)

Risk: **Change in production due to changes in temperature**

- **CCS** - Capacity to change species (*Number of species suitable for the farm*)
- **BWS** - Early Warning System (*Existence and efficiency of an early warning system to detect temperature, Dissolved Oxygen, algae bloom etc.*)
- **WCR** - Working Capital Ratio (*liquidity ratio that measures a firm's ability to pay off its current liabilities with current assets*)
- **TDP** - Treating Diseases/Parasites (*Amount for treatments or prevention measures applied as a fraction of total costs of the farm*)

#### *4.2.4 Exposure*

Risk: **Increased fragility of the aquaculture activity due to extreme events**

- **BTot** - annual total Biomass in stocks
- **VFS** - Value of Farm Structures (*Total value of assets used for farming in the water in each year)*
- **NemplA** - Number of Employees working in the Aquaculture farms in each year
- **PGDPA** – Percentage of regional Gross Domestic Product produced by Aquaculture in each year

Risk: **Change in production due to changes in temperature**

- **NEmplA** - Number of Employees working in the Aquaculture farms in each year
- **BTot** - Annual Total Biomass in stocks
- **VPATot** - Economic Value of total Aquaculture production per year
- **PGDPA** – percentage of regional Gross Domestic Product produced by Aquaculture in each year

### 4.3. Marine Energy

The focus of the energy risks and indicators has been put on the electrical system, due to the central role of electrification in the decarbonisation of the energy sector. The indicators have been selected taking into account the three main aspects of the electrical system: power demand, generation and transport, which correspond respectively to the three general risks considered.

Demand indicators do not include heating, due to the mild winters that characterize the islands analysed in SOCLIMPACT. Cooling demand is already high in several islands, like Cyprus and Malta (Jakubcionis and Carlsson, 2017), and will increase generally due to future increased temperatures. Water scarcity is also already a problem, generating the need for desalination in several islands. Some islands like the Canary Islands have a long history of desalination needs (Gómez-Gotor et al., 2018).

The selection of power generation indicators focuses on renewable energy sources as one of the aims of SOCLIMPACT is the analysis of decarbonisation pathways. The chosen sources are the

main renewable energy sources already used and that will likely provide a large part of the future renewable energy: wind and solar photovoltaic power. Energy sources like wave energy have not been included here due to their negligible present use and relatively low expected future contribution. The main direct link to marine energy is given by offshore wind energy, which likely will play an important role in the future due to land constraints in the islands.

Power transport indicators do not cover impacts caused by cold extremes, like icing and snow, due to the mild winters of the islands. Relevant extremes for power transport infrastructure are therefore strong winds, high temperatures and flooding. A key transport indicator for islands is the capacity of interconnections with mainland, which exist only for part of the islands.

Regarding the time periods of the indicators, the approach is hybrid, so that some indicators are considered static and some vary with time. In the computation of the indicators, in a first stage only the climate hazard indicators will vary with time. Socioeconomic modelling in SOCLIMPACT will provide future projections for some vulnerability and exposure indicators, allowing for a more detailed risk computation in a second stage, including the consideration of future increased renewable energy shares.

There are several sources of data that are expected to be used for computing the indicators. For climate hazards, both observed and climate model data will be used. For the calculation of vulnerability and exposure indicators, local information is expected to be gathered by the Island Focal Points, while public databases like EUROSTAT can provide part of the needed data. Socioeconomic model data are also expected to be used for obtaining projected changes of some vulnerability and exposure indicators. Additionally, for certain indicators like the Cooling Penetration Rate approximate formulas dependent on climatic conditions can be used (Jakubcionis et al., 2017).

### *4.3.1 Hazard*

Risk: **Changes in energy demand due to changes in precipitations and temperatures**

- **CooDeD** - Cooling Degree Days (*Accumulated temperature difference above 18ºC in each year, calculated using average daily temperature values*)
- **SPI** - Standardised precipitation index (*index obtained transforming the monthly precipitation time series into a standardized normal distribution*)

Risk: **Changes in power generation due to long term climate change and variability**

- **WiX98p** – Windstorm maximum intensity (*annual value of the 98th percentile daily of the daily wind speed maximum)*
- **WiAVE** – Monthly average wind speed
- **SRAVE** - Monthly average downward solar radiation at the surface

Risk: **Damages to transmission grids due to extreme events**

- **NEME** - Frequency of extreme meteorological events (*frequency of high wind gusts, flash floods, lightning, high temperatures that can damage transmission lines and substations*)

### *4.3.2. Sensitivity*

Risk: **Changes in energy demand due to changes in precipitations and temperatures**

- **CED** - Cooling energy demand sensitivity (*Change of cooling energy demand per unit change of CDD*)

- **DED** - Desalination energy demand sensitivity (*Change of desalination and pumping energy demand per unit change of SPI*)

Risk: **Changes in power generation due to long term climate change and variability**

- **PWPV** - Wind power variability (*Coefficient of variation: standard deviation divided by mean value*)
- **PSPV** - Solar PV power variability (*Coefficient of variation: standard deviation divided by mean value*)
- **PREn** - Percentage of renewable energy in gross final energy consumption (*Vulnerability of energy production to extreme events will depend on the share of renewable energy)*

Risk: **Damages to transmission grids due to extreme events**

- **CTLRep** - Cost of transmission Line Reparation (*Specific cost of repairing transmission lines and substations (per extreme event)*)
- **PCU** - Percentage of consumption units affected by power outages (*Percentage of consumption units affected by power outages (blackouts) resulting from damages to power lines (per extreme event)*)

### *4.3.3 Adaptive capacity*

Risk: **Changes in energy demand due to changes in precipitations and temperatures**

- **LCrCho -** Lickert scale based on expert estimate on crop choices and irrigation needs assessing flexibility to switch to more resistant crops
- **PP** - Purchasing power (*Capacity of local residents and industry, and of tourists, to assume increased energy bills*)
- **DSM** - Demand side management (*Adaptation of demand to power generation: non-critical deferrable loads could be postponed to adjust power demand to variable RES power generation*)
- **PEE** - Percentage of buildings (properties) with a certificated energy efficiency class higher than D

Risk: **Changes in power generation due to long term climate change and variability**

- **ABU** - Available back-up generation and storage (*Increased variation in RES generation will need additional storage capacity to guarantee quality and security of power supply*)
- **PWSE** - Percentage of wind and solar energy in gross final energy consumption (*Wind and solar energy generators have a shorter lifetime than conventional energy plants, which makes them more adaptable in the long term, less technological lock-in, more modularity*)
- **NCN** - Number of consumption nodes per number of power plants
- **PPS** - Average power plant size

Risk: **Damages to transmission grids due to extreme events**

- **IM** - Capacity of interconnections with mainland (*Power Capacity of existing submarine cables interconnecting the island electrical system to a continental grid*)
- **NCN** - Number of consumption nodes per number of power plants
- **PPS** - Average power plant size

### *4.3.4 Exposure*

Risk: **Changes in energy demand due to changes in precipitations and temperatures**

- **NResP** - Island resident's population (*Number of permanent residents*)

- **NTouP** - Number of tourist population (*total annual number of visitors reaching the island)*
- **GDPEDA** – economic value of energy demanding economic activities
- **CPR** - Cooling penetration rate (*Potential percentage of households using air conditioning as a function of cooling degree days' value of an island*)
- **PDWtr** - percentage of desalinated water with respect to the total water domestic consumption

Risk: **Changes in power generation due to long term climate change and variability**

- **WWi** - Wind power capacity (*Installed wind energy capacity including onshore and offshore wind turbines*)
- **WSPv** - Solar photovoltaic capacity (*Installed solar Photo Voltaic capacity*)

Risk: **Damages to transmission grids due to extreme events**

- **LTrGr** – Total length of the implemented transmission grids
- **NTotP** – Total population of the Island (*Inhabitants in the island, both permanent residents, and tourist equivalent*)

## 4.4. Maritime transport

The following list of selected indicators is meant to provide information on the trends on the basis of data series are relatively easy to find for the islands under study. The maritime transport sector is highly regulated, and there are international and national organisations that provide indicators monthly or annually. These indicators will contribute to quantify the impact chains' elements. Moreover, they are relevant to measure the hazards, exposure, sensitivity and adaptive capacity of each impact chain.

Regarding the meteorological and oceanographic data, maritime and ports authorities at national level have developed, and support, systems for measuring and forecasting the marine environment. For example, in Spain, their objective is to provide the Spanish port system with the essential oceanographic and meteorological data for its design and exploitation and help to reduce costs and increases efficiency, sustainability and security of port operations.

In relation data on trading and commerce, regionalized information is widely available at national level, in its international trade entities, since maritime transport is the main means used to transport goods and passengers in island territories.

Concerning the data on demography and existing infrastructures, they are basic statistical information, which are readily available at the regional level.

It is expected that most of the indicators can be found at regional or national level, for example in the port authorities' websites. For this reason, the collaboration of the Island Focal Points and sectoral stakeholders will be necessary. However, aggregated data are useful and available in international organizations.

### *4.4.1 Hazard*

RISK**: Damages to ports' infrastructures and equipment due to floods and waves**

- **MSLAVE -** Annual Mean Sea Level

- **NSWHX98p -** frequency of extreme marine storm (*number of days per year with Significant Wave Height maximum above the 98th percentile of a reference baseline period*)
- **NWiX98p -** frequency of extreme high winds (*number of days per year with Wind speed maximum above the 98th percentile of a reference baseline period*)

RISK**: Damages to ships on route (open water and near coast) due to extreme weather events**
The indicators are **NSWHX98p** and **NWiX98p,** same as above, except these indicators need to be computed in an open area surrounding the island

RISK: **isolation due to transport disruption**
The indicators are **NSWHX98p, MSL** and **NWiX98p,** same as above, except these indicators need to be computed in the open sea surrounding the island including the ship route connecting it to the mainland

### ***4.4.2 Sensitivity***

RISK: **Damages to ports' infrastructures and equipment due to floods and waves**

- **NnOpPo** - Number of Ports that cannot Operate during extreme storms
- **NAgePo** - Number of Ports with critical infrastructures not renovated since **1993**

RISK: **Damages to ships on route (open water and near coast) due to extreme weather events**

- **NShDL** - Number of Ships on Paris MOU Detention List

RISK: **isolation due to transport disruption**

- **NAgeP** - Number of ports with critical infrastructures not renovated since **1993**
- **NIID** - Number of days in a year when the island was isolated from the main land

### ***4.4.3 Adaptive capacity***

RISK: **Damages to ports' infrastructures and equipment due to floods and waves**

- **NSPlaCCA** - Number of Strategic Plans which include a Climate Change Adaptation approach
- **NTrCoRM** - Number. of specialized Training Courses in Risk Management.
- **NOcSta** – Number of active Ocenographic Stations.

RISK: **Damages to ships on route (open water and near coast) due to extreme weather events**

- **NCPla** - Number of times in each year the Contingency Plan was triggered
- **NTrCoRM** - Number of specialized Training Courses in Risk Management.
- **NOcSta** - Number of active Oceanographic Stations

RISK: **isolation due to transport disruption**

- **PEnRR** – percentage of Energy produced by Renewable Resources.
- **NApt** - Number of Airport infrastructures (airports and heliports)

- **NTrCoRM** - Number of specialized training courses in risk management.
- **NOcSta** - Number of active Oceanographic Stations

### *4.4.4 Exposure*

RISK: **Damages to ports' infrastructures and equipment due to floods and waves**

- **NPax** - Total number of Passengers transported every year by ships docked at the islands' ports
- **NTotP** – Total Population of the Island (*Inhabitants in the island, both permanent residents, and tourist equivalent*)
- **VGTSTot** – Annual economic Value of total gGoods Transported to the Island by Ships per year
- **NPo** – Number of Port infrastructures in the Island

RISK: **isolation due to transport disruption**

Same indicators as for "Damages to ports' infrastructures and equipment due to floods and waves"

RISK: **Damages to ships on route (open water and near coast) due to extreme weather events**

- **PFFSh** - Annual percentage of Foreign Flag Ships that dock at the islands' port with respect to the total number of ships
- **NPax** - Total number of Passengers transported every year by ships docked at the islands' ports
- **VGTShTot** – Annual economic value of total Goods Transported to the Island by Ships per year
- **NCSh** – Total number of Cargo Ships docking at islands' ports every year

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# 5. Results: Summary tables

## 5.1. Coastal and Maritime Tourism, General Impact Chains

| TOURISM | | | | |
|---|---|---|---|---|
| | GENERAL IMPACT CHAINS | | | |
| RISK FACTORS | Loss of attractiveness and comfort due to beach availability reduction | Loss of attractiveness due to climate discomfort | Decrease of available domestic water for the tourism industry | Increase of damages to infrastructure and facilities due to sea level rise and storms |
| HAZARD | MSL | HWM | NTX90p | NSWHX98p |
| | NSWHX98p | NTX90p | Ptot | MSL |
| | NSLX98p | TN_HD | NSPI | NWiX98p |
| | | NEWC | | RX5d |
| | | | | |
| EXPOSURE | ASaB | NTouP | PLWtrPe | LeCoastTou |
| | NSaB | NTouP_JJAS | NTouP_JJAS | LeCoastF |
| | NTouBP | | | |
| SENSITIVITY | Ngro | NAirPOLL | TouWtrD | NDnSH |
| | PTopSocks | PTou6_65 | WtrDE | CDR |
| | Pjelly | | DWtrC | |
| | PAlgae | | LGWtrA | |
| ADAPTIVE CAPACITY | FACoastM | BWS | XWtr | BWS |
| | LCoastPA | FAWS | BWtrM | FAWS |
| | | NEWS | FAWtrM | NEWS |
| | | PTouBC | PWtrR25 | FMMCoastI |

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## 5.2. Coastal and Maritime Tourism, Specific Impact Chains

| TOURISM | | | | |
|---|---|---|---|---|
| | SPECIFIC IMPACT CHAINS | | | |
| RISK FACTORS | Loss of attractiveness of touristic marine environments | Loss of attractiveness due to increased danger of forest fire in touristic areas | Loss of attractiveness of touristic land environments | Loss of attractiveness due to loss of cultural and patrimonial heritage |
| HAZARD | SSTAVE | SPI | NTX90p | MSL |
| | SST_2-98 | NSPI | Ptot | NSWHX98p |
| | SSpHAVE | FWI | HWM | NSLX98p |
| | SSpH_22-98 | CDD | NSPI | |
| | | HWM | FI | |
| | | NWi20 | NWiX98p | |
| EXPOSURE | Lcoast | NTotP | AS | NTouP_CuHe |
| | ACoastSea | CP6-65P | ALCCE | NCuHe |
| | PMPA | Acrops | NSpecies | |
| | Neco | Afrs | NFSpecies | |
| | ER | PfrsPA | NTouP | |
| | NFSpecies | NFSpecies | | |
| | NTouP | NTouP | | |
| | | LWaPa | | |
| SENSITIVITY | FSpD | PALF | FP | LFVI |
| | FSpS | NRAB | PHUP | |
| | PSFSp | | API | |
| | PISp | | EI | |
| | POFS | | MSWA | |
| | PFFFS | | MWA | |
| | PHUP | | FSpD | |
| | SeTD | | FSpS | |
| | ChlC | | | |
| | EcoliC | | | |
| ADAPTIVE CAPACITY | PCWWtr | BWS | APA | FMCH |
| | TWtr | FAWS | NPA | LWS |
| | PPopWWtrT | NEWS | POC | |
| | | NFF | AHBD | |
| | | NFRPla | | |
| | | NV | | |
| | | PEL | | |

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## 5.3. Aquaculture

| AQUACULTURE | | |
|---|---|---|
| | IMPACT CHAINS | |
| RISK FACTORS | Increased fragility of the aquaculture activity due to extreme events | Decrease in production due to changes in seawater characteristics and increase in temperature |
| HAZARD | NWi98p | NSSTX |
| | SLX98p | |
| | SWHX98p | |
| EXPOSURE | BTot | BTot |
| | VFS | VPATot |
| | NemplA | NemplA |
| | PGDPA | PGDPA |
| SENSITIVITY | PCRep | SGR |
| | MRT | MRT |
| ADAPTIVE CAPACITY | STD | CCS |
| | EWS | EWS |
| | WCR | WCR |
| | | TDP |

## 5.4. Marine Energy

| MARINE ENERGY | | | |
|---|---|---|---|
| | IMPACT CHAINS | | |
| RISK FACTORS | Changes in energy demand due to changes in precipitations and temperatures | Changes in power generation due to long term climate change and variability | Damages to transmission grids due to extreme events |
| HAZARD | CooDeD | WiX98p | NEME |
| | SPI | WiAVE | |
| | | SRAVE | |
| EXPOSURE | NResP | Wwi | LTrGr |
| | NTouP | WSPv | NTotP |
| | GDPEDA | | |
| | CPR | | |
| | PDW | | |
| SENSITIVITY | CED | PWPV | CTLRep |
| | DED | PSPV | PCU |
| | | PREn | |
| ADAPTIVE CAPACITY | LCrCh | ABU | IM |
| | PP | NCN | NCN |
| | DSM | PPS | PPS |
| | PEE | PWSE | |

## 5.5. Maritime Transport

| Maritime Transport | | | |
|---|---|---|---|
| | IMPACT CHAINS | | |
| RISK FACTORS | Risk of damages in port infrastructures | Risk of damages to ships on route | Risk of isolation due to transport disruption |
| HAZARD | NSWHX98 | NSWHX98 | NSWHX98 |
| | NWiX98 | NWiX98 | NWiX98 |
| | MSLAVE | | MSLAVE |
| EXPOSURE | Npax | NPax | NPax |
| | NTotP | PFFSh | NTotP |
| | VGTSTot | VGTSTot | VGTSTot |
| | NPo | NCSh | NPo |
| | | | |
| SENSITIVITY | NNOpPo | NShDL | NIID |
| | NAgePo | | NAgePo |
| ADAPTIVE CAPACITY | NSPlaCCA | NCPla | PEnRR |
| | NTrCoRM | NTrCoRM | NTrCoRM |
| | NOcSta | NOcSta | NOcSta |
| | | | NApt |

# 6. Results: IC diagram tool by sectors

This section presents the association between identified suitable indicators and the identified factors of the impact chain through diagram tool, presented in D3.2.

For each reference factor (white box) inside the different risk components, a number of indicators are proposed accordingly with Section 4 and Section 5 of the present document. As the vulnerability component is concerned, sensitivity and adaptive capacity factors are differentiated, also using an orange contour for the adaptive capacity indicators. Within the coloured boxes (light blue for hazard, mustard for exposure, green for vulnerability) is showed the indicator name with the short name in bold.

The arrows reflect the cause-effect relationships for the IC presented in D3.2, and were not modified in this work.

## 6.1. Coastal and Maritime Tourism

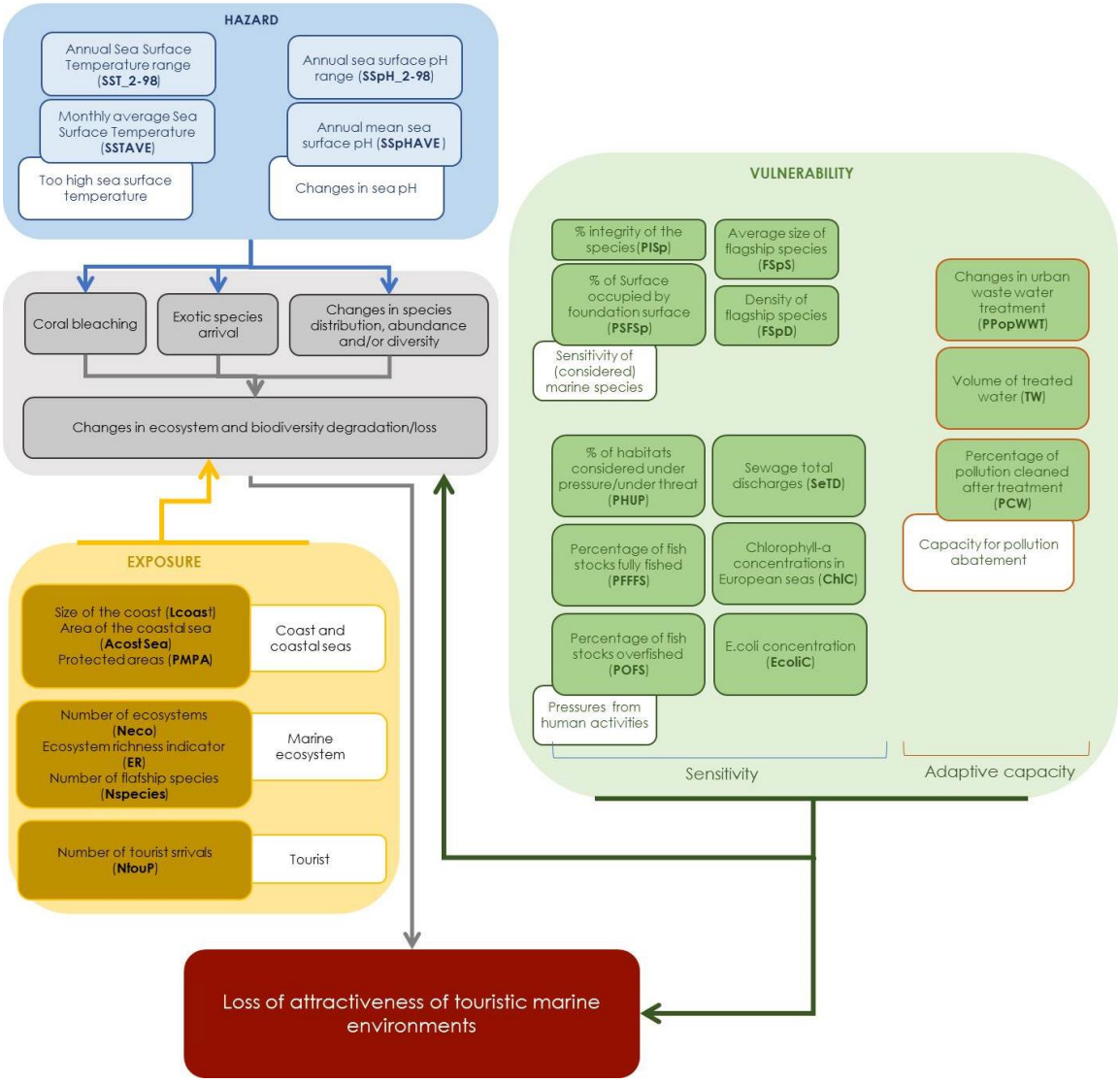


FIGURE 1: 1-1-LOSS OF ATTRACTIVENESS OF TOURISTIC MARINE ENVIRONMENTS

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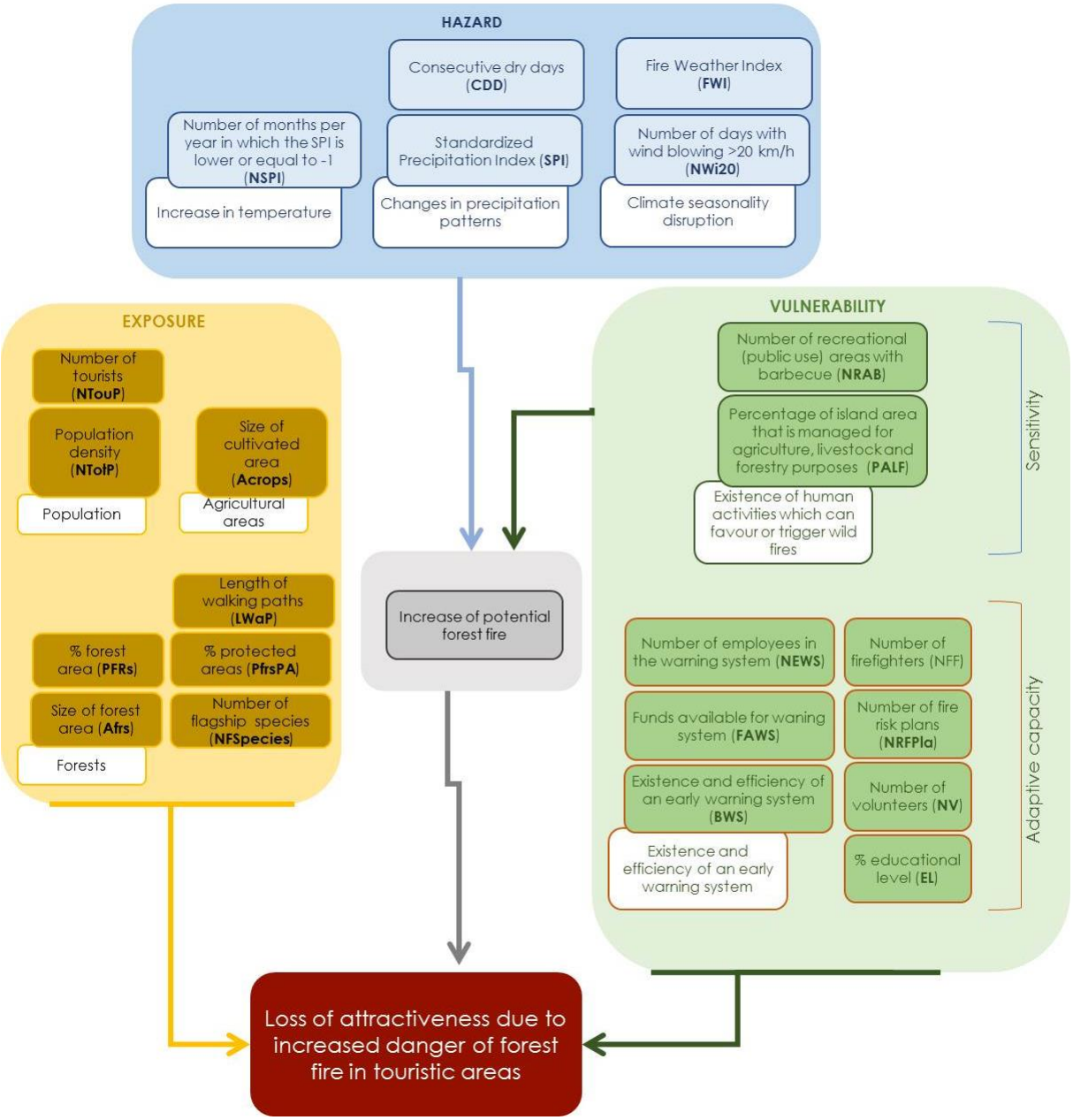


FIGURE 2: 1-2- LOSS OF ATTRACTIVENESS DUE TO INCREASED DANGER OF FOREST FIRE IN TOURISTIC AREAS

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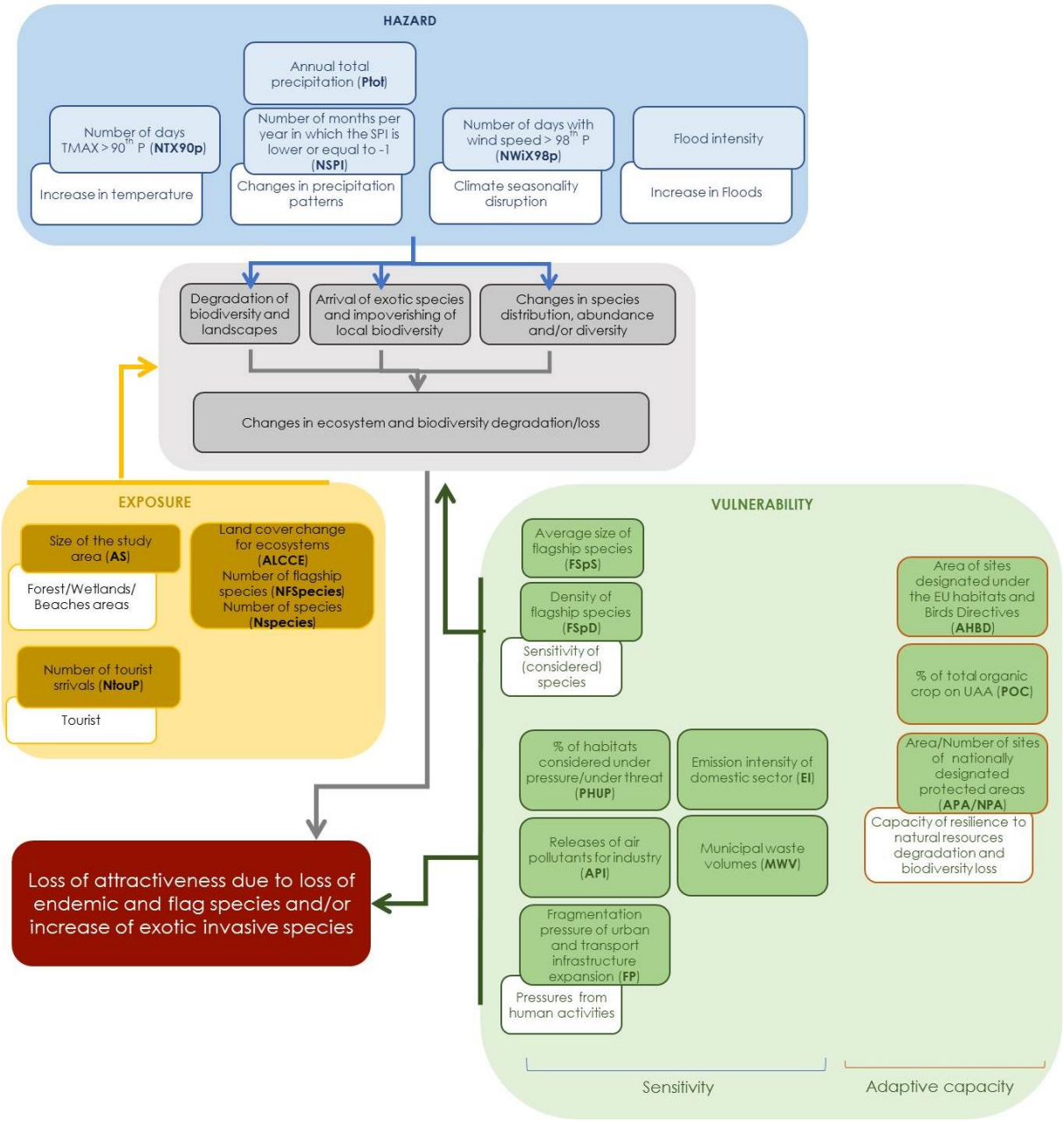


FIGURE 3: 1-3- LOSS OF ATTRACTIVENESS OF TOURISTIC LAND ENVIRONMENTS

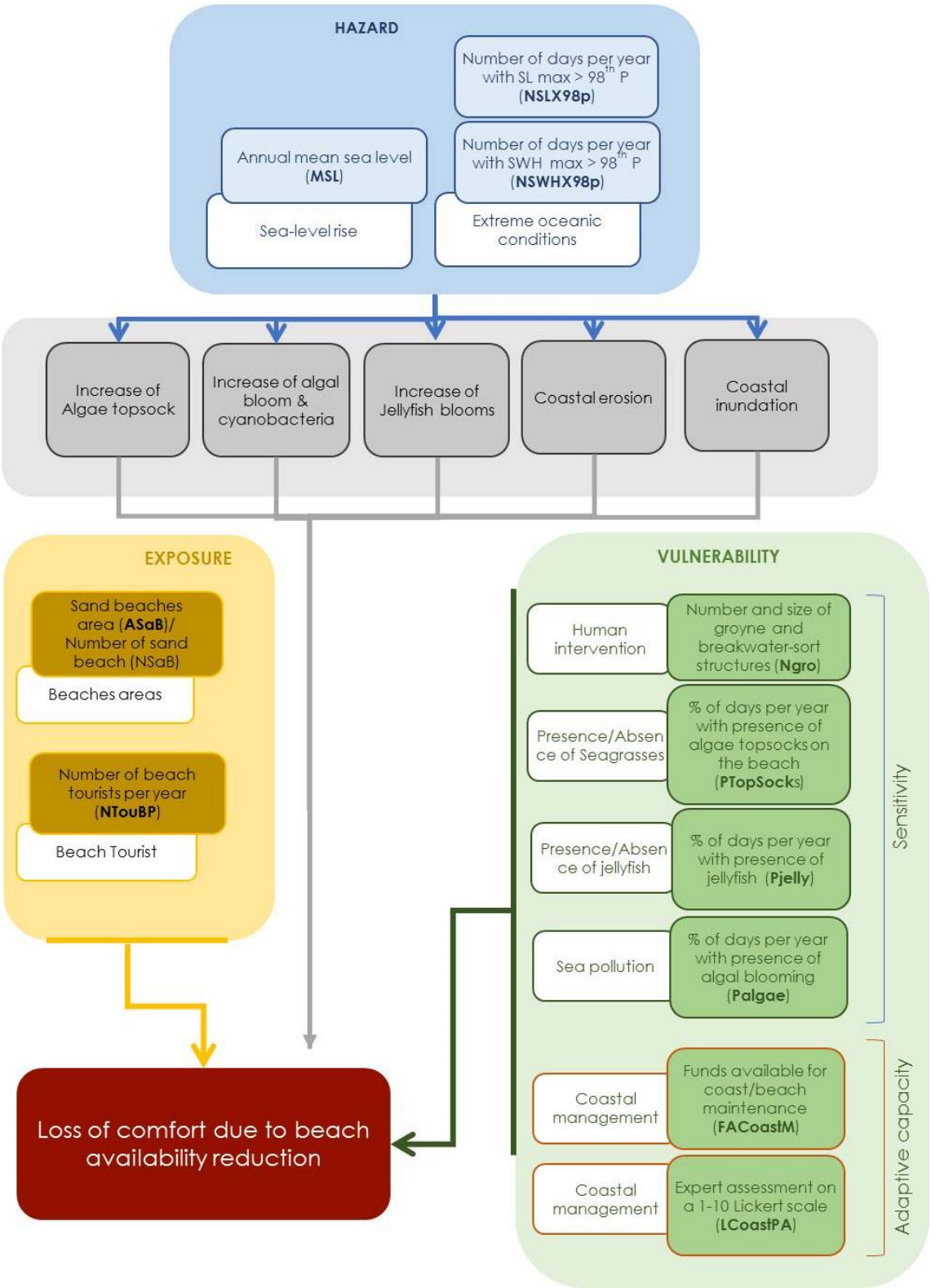


FIGURE 4: 1-4- LOSS OF COMFORT DUE TO BEACH SURFACE REDUCTION

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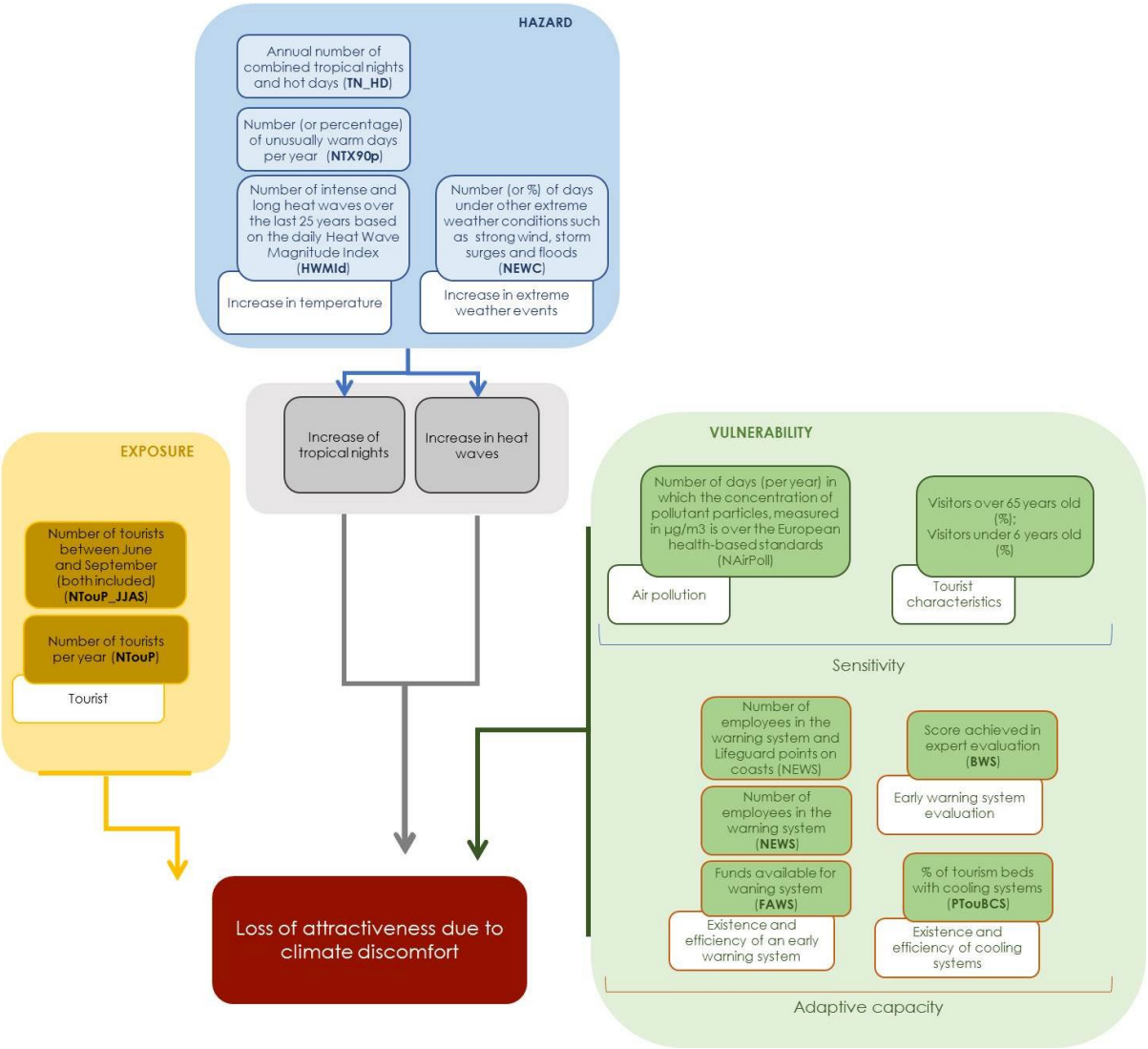


FIGURE 5: 2-1- LOSS OF ATTRACTIVENESS DUE TO CLIMATE DISCOMFORT

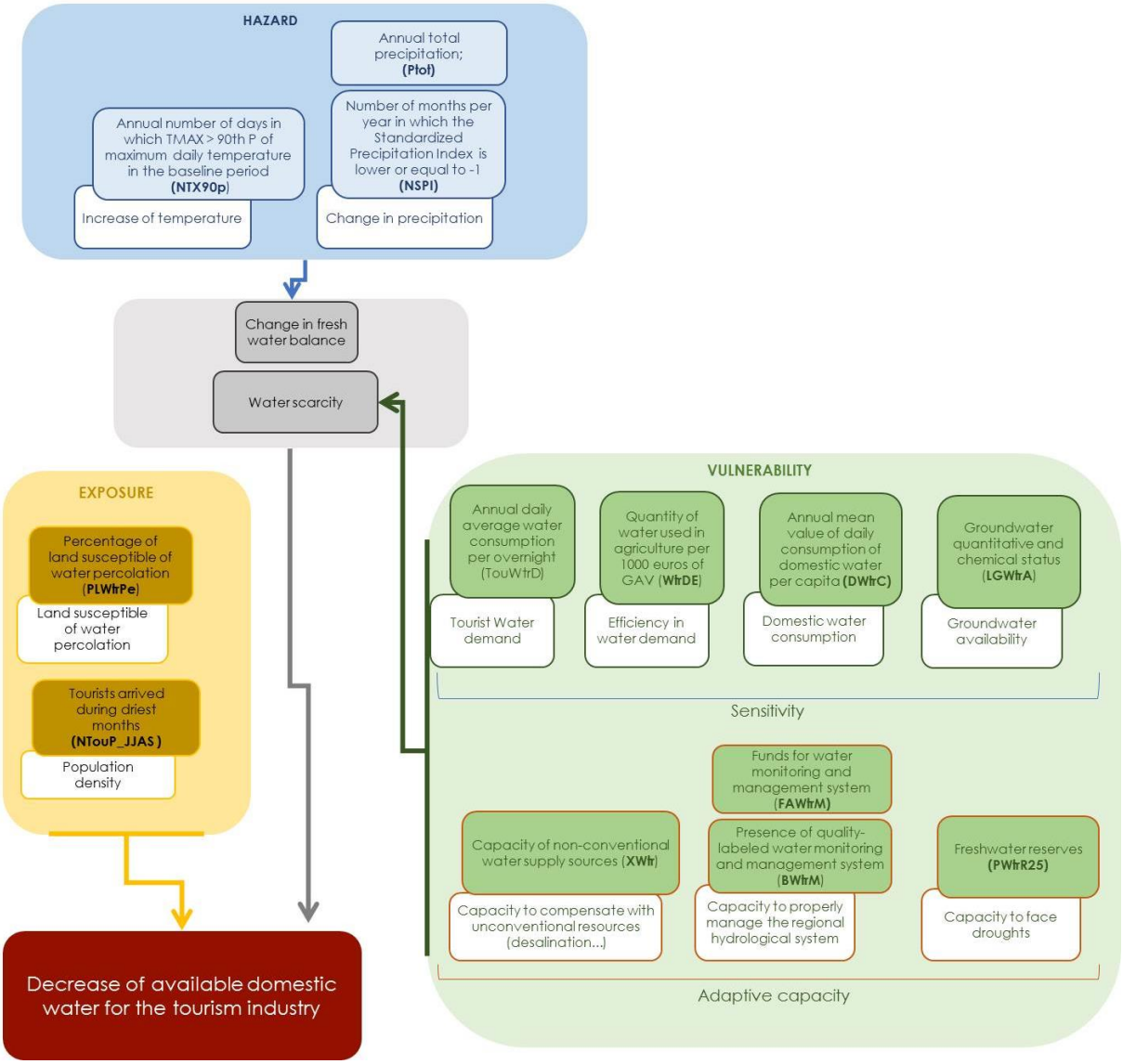


FIGURE 6: 3-1- DECREASE OF AVAILABLE DOMESTIC WATER FOR THE TOURISM INDUSTRY

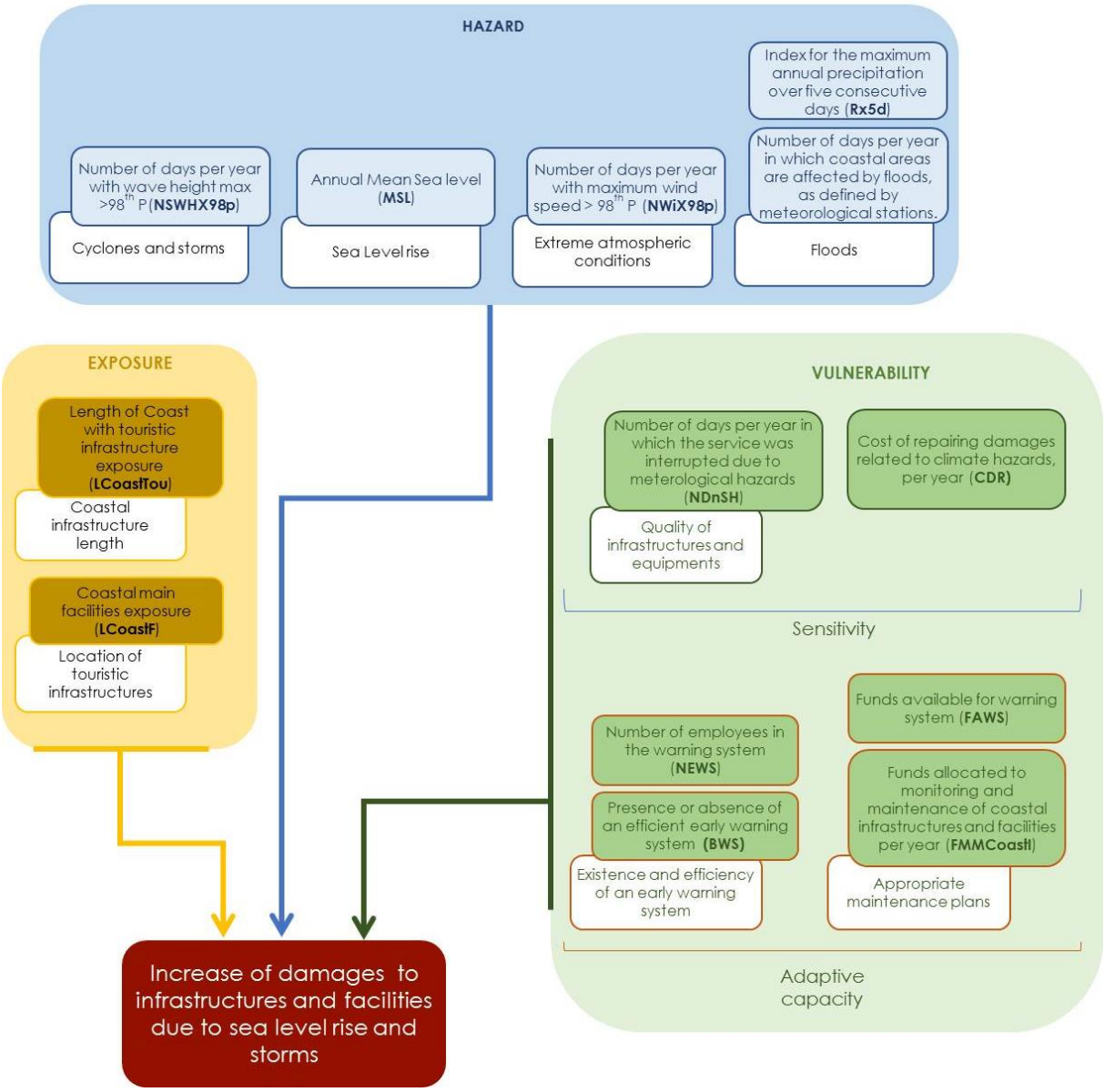


FIGURE 7: 3-2- INCREASE OF DAMAGES TO INFRASTRUCTURES AND FACILITIES (ACCOMMODATION, PROMENADES, WATER TREATMENT SYSTEM, ETC.) DUE TO SEA LEVEL RISE AND STORMS

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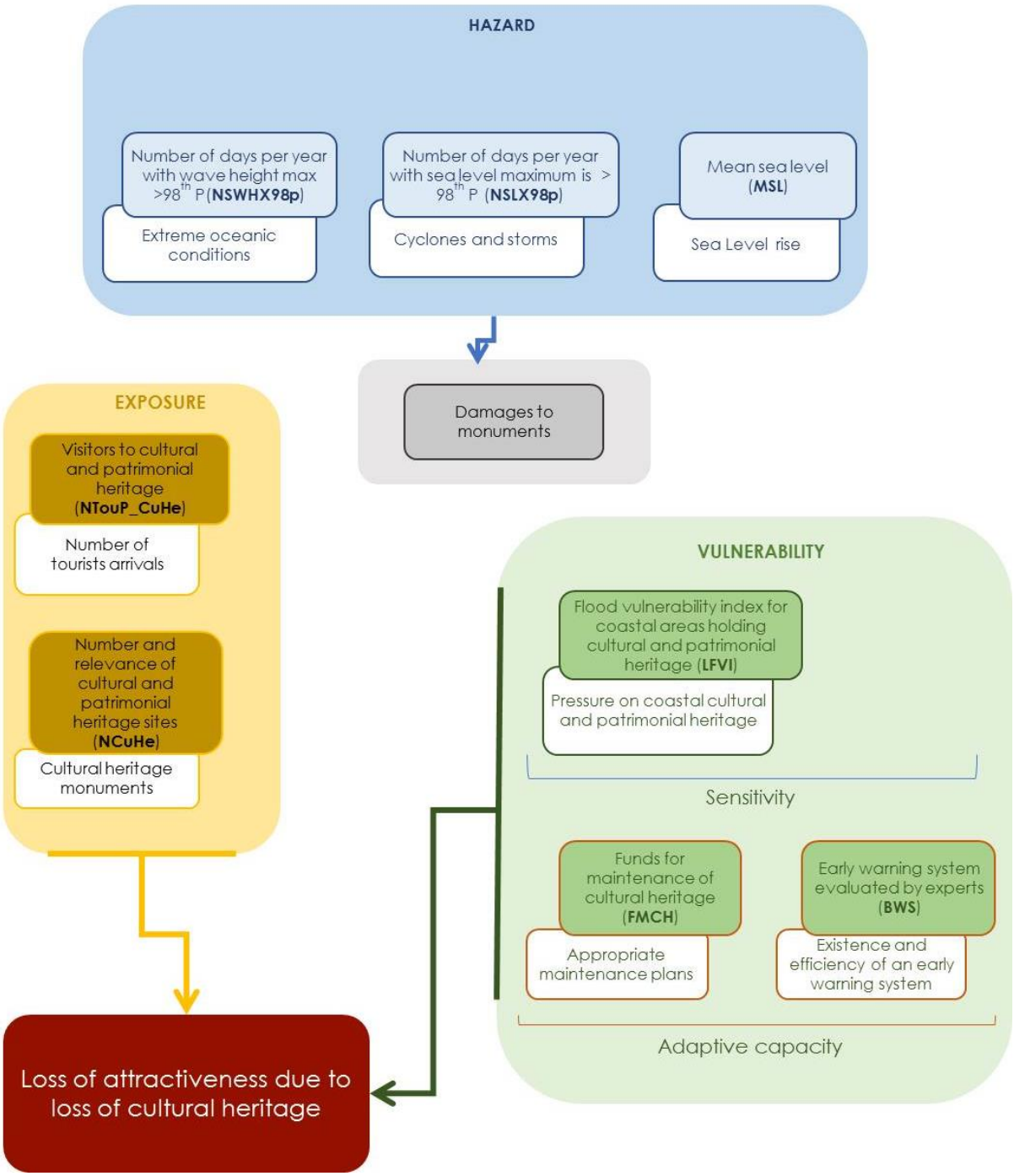


FIGURE 8: 3-3-LOSS OF ATTRACTIVENESS DUE TO LOSS OF CULTURAL HERITAGE

## 6.2. Aquaculture

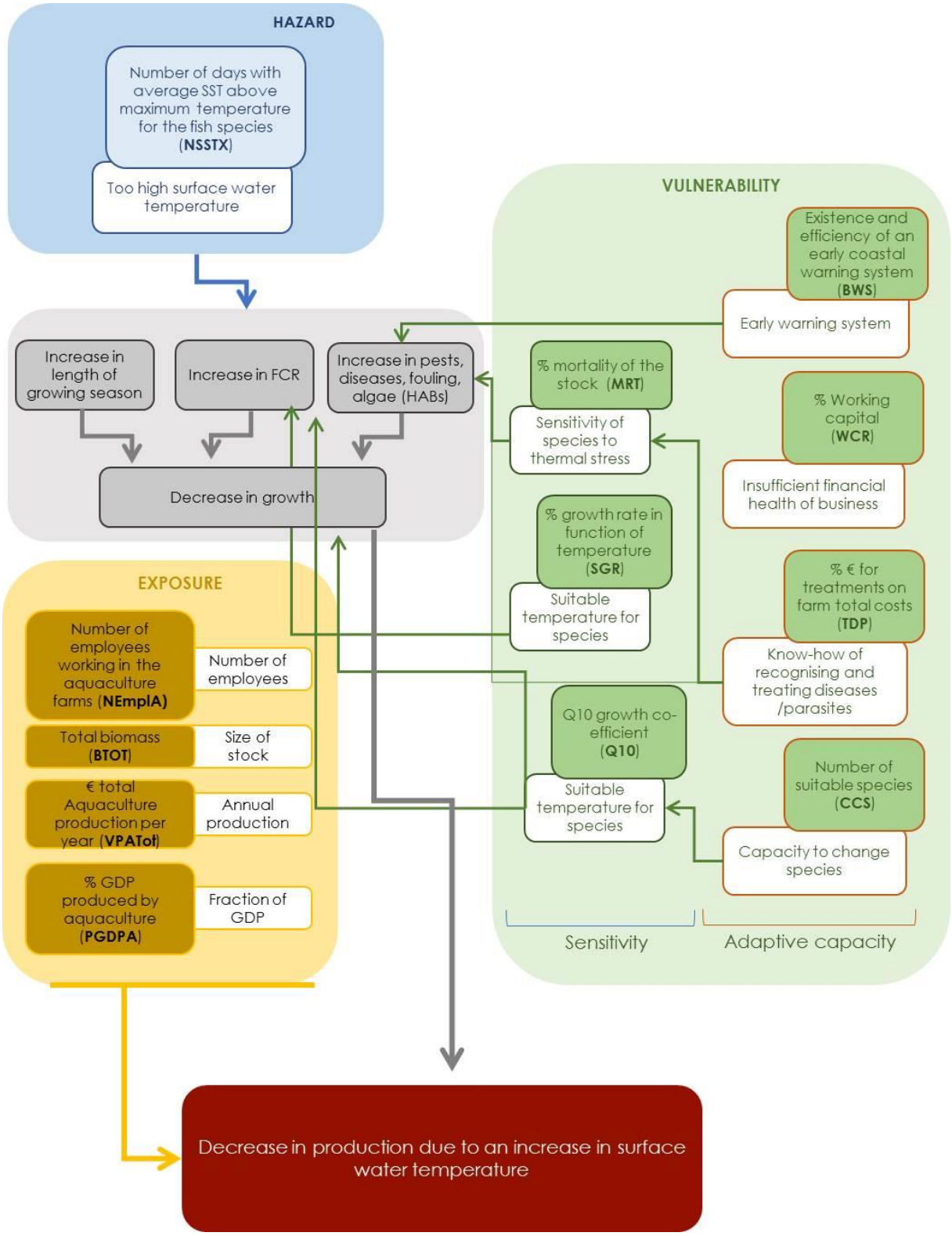


FIGURE 9: 1-DECREASE IN PRODUCTION DUE TO AN INCREASE IN SURFACE WATER TEMPERATURE

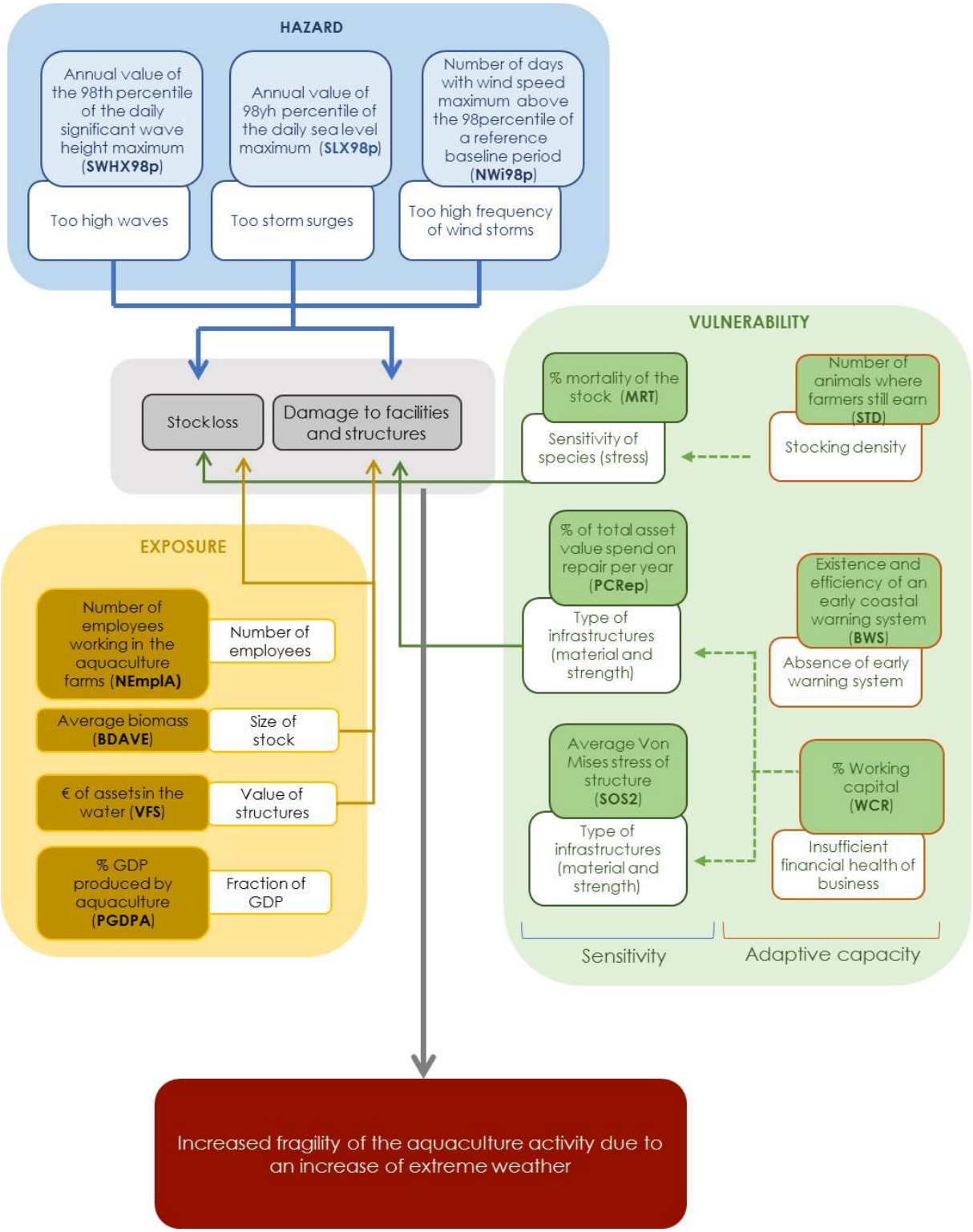


FIGURE 10: INCREASED FRAGILITY OF THE AQUACULTURE ACTIVITY DUE TO EXTREME EVENTS

## 6.3. Marine Energy

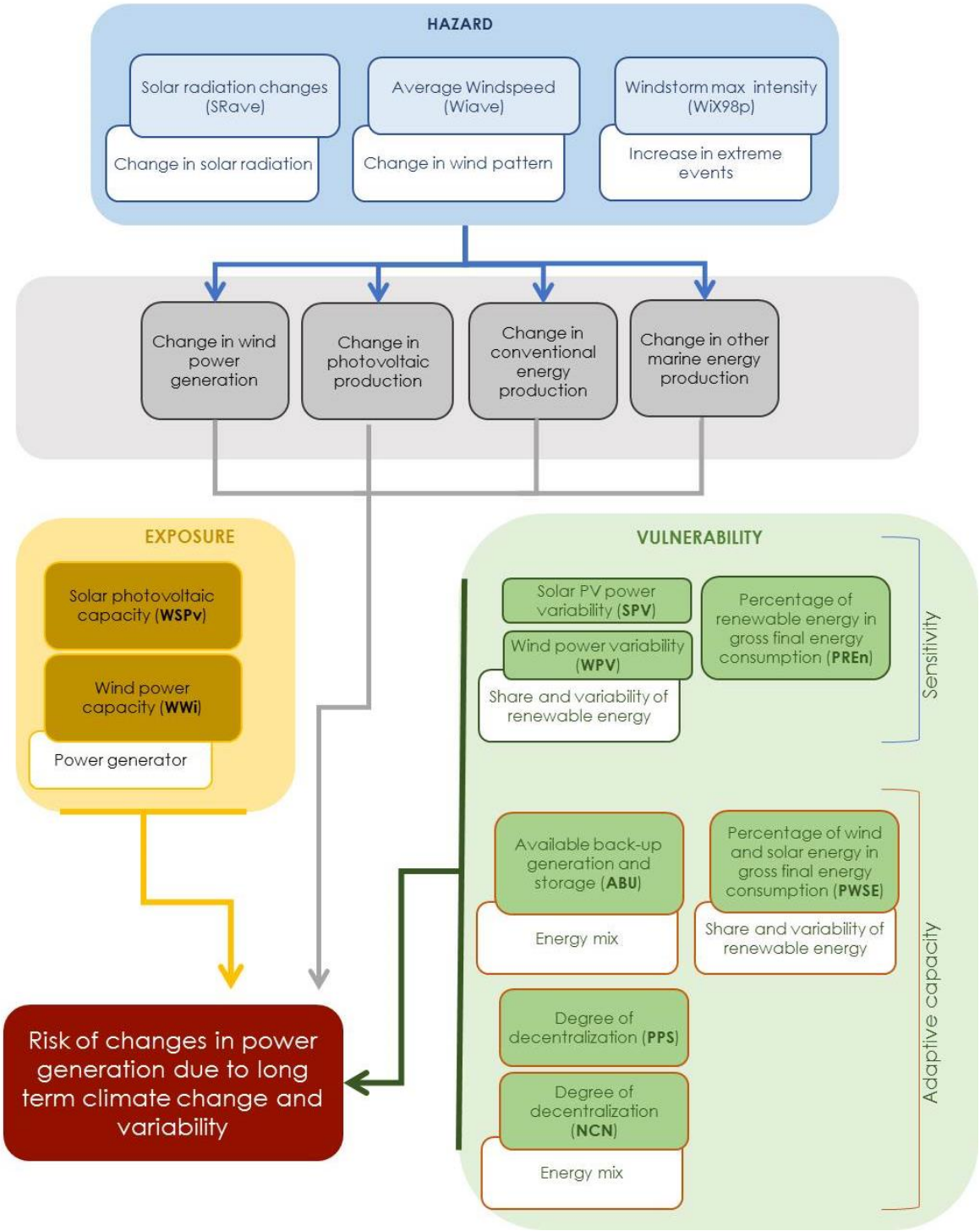


FIGURE 11: 1-RISK OF CHANGES IN POWER GENERATION DUE TO LONG TERM CLIMATE CHANGE AND VARIABILITY

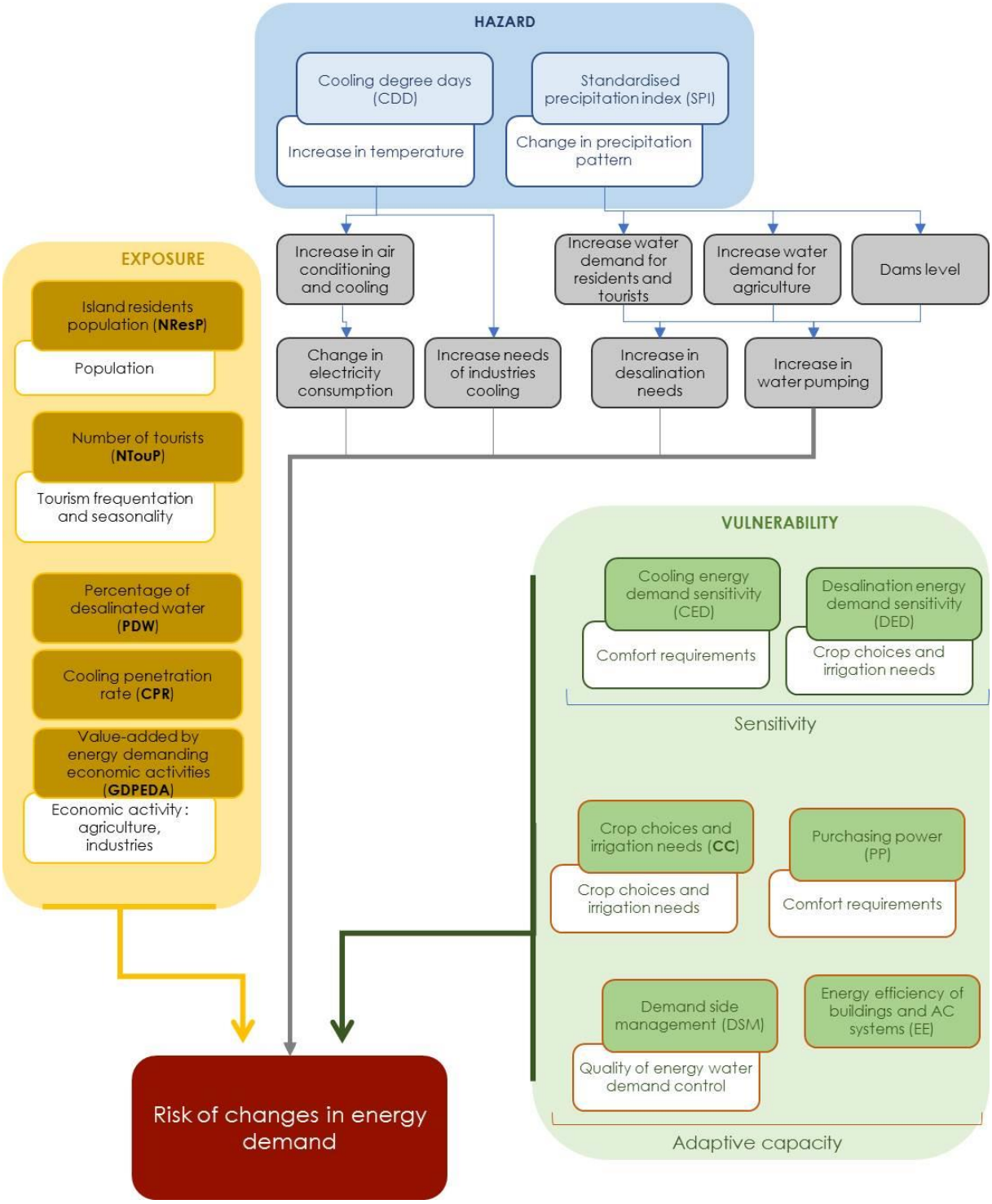


FIGURE 12: 2-RISK OF CHANGES IN ENERGY DEMAND DUE TO CHANGES IN PRECIPITATIONS AND TEMPERATURES

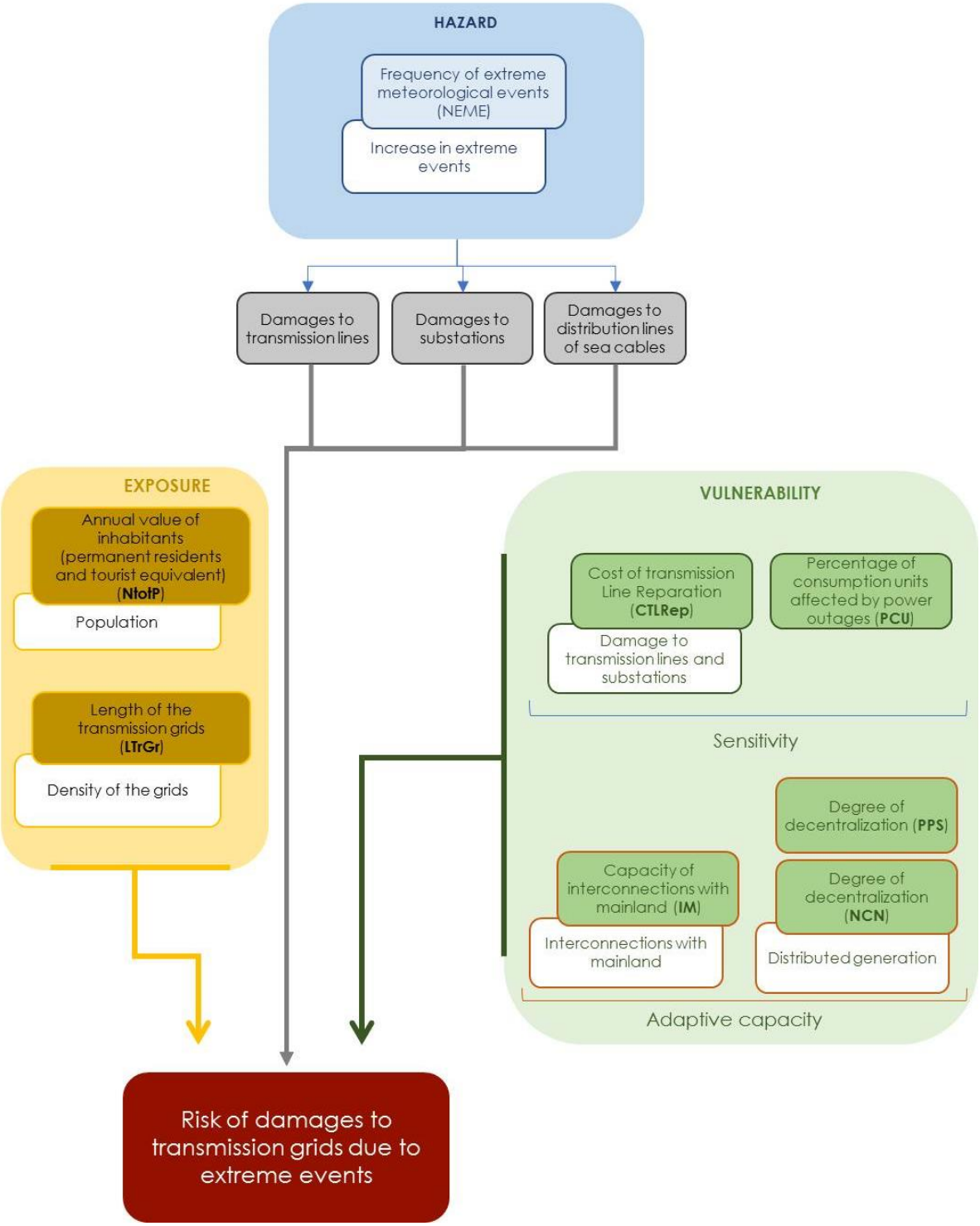


FIGURE 13: 3- RISK OF DAMAGES TO TRANSMISSION GRIDS DUE TO EXTREME EVENTS

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## 6.4. Maritime Transport

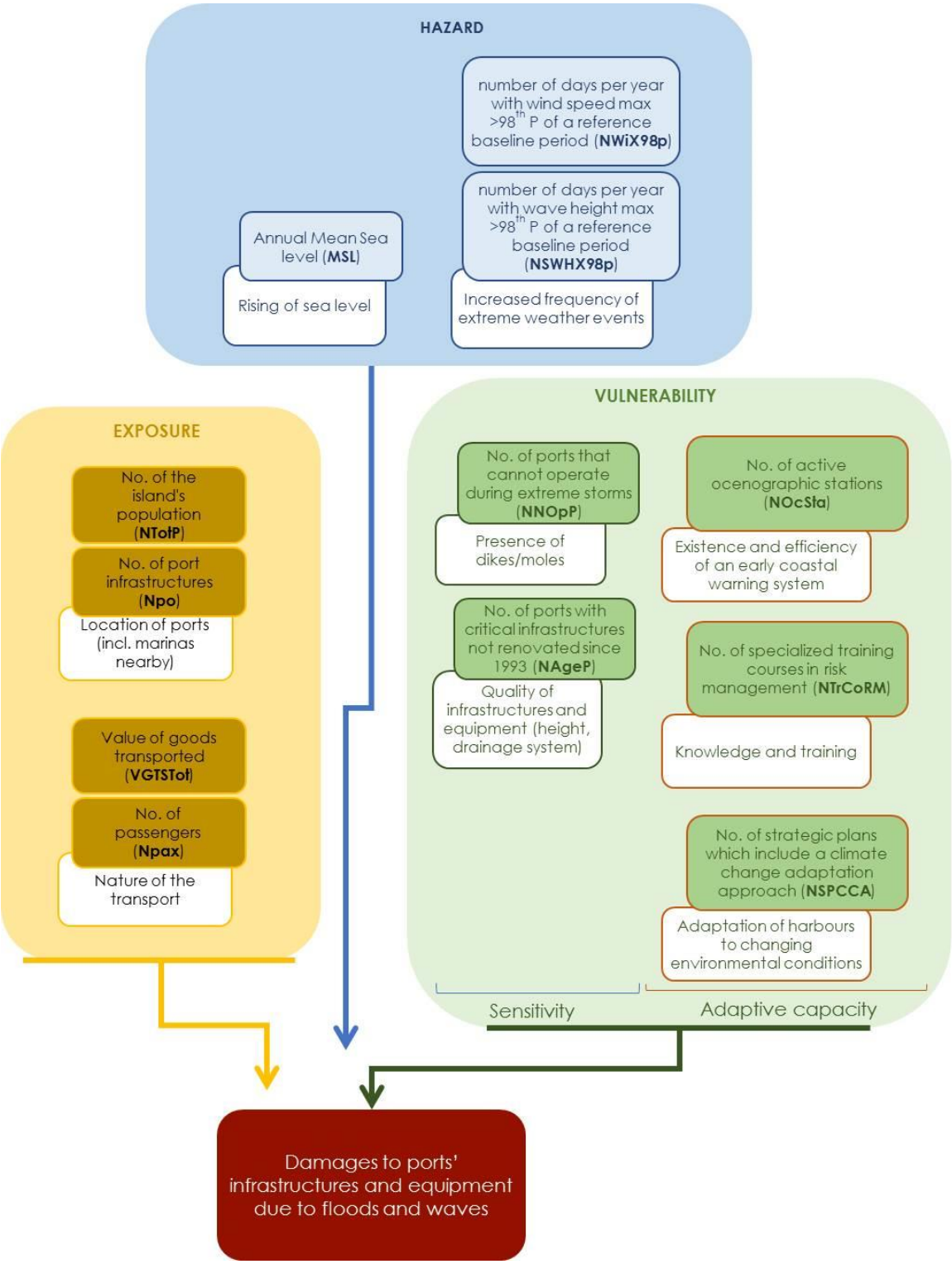


FIGURE 14: 1-RISK OF DAMAGES IN PORT INFRASTRUCTURES

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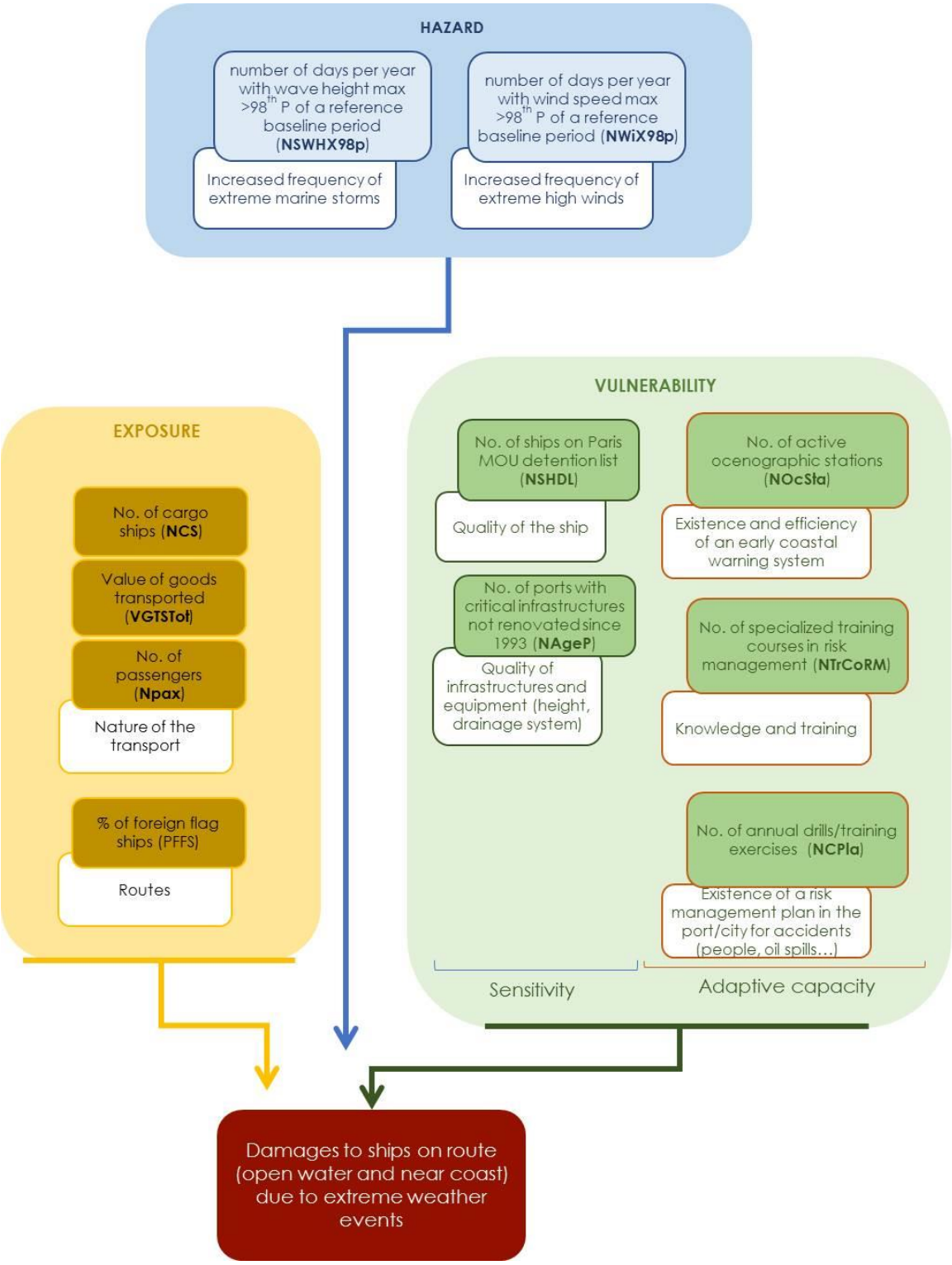


FIGURE 15: 2- DAMAGES TO SHIPS ON ROUTE

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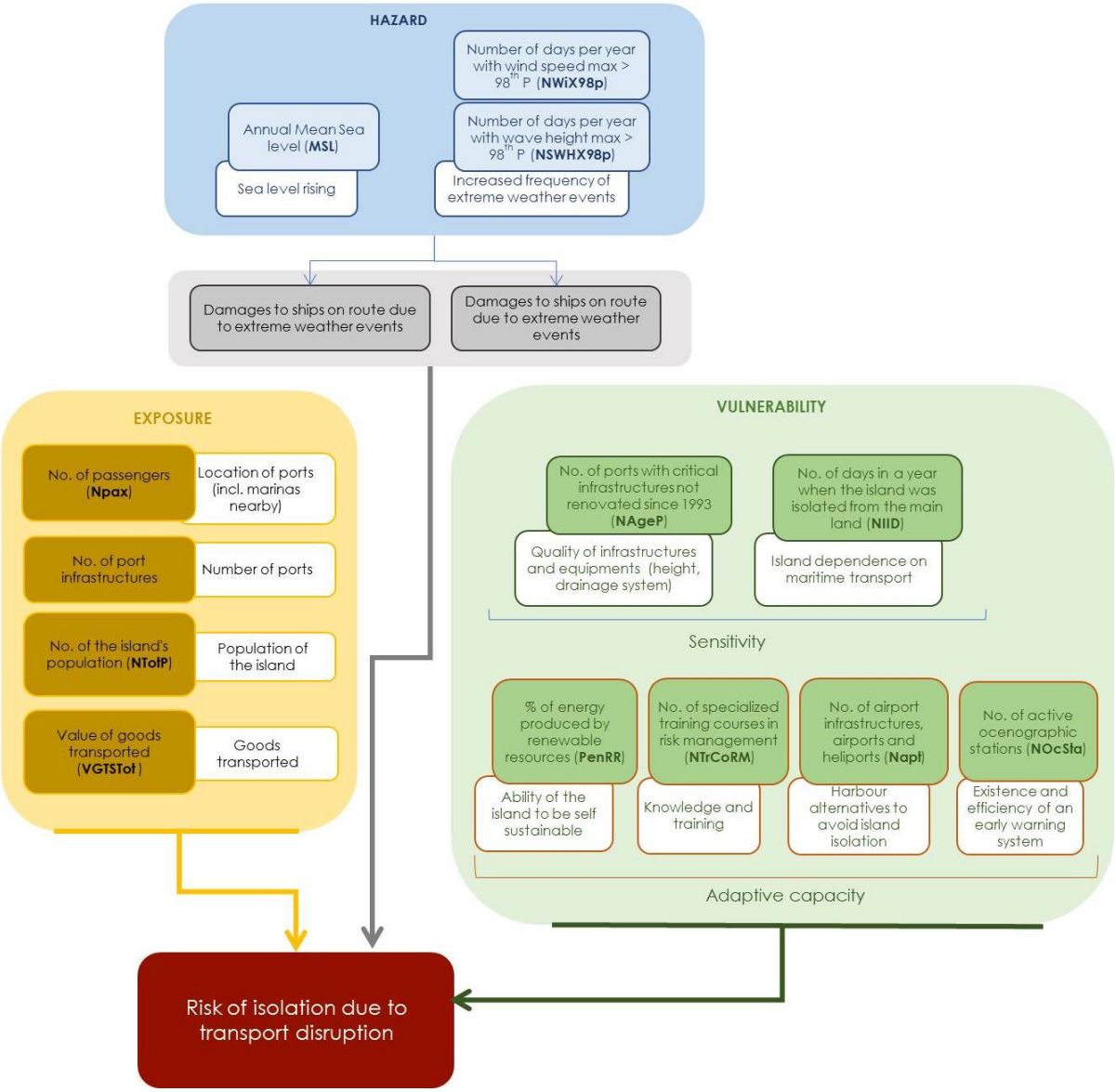


FIGURE 16: 3- RISK OF TRANSPORT DISRUPTION

# 7. Operationalization of indicators

## 7.1. Normalization of indicator data

The selected indicators are normally expressed in different units. As such, they cannot be compared or aggregated unless the normalization step is applied. Indeed, the normalization transforms and interprets the different data sets into unit-less values with a common scale from 0 (optimal, no improvement necessary or possible) to 1 (critical, system no longer functions).
Depending on the scale of measurement, (i.e. metric, nominal, ordinal) different methods of normalisation could be used.

### 7.1.1. Metric indicator values.

Indicators measured using a metric scale (i.e. temperature, precipitation) can be normalised by applying the Min-Max method, that transforms all values to a standardised value range from 0 to 1 by subtracting the minimum score and dividing it by the range of the indicator values. The following formula is used to apply min-max:

$$X_{i,0\ to\ 1} = (X_i - X_{min}) / (X_{max} - X_{min})$$

where,
Xi,0 to 1 = the new value normalised at step i
Xi = the data point to be transformed at step i
Xmin = the lowest value for that indicator
Xmax = the highest value for that indicator
and lowest and highest can refer to the actual time series or to general criteria that determines a suitable range of Xi

After the normalization, the indicator values need to be aligned, that means they need to be examined in order to verify the "direction" of the value range. It is often desirable that lower values should reflect positive conditions in terms of hazard/exposure/vulnerability and higher values negative conditions. In case the direction of the indicator's value range is negative, the indicators value range should be inverted, subtracting the value from 1.

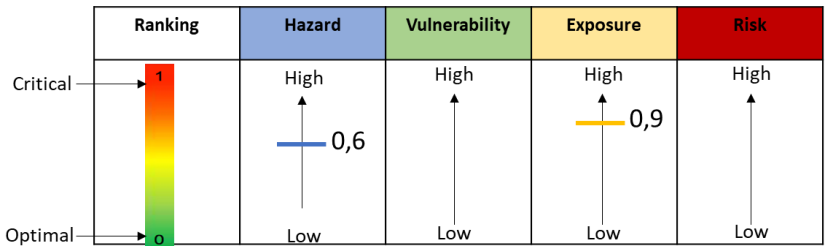


Figure 17: Comparisons of normalized scores

### 7.1.2. Categorical indicator values

In case of ordinal or nominal indicator values, normalization process goes through the definition of classes in negative or positive terms. The most positive conditions represented by the lowest class and the most negative represented by the highest class.

*Tab. 2 – Example of a five-class scale for categorical indicators*

| CLASS N. | DESCRIPTION |
|---|---|
| 1 | Optimal |
| 2 | Rather positive |
| 3 | Neutral |
| 4 | Rather negative |
| 5 | Critical |

Each indicator value for nominally scaled data will be then allocated to one of the five classes, on the basis of the meaning attributed to the indicator within the context of the exposure assessment. This allocation is normally supported by the best available knowledge (i.e. scientific literature, local experts, and other reliable sources). The classified values were then transformed into the value range of 0 to 1.

*Table 3 - Transformation of normalised indicator values on a categorical scale to the value range 0 - 1*

| CLASS N. | DESCRIPTION | CLASS VALUE: corresponding range |
|---|---|---|
| 1 | Optimal | 0 – 0,2 |
| 2 | Rather positive | ➢ 0,2 – 0,4 |
| 3 | Neutral | ➢ 0,4 – 0,6 |
| 4 | Rather negative | ➢ 0,6 – 0,8 |
| 5 | Critical | ➢ 0,8 - 1 |

### 7.1.3. Weighting of indicators

The selected indicators do not necessarily have equal influence on the evaluation of the risk. Certain factors could be more important than others, and thus different weights could be assigned to them and corresponding indicators. Indicators receiving a greater (or lesser) weight have thus a greater (or lesser) influence on the overall risk and risk components. Weighting should be regarded as value judgments (OECD 2008), and the different weights assigned to indicators can be derived from existing literature, stakeholder information or expert opinion: the risk R at time i $R_i$ can be assessed as sum of the relevant indicators X, Y, Z, U, …

$$R_i = w_x X_{i,0 \text{ to } 1} + w_y Y_{i,0 \text{ to } 1} + w_z Z_{i,0 \text{ to } 1} + w_U U_{i,0 \text{ to } 1} + \ldots.$$

or a product

$$R_i = w_x X_{i,0 \text{ to } 1} \cdot w_y Y_{i,0 \text{ to } 1} \cdot w_z Z_{i,0 \text{ to } 1} \cdot w_U U_{i,0 \text{ to } 1} \cdot \ldots.$$

Or a combination the two.

Weighting could also be a tool for accounting for critical thresholds, in such that it is not necessarily linear in all the indicators. In correspondence with critical value the risk value could be discretized to a maximum value:

If $X_{i,0 \text{ to } 1} > X_{thresold}$ then $R_i = R_{max}$

The actual shape of the risk expression depends on the specific Impact Chain and it will be discussed in the WP devoted to the actual implementation

### 7.1.4. baseline period and time horizons

All indicators depending on time are characterized by a time period during which they are available.

Indicators provided by models are available for the period covered by the simulation, generally extending to the past to the present (for model reanalysis and hindcasts) or to the future (for model projections). This is the optimal condition, because there is large freedom to extract the most suitable time range and also for the selection of the baseline, which is needed for assessing variations with respect to a convenient reference.

Indicators provided by observations have a much lower flexibility. Obviously they do not extend to the future and their capability to reconstruct the past relies on the availability of instrumentation. This is a major problem and hindcast simulations are often a necessary replacement. For indicators provided by the different types of archives of national, regional and local administration availability in the past is often a major problem. In these cases, the selection of the baseline and of the criteria for time references are necessarily limited by data availability.

## 8. Conclusions

This deliverable has presented the list of indicators that have been identified from the theoretical impacts chains detailed in D3.2, namely:

- 8 impact chains for maritime and coastal tourism,
- 3 for marine energy and maritime transport
- 2 for aquaculture.

The indicators have been set up with the help of the sector leaders, analysing also scientific publications or projects on climate change on the 4 Blue Growth sectors.
The results of this work were presented in several formats, from list to fact-sheet to IC diagrams, all useful for further work in SOCLIMPACT, especially for WP4, 5 and 6.
Indeed, this deliverable makes possible to lay the foundations and bases and more especially the framework of the SOCLIMPACT project in terms of sectorial definitions and boundaries and of sectorial brainstorming.

Different sectors and science branches will use this information to combine efforts in order to deliver an integrated view of climate impacts and climate adaptation pathways on the Blue Growth sectors of selected EU islands.

Yet, further work is needed to detail spatial and temporal coverage and check data availability. The sectorial modelling groups will retrieve this information on an earlier stage and thus further refine the proposed list of indicators. Then, this allow WP4 to model climate data and to propose and suggest to each modelling WPs (WP4, 5 and 6) the parameters to be modelled.

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(other specific references are annotated in the indicator factsheets)

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# Appendix I Indicators Factsheets

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# Coastal and Maritime Tourism

| Sector affected | **Coastal and Maritime Tourism** | | |
|---|---|---|---|
| Risk impact chains | Loss of attractiveness and comfort due to beach availability reduction | | |
| Indicator type (4 choices) | **hazard** | | |
| reference factor(s) in the risk IC | Sea-level rise | Extreme oceanic conditions | Extreme oceanic conditions |
| Indicator short name | MSL | NSWHX98p | NSLX98p |
| description of the indicator | annual mean sea level | change of frequency of marine storms: Number of days per year with SWH maximum above the 98 percentile of the daily maximum in the reference baseline period | Changes of frequency of storm surges and coastal floods : Number of days per year with SL maximum above the 98 percentile of the daily sea level maximum in the reference baseline period |
| unit | mm | number | number |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | tide gauges, satellite data, models | wave gauges, models | tide gauges, models |
| supplementary information | | | |

| Sector affected | Coastal and Maritime Tourism | | | |
|---|---|---|---|---|
| Risk impact chains | Loss of attractiveness and comfort due to beach availability reduction | | | |
| Indicator type (4 choices) | vulnerability (sensitivity) | | | |
| reference factor(s) in the risk IC | Human intervention | Presence of seagrasses on the beach | Presence of jellyfish | Algal bloom and cyanobacteria |
| Indicator short name | Ngro | PTopSocks | Pjelly | Palgae |
| description of the indicator | Number of groyne and breakwater-sort structures, including ports, affecting sand beachs. Any human made structure on the shoreline can be represented as the combination of single groynes and beakwaters | Percentage of days per year in which the beach registered the presence of algae topsocks on the beach. It refers to beaches frequented by tourists for recreative purposes. Indicator can be refined by considering the percentage of each beachs affected. | Percentage of days per year in which the beach registered the presence of jellyfish on sea bathing waters | Percentage of days per year in which the beach registered the presence of big and dense amount of microalgas/cyanobacterias on sea bathing waters or visible area around. |
| unit | number | % | % | % |
| Indicator classification (3 choices) | EVI: Environmental value I | ESI: Environmental Services I | ESI: Environmental Services I | ESI: Environmental Services I |
| sources of information (general categories) | | | | |
| supplementary information | Groynes trait to avoid longshore drift (sediment movement along acoasta parallel to the shoreline) while breakwater reduce the wave action on the coast. | Algae topsocks form part of the natural cycle contributing to nourish the ecosystem and protect coastal sediments. Yet, increasing sea temperatures exacerbate this phenomenon enlarging dead algae presence on the beaches and thus | Literature has reported some evidence on the relationship between sea water temperature and the presence of jellyfish in sea waters. It requires the previous delimitation of the sea bathing waters. | The combination of sea water temperature and the presence of nutrients, join with calm waters, seems to influence the frequency and intensity of episodes. It requires the previous delimitation of the sea bathing waters. |

| | | |
|---|---|---|
| Sector affected | **Coastal and Maritime Tourism** | |
| Risk impact chains | Loss of attractiveness and comfort due to beach availability reduction | |
| Indicator type (4 choices) | **vulnerability (adapative capacity)** | |
| reference factor(s) in the risk IC | Coastal management | Expert assessment of effectiveness of the coastal protection actions |
| Indicator short name | FACoastM | CoastPA |
| description of the indicator | Funds available for coast/beach | Expert assessment on a 1-10 |
| unit | Euros per year | 1-10 score |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | | |
| Supplementary information | | |

| Sector affected | **Coastal and Maritime Tourism** | | |
|---|---|---|---|
| Risk impact chains | Loss of attractiveness and comfort due to beach availability reduction | | |
| Indicator type (4 choices) | **exposure** | | |
| reference factor(s) in the risk IC | Area of sand beaches | Number of sand beaches | Number of tourists |
| Indicator short name | ASaB | Nsab | NTouB |
| description of the indicator | Area of sand beaches (ASaB) | Number of sand beaches | Number of beach tourists per year |
| unit | ha | number | number |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I | EVI: Environmental value I |
| sources of information (general categories) | Teledetection/Orthophoto | | Regional Statistic Institutes |
| Supplementary Information | | | http://statistics.unwto.org/sites/all/files/docpdf/glossaryterms.pdf |

| Sector affected | Coastal and Maritime Tourism | | | |
|---|---|---|---|---|
| Risk impact chains | Loss of attractiveness due to climate discomfort | | | |
| Indicator type (4 choices) | hazard | | | |
| reference factor(s) in the risk IC | Weather discomfort due to extreme temperature | Weather discomfort due to extreme temperature | Weather discomfort due to extreme temperature | Weather discomfort due to extreme weather events |
| Indicator short name | HWMId | NTX90p | NTN_HD | NEWC |
| description of the indicator | Number of intense and long heat waves over the last 25 years based on the daily Heat Wave Magnitude Index. A "heat wave" is defined as a sequence of 3 or more days in which the daily maximum temperature is above the 90th percentile of daily maximum temperature for a 31-day running window surrounding this day during the baseline period | Number (or percentage) of unusually warm days per year : Number of days per year in which temperature maximum is above than 90th percentile of maximum daily temperature of a suitable baseline period. | Annual number of combined tropical nights and hot days: Number of days when minimum temperature >20ºC and maximun temperature >35ºC occur in sequence | Number (or percentage) of days under other extreme weather condictions such as strong wind, storm surges and floods: changes in extreme wind speed (defined as the 98th percentile of daily maximum wind speed) + Number of days of storm surges affecting coastal areas + Number of days tourism areas affected by floods = Total annual days exhibiting non-temperature-based weather discomfort |
| unit | Number per year | Numer/percentage | Number of days | number of days |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | Research journals | Research journals | EEA Report 2017 | EEA Report 2017 |
| Supplementaryinformation | Daniela D'Ippoliti et al., 'The Impact of Heat Waves on Mortality in 9 European Cities: Results from the EuroHEAT Project',Environmental Health: A Global Access Science Source 9 (2010): 37, doi:10.1186/1476-069X-9-37; M. Baccini et al., 'Impact of Heat on Mortality in 15 European Cities: Attributable Deaths under Different Weather Scenarios',Journal of Epidemiology and Community Health 65, no. 1 (January 2011): 64–70, doi:10.1136/jech.2008.085639. Antonio Gasparrini et al., 'Mortality Risk Attributable to High and Low Ambient Temperature: A Multicountry Observational Study',Lancet (London, England) 386, no. 9991 (25 July 2015): 369–75, doi:10.1016/S0140-6736(14)62114-0Russo, S., Sillmann, J. and Fischer, E. M., 2015, 'Top ten European heatwaves since 1950 and their occurrence in the coming decades', Environmental Research Letters 10(12), 124003 (doi: 10.1088/1748-9326/10/12/124003). | Russo, S., Sillmann, J. and Fischer, E. M., 2015, 'Top ten European heatwaves since 1950 and their occurrence in the coming decades', Environmental Research Letters 10(12), 124003 (doi: 10.1088/1748-9326/10/12/124003). | Füssel, H. M., Jol, A., Marx, A., Hildén, M., Aparicio, A., Bastrup-Birk, A., ... & Isoard, S. (2017). Climate change, impacts and vulnerability in Europe 2016-An indicator-based report. Fischer, E. M. and Schär, C., 2010, 'Consistent geographical patterns of changes in high-impact European heatwaves', Nature Geoscience 3(6), 398–403 (doi: 10.1038/ngeo866). | Füssel, H. M., Jol, A., Marx, A., Hildén, M., Aparicio, A., Bastrup-Birk, A., ... & Isoard, S. (2017). Climate change, impacts and vulnerability in Europe 2016-An indicator-based report. M. G. Donat et al., "Future Changes in European Winter Storm Losses and Extreme Wind Speeds Inferred from GCM and RCM Multi-Model Simulations,"Natural Hazards and Earth System Science 11, no. 5 (May 12, 2011): 1351–70, doi:10.5194/nhess-11-1351-2011 |
| Info and criteria for normalization | | | | |

| | | |
|---|---|---|
| Sector affected | **Coastal and Maritime Tourism** | |
| Risk impact chains | Loss of attractiveness due to climate discomfort | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| reference factor(s) in the risk IC | Air pollution | Tourist characteristics |
| Indicator short name | (NAirPoll) | PTou6_65 |
| description of the indicator | Number of days (per year) in which the concentration of pollutant particles, measured in µg/m3 is over the European health-based standards, meaning SOX or NOX or O3 or CO or PM10 or PM2.5 concentration is higher than that established in the Directive 2008/50/EU | Percentage of visitors over 65 years or under 6 years |
| unit | Number | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | EEA Report | Research journal |
| Supplementary information | Pollution is a co-stressor of human health that may exacerbate the effects of heat waves. http://ec.europa.eu/environment/air/quality/standards.htm | Most of literature refers elderly vulnerability to heat waves in terms of relative weakness of their organisms. In the case of childhood, the main explicative factor would be a deficit of capability to take care of themselves in contexts of extreme weather events. Refs: Kovats, R. S. and Hajat, S., 2008, 'Heat stress and public health: A critical review', Annual Review of Public Health 29, 41–55 (doi: 10.1146/annurev. publhealth.29.020907.090843). Johnston, F. H., Henderson, S. B., Chen, Y., Randerson, J. T., Marlier, M., DeFries, R. S., Kinney, P., Bowman, D. M. J. S. and Brauer, M., 2012, 'Estimated global mortality attributable to smoke from landscape fires', Environmental Health Perspectives 120(5), 695–701 (doi: 10.1289/ehp.1104422). Huynen, M. M. T. E., Martens, P., Schram, D.,Weijenberg, M. P. and Kunst, A. E., 2001, 'The impact of heat waves and cold spells on mortality rates in the Dutch population', Environmental Health Perspectives 109(5), 463–470 (doi: 10.1289/ehp.01109463). |
| Info and criteria for normalization | | |

| Sector affected | **Coastal and Maritime Tourism** | | | |
|---|---|---|---|---|
| Risk impact chains | Loss of attractiveness due to climate discomfort | | | |
| Indicator type (4 choices) | **vulnerability (adapative capacity)** | | | |
| reference factor(s) in the risk IC | Existence and efficiency of an early warning system | Existence and efficiency of an early warning system | Existence and efficiency of an early warning system | Existence and efficiency of cooling systems |
| Indicator name with (optional) short name | BWS | FAWS | NEWS | PTouBC |
| description of the indicator | Existence of an evaluated by experts as efficient early warning system of extreme weather events potentially affecting the health of visitors. | Funds available for waning system | Number of employees in the warning system | Percentage of tourism beds with cooling systems |
| unit | Boolean (YES or NO) variable | euro | number | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Regional governments | | | Tourism regional authority |
| supplementary Information | The indicator is based on Public information consultancy and information from regionaladministrations Confalonieri, U., Menne, B., Akhtar, R., Ebi, K. L., Hauengue, M., Kovats, R. S., Revich, B. and Woodward, A., 2007, 'Human health', in: Parry, M. L., Canziani, O. F., Palutikof, J. P., et al. (eds), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* , Cambridge University Press, Cambridge, pp. 391–431. EEA, 2011a, Mapping the impacts of natural hazards and technological accidents in Europe, EEA Technical report No 13/2010, European Environment Agency.<br>IPCC, 2012, Managing the risks of extreme events and disasters to advance climate change adaptation — Special report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge. | | | |
| | Four different indicators that jointly provide a evaluation of the public resources allocated to prevent visitors to become impacted by extreme temperatures, storm surges, extreme winds and floods. | | | According to the characteristics of the accommodation, the law requires specific cooling systems. Therefore, the number of hotels and accommodations with those characteristics would be a good proxy |

| Sector affected | Coastal and Maritime Tourism | |
|---|---|---|
| Risk impact chains | Loss of attractiveness due to climate discomfort | |
| Indicator type (4 choices) | exposure | |
| reference factor(s) in the risk IC | Number of tourists | Number of tourists in critical season |
| Indicatorshort name | NTouP | NTouP_JJAS |
| description of the indicator | Number of tourists per year : A visitor is a traveller taking a trip to a main destination outside his/her usual environment, for less than a year, for any main purpose (business, leisure or other personal purpose) other than to be employed by a resident entity in the country or place visited (IRTS 2008, 2.9). A visitor (domestic, inbound or outbound) is classified as a tourist (or overnight visitor), if his/her trip includes an overnight stay, or as a same-day visitor (or excursionist) otherwise (IRTS 2008, 2.13) | Number of tourists between June and September (both included) , that is Number of tourists visiting the destination during the months of more likely occurrence of heatwaves events |
| unit | number | number |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Regional Statistic Institutes | Regional Statistic Institutes |
| reference tresholds (description and values ) | | |
| method used for computation | | Registration by ports and airports authorities |
| supplementary Information | Information is based on registration by ports and airports authorities http://statistics.unwto.org/sites/all/files/docpdf/glossaryterms.pdf | Information is based on registration by ports and airports authorities http://statistics.unwto.org/sites/all/files/docpdf/glossaryterms.pdf |

| Sector affected | **Coastal and Maritime Tourism** | | |
|---|---|---|---|
| Risk impact chains | Decrease of available domestic water for the tourism industry | | |
| Indicator type (4 choices) | **hazard** | | |
| reference factor(s) in the risk IC | Increase of temperature | Precipitation | Drought |
| Indicator short name | NTX90p | Ptot | NSPI |
| description of the indicator | annual number of days in which maximum temperature is above than 90th percentile of maximum daily temperature in the baseline perioid. Days that high temperatures give place to an extra water demand for irrigation and refreshing purposes | Annual total precipitation | Number of months per year in which the Standardized Precipitation Index (SPI) is lower or equal to -1 |
| unit | Number per year | mm | number |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | weather monitoring stations and models | weather monitoring stations ansd models | weather monitoring stations ansd models |
| Supplementary Information | Morice, C. P., Kennedy, J. J., Rayner, N. A. and Jones, P. D., 2012, 'Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 data set', Journal of Geophysical Research 117(D8), D08101 (doi: 10.1029/2011JD017187). | Jacob, D., Petersen, J., Eggert, B., Alias, A., Christensen, O. B., Bouwer, L. M., Braun, A., Colette, A., Déqué, M., Georgievski, G., Georgopoulou, E., Gobiet, A., Menut, L., Nikulin, G., Haensler, A., Hempelmann, N., Jones, C., Keuler, K., Kovats, S. et al., 2014, 'EURO-CORDEX: New high-resolution climate change projections for European impact research', Regional Environmental Change 14(2), 563–578 (doi: 10.1007/s10113-013-0499-2). | Spinoni, J., Vogt, J., Naumann, G., Barbosa, P., European Commission and Joint Research Centre, 2016, Meteorological droughts in Europe: events and impacts, past trends and future projections, Publications Office, Luxembourg. |

| Sector affected | Coastal and Maritime Tourism | | | |
|---|---|---|---|---|
| Risk impact chains | Decrease of available domestic water for the tourism industry | | | |
| Indicator type (4 choices) | vulnerability (sensitivity) | | | |
| reference factor(s) in the risk IC | Tourism water demand | Efficiency in water demand | Domestic water consumption | Groundwater availability |
| Indicator name with (optional) short name | TouWtrD | WtrDE | DWtrC | LGWtrA |
| description of the indicator | Annual daily average water tourust consumption per overnight | Quantity of water used in agriculture per 1000 euros of GAV | annual mean value of daily consumption of domestic water per capita | Groundwater quantitative and chemical status . Expert assessment of Chemical status: poor or good (or unknown) |
| unit | litres per day per person | M3/1000 E. GAV | liters/day per capita | Lickert variable from-1 (Poor) to 1 (good) |
| Indicator classification (3 choices) | EVI: Environmental value I | ESI: Environmental Services I | ESI: Environmental Services I | CCI: Climate Change I |
| sources of information (general categories) | Regional water management authority | Regional water management authority | Regional water management authority | Regional water management authority |
| Supplementary Information | >European Tourism Indicators System for sustainable destination management. See at http://ec.europa.eu/growth/sectors/tourism/offer/sustainable/indicators_en | >Water intensity of crop production, European Environmental Agency (EEA). See at https://www.eea.europa.eu/data-and-maps/indicators/economic-water-productivity-of-irrigated-1/assessment - last modified 10 Jan, 2018 | >Use of freshwater resources, EEA. See at https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-3. Last modified 10 October 2018 | >European waters Assessment of status and pressures 2018. EEA Report No 7/2018.ISSN 1977-8449<br>>Nutrients in freshwater, EEA. See at https://www.eea.europa.eu/data-and-maps/indicators/nutrients-in-freshwater/nutrients-in-freshwater-assessment-published-6. Last modified 29 January 2018.<br>Good groundwater quantitative status means that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction. Accordingly, the groundwater level may not be subject to:<br>- any diminution in the ecological status of surface water linked with groundwater;<br>- significant damage to groundwater-dependent terrestrial ecosystems;<br>- any flow reversals that lead to saline or other intrusions.<br>Good groundwater chemical status is achieved when:<br>- there is no sign of saline intrusion in the groundwater body;<br>- the concentrations of pollutants do not exceed those permitted under the applicable groundwater quality standards or threshold values, including those for drinking water protected areas;<br>- the concentrations of pollutants do not result in failure to achieve ecological or chemical status of associated surface waters, nor in any significant damage to terrestrial ecosystems that depend directly on the groundwater body. |

| Sector affected | Coastal and Maritime Tourism | | | |
|---|---|---|---|---|
| Risk impact chains | Decrease of available domestic water for the tourism industry | | | |
| Indicator type (4 choices) | vulnerability (adapative capacity) | | | |
| reference factor(s) in the risk IC | Capacity to compensate with unconventional resources (desalination, etc.) | Capacity to properly manage the regional hydrological system | Capacity to properly manage the regional hydrological system | Capacity to face droughts |
| Indicator short name | XWtr | BWtrM | FAWtrM | PWtrR25 |
| description of the indicator | Annual Maximun Amount of water that can by provided for desalination and sewage treatment plants | Presence of quality-labeled water monitoring and management system | Funds for water monitoring and management system | Percentge of days per year in which freshwater reserves are under 25% |
| unit | $M^3$ | Boolean (Yes/No) variable | Euros/year. | percentage |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | ESI: Environmental Services I |
| sources of information (general categories) | Water management regional authority | Water management regional authority | Water management regional authority | Water management regional authority |
| Supplementary Information | Non-conventional water sources, mainly desalination and sewage treatment, are crucial to allow for tourism development in a context in which conventional sources evolve negatively. Collins, R., Kristensen, P., & Thyssen, N. (2009). Water resources across Europe-confronting water scarcity and drought. Office for Official Publications of the European Communities. Drought and water overuse in Europe, 2017 https://www.eea.europa.eu/media/newsreleases/drought-and-water-overuse-in-europe | As water management issue is a dynamic and complex one, the existence of an effective and efficient water management system is crucial to adopt well informed decisions. Collins, R., Kristensen, P., & Thyssen, N. (2009). Water resources across Europe-confronting water scarcity and drought. Office for Official Publications of the European Communities. Drought and water overuse in Europe, 2017 https://www.eea.europa.eu/media/newsreleases/drought-and-water-overuse-in-europe | As water management issue is a dynamic and complex one, the existence of an effective and efficient water management system is crucial to adopt well informed decisions. Collins, R., Kristensen, P., & Thyssen, N. (2009). Water resources across Europe-confronting water scarcity and drought. Office for Official Publications of the European Communities. Drought and water overuse in Europe, 2017 https://www.eea.europa.eu/media/newsreleases/drought-and-water-overuse-in-europe | When droughts happen, the capacity to long-play freshwater supply heavily depends on the reserves of freshwater. Collins, R., Kristensen, P., & Thyssen, N. (2009). Water resources across Europe-confronting water scarcity and drought. Office for Official Publications of the European Communities. Drought and water overuse in Europe, 2017 https://www.eea.europa.eu/media/newsreleases/drought-and-water-overuse-in-europe |
| Info and criteria for normalization | | | | |
| comment (optional) | | | | |

| Sector affected | **Coastal and Maritime Tourism** | |
|---|---|---|
| Risk impact chains | Decrease of available domestic water for the tourism industry | |
| Indicator type (4 choices) | **exposure** | |
| reference factor(s) in the risk IC | Land susceptible of water percolation | Visitors exposed the most to water scarcity |
| Indicator short name | PLWtrPe | NTouP_JJAS |
| description of the indicator | Percentage of land susceptible of water percolation | Number of tourists that arrived to destination during the driest months, per year |
| unit | % | Number |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I |
| Indicator type (4 choices) | exposure | Exposure |
| sources of information (general categories) | Regional land management authority | Regional Tourism authority |
| Supplementary Information | Water resources across Europe - confronting water scarcity and drought, EEA Report No 2/2009, ISSN 1725-9177 | UNWTO tourist' definition at http://cf.cdn.unwto.org/sites/all/files/docpdf/glossaryenrev.pdf |

| Sector affected | Coastal and Maritime Tourism | | | |
|---|---|---|---|---|
| Risk impact chains | Increase of damages to infrastructure and facilities due to sea level rise and storms | | | |
| Indicator type (4 choices) | hazard | | | |
| reference factor(s) in the risk IC | frequency of extreme marine storm | sea level rise | frequency of extreme high winds | Floods |
| Indicator short name | NSWHX98p | MSL | NWiX98p | Rx5d |
| description of the indicator | number of days per year with wave height maximum above the 98percentile of a reference baseline period | Annual Mean Sea level | number of days per year with maximum wind speed maximum above the 98percentile of a reference baseline period | Index for the maximum annual precipitation over five consecutive days |
| unit | number of days | meter | number of days | mm |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | Oceanographic stations and models | Oceanographic stations and models | Meteorological stations and models | Meteorological stations and models |
| Supplementary Information | Altomare, C., Crespo, A. J., Domínguez, J. M., Gómez-Gesteira, M., Suzuki, T., & Verwaest, T. (2015). Applicability of smoothed particle hydrodynamics for estimation of sea wave impact on coastal structures. Coastal Engineering, 96, 1-12. | https://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise-5/assessment | Donat, M. G., Leckebusch, G. C., Wild, S., and Ulbrich, U.: Future changes in European winter storm losses and extreme wind speeds inferred from GCM and RCM multi-model simulations, Nat. Hazards Earth Syst. Sci., 11, 1351-1370, doi:10.5194/nhess-11-1351-2011, 2011 | > Hallegatte, S., Green, C., Nicholls, R. J., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. Nature climate change, 3(9), 802.<br><br>> Jacob, D., Petersen, J., Eggert, B., Alias, A., Christensen, O. B., Bouwer, L. M., Braun, A., Colette, A., Déqué, M., Georgievski, G., Georgopoulou, E., Gobiet, A., Menut, L., Nikulin, G., Haensler, A., Hempelmann, N., Jones, C., Keuler, K., Kovats, S. et al., 2014, 'EURO-CORDEX: New high-resolution climate change projections for European impact research', Regional Environmental Change 14(2), 563–578 (doi: 10.1007/s10113-013-0499-2).<br><br>>Donat, M. G., Alexander, L. V., Yang, H., Durre, I., Vose, R., Dunn, R. J. H., Willett, K. M., Aguilar, E., Brunet, M., Caesar, J., Hewitson, B., Jack, C., Klein Tank, A. M. G., Kruger, A. C., Marengo, J., Peterson, T. C., Renom, M., Oria Rojas, C., Rusticucci, M. et al., 2013, 'Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset', Journal of Geophysical Research: Atmospheres 118(5), 2 098–2 118 (doi: 10.1002/jgrd.50150). |
| Info and criteria for normalization | | | | |
| comment (optional) | Waves express the way ocean surface kicks coastal areas. As the structures is expected has been build to support for a very long time the regular wave beating, this indicator just takes into account the outstanding waves, using for that the concept of percentile. | Sea level determine the amount of sea water that is permanently beating the coastal infrastructures and facilities; so the more height sea level, the higher the damage caused to those tourist goods. I.e., an increase of 0,5 m in s.l.r. may double the devastating power of a tsunami. | According to Munich RE's natural catastrophe loss database (NatCatSERVICE), storms were the costliest natural hazard (in terms of insured losses) in Europe between 1980 and 2013; they ranked fourth in terms of the number of human casualties . | Coastal areas are usually very vulnerable to runoff episodes, in turn depending on the intensity of precipitations and the orography. Those floods can impact coastal structures and facilities by breaking them or damaging the raw material they work with (seawater in case of desalination plants, etc.). |

| Sector affected | **Coastal and Maritime Tourism** | |
|---|---|---|
| Risk impact chains | Increase of damages to infrastructure and facilities due to sea level rise and storms | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| reference factor(s) in the risk IC | Facilities services (water, energy and telecommunication provision) | Infrastructures |
| Indicator short name | NDnSH | CDR |
| description of the indicator | Number of days per year in which the service was interrupted due to meterological hazards. Three services areconsidered: water, energy and telecommunications | Cost of repairing damages related to climate hazards, per year. The consodered infrastructures are those related with the touristic activity (promenades, marinas, etc.) |
| unit | number | euros |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Coastal Public Authority | Coastal Public Authority |
| Supplementary Information | In the case of facilities here considered (water, electricity and telecommunication), sensitivity can be measured by the time (days) in which services that they provide result interrupted due to climate events. Ref: Larsen, P. H., Goldsmith, S., Smith, O., Wilson, M. L., Strzepek, K., Chinowsky, P., & Saylor, B. (2008). Estimating future costs for Alaska public infrastructure at risk from climate change. *Global Environmental Change* , *18* (3), 442-457. | Sensitivity of along-the-coast facilities it is very difficult to be measured by ex ante methods related to intrinsic properties of it. Cost of repairing damages produced by climate hazards is a way of overcoming this problem. Ref: Larsen, P. H., Goldsmith, S., Smith, O., Wilson, M. L., Strzepek, K., Chinowsky, P., & Saylor, B. (2008). Estimating future costs for Alaska public infrastructure at risk from climate change. *Global Environmental Change* , *18* (3), 442-457. |

| Sector affected | Coastal and Maritime Tourism | | | |
|---|---|---|---|---|
| Risk impact chains | Increase of damages to infrastructure and facilities due to sea level rise and storms | | | |
| Indicator type (4 choices) | vulnerability (adapative capacity) | | | |
| reference factor(s) in the risk IC | Existence and efficiency of an early warning system | Existence and efficiency of an early warning system | Existence and efficiency of an early warning system | Appropriate maintenance plans |
| Indicator short name | BWS | FAWS | NEWS | FMMCoastI |
| description of the indicator | Presence or absence of an efficient early warning system | Funds available for warning system | Number of employees in the warning system | Funds allocated to monitoring and maintenance of coastal infrastructures and facilities per year |
| unit | Boolean (YES or NO) variable | euro | number | Euros |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Regional Government - Department of Infrastructures | | | Regional Government - Department of Infrastructures |
| Supplementary Information | Impacts on tourism industry from potential climate-shock damages on infrastructures and facilities can be notably diminished by a proper warning system for tourists and tourism business.<br>Patz, J. A., Campbell-Lendrum, D., Holloway, T., & Foley, J. A. (2005). Impact of regional climate change on human health. Nature, 438(7066), 310.<br><br>Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. Science, 309(5737), 1036-1039. | | | protection – summary of evidence Report –SC080039/R7 (2015). Environment Agency, Horizon House, Deanery Road,<br>Bristol, BS1 5AH. Available at Maintenance can prevent coastal infrastructures and facilities from damages due to climate related shocks. Maintenance funding indicator can properly approach the level of that societal capacity. http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SC080039_cost_coastal_protection.sflb.ashx.<br><br>Kirkpatrick, S. The Economic Value of Natural and Built Coastal Assets. ACCARNSI DISCUSSION PAPER – NODE 1 COASTAL SETTLEMENTS (2011).<br><br>Azevedo de Almeida, B., & Mostafavi, A. (2016). Resilience of infrastructure systems to sea-level rise in coastal areas: Impacts, adaptation measures, and |

| Sector affected | **Coastal and Maritime Tourism** | |
|---|---|---|
| Risk impact chains | Increase of damages to infrastructure and facilities due to sea level rise and storms | |
| Indicator type (4 choices) | **exposure** | |
| reference factor(s) in the risk IC | Coastal infrastructure length | Facilities along the coast |
| Indicator short name | LCoastTou | LCoastF |
| description of the indicator | Length of Coast with touristic infrastructure exposure | Coastal main facilities exposure: Length of water, electricity and telecomunications facilities along the coast |
| unit | km | km |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Regional Land management authority | Regional Land management authority |
| Supplementary Information | Extreme events and huge waves can cause damage to infrastructures by reducing the stability of foundations, causing settlement of the structure or directly undercutting the structure, causing collapse of the footings or exposure to wave action.<br><br>Lewsey, C., Cid, G., & Kruse, E. (2004). Assessing climate change impacts on coastal infrastructure in the Eastern Caribbean. *Marine Policy*, *28*(5), 393-409. | |

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# Aquaculture

| | | | |
|---|---|---|---|
| Sector affected | **Aquaculture** | | |
| Risk impact chains | Increased fragility of the aquaculture activity due to extreme events | | |
| Indicator type (4 choices) | **hazard** | | |
| reference factor(s) in the risk IC | Frequency of wind storms | extreme storm surge height | extreme significant wave height |
| Indicator name with (optional) short name | NWi98p | SLX98p | SWHX98p |
| description of the indicator | Yearly number of days with storms,computed as days when maximum wind speed exceeda reference high threshold | annual value of 98th percentile of the daily sea level maximum | annual value of the 98th percentile of the daily significant wave height maximum |
| unit | Number of days/year | meters | meters |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | Observations and models | Observations and models | Observations and models |
| Supplementary information | results are provided by climate model simulations, hindcasts, observations (anemometers, tide gauges, wave gauges). Two useful refs are: Conte D, Lionello P (2013) Characteristics of large positive and negative surges in the Mediterranean Sea and their attenuation in future climate scenarios. Glob Planet Change 111:159-173. doi:10.1016/j.gloplacha.2013.09.006 ; Lionello P, Conte D, Marzo L, Scarascia L (2016) The contrasting effect of increasing mean sea level and decreasing storminess on the maximum water level during storms along the coast of the Mediterranean Sea in the mid 21st century. Glob Planet Change http://dxdoiorg/10.1016/j.gloplacha.2016.06.012 ; | | |

| Sector affected | **Aquaculture** | |
|---|---|---|
| Risk impact chains | Increased fragility of the aquaculture activity due to extreme events | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| reference factor(s) in the risk IC | Quality and strength of structures | Physiological sensitivity of species -Mortality |
| short name | PCRep | MRT |
| description of the indicator | Amount spend on repair per year (percentage of total asset value) | Average mortality rate of the stock (number of deaths/total number farmed x100) |
| unit | % | % |
| Indicator classification (3 choices) | EVI: Environmental value I | ESI: Environmental Services I |
| sources of information (general categories) | Aquaculture operators | aquaculture operators |
| Supplementary Information | | http://www.fao.org/3/a-i2075e.pdf |

| Sector affected | Aquaculture | | |
|---|---|---|---|
| Risk impact chains | Increased fragility of the aquaculture activity due to extreme events | | |
| Indicator type (4 choices) | **vulnerability (adapative capacity)** | | |
| reference factor(s) in the risk IC | Stocking density | Existence and efficiency of an early coastal warning system | Financial health of business |
| Indicator short name | STD | BWS | WCR |
| description of the indicator | Number of animals per m3 | Boolean (YES or NO) variable denoting presence or absence of active oceanographic stations | Working capital ratio: liquidity ratio that measures a firm's ability to pay off its current liabilities with current assets (Currets assets/current liabilities) |
| unit | kg/ m3 | presence or absence (Boolean variable) | dimensionless |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I | EVI: Environmental value I |
| sources of information (general categories) | Aquaculture operators | Aquaculture operators, aquaculture association | farmers |
| supplementary information | There is a minimum stocking density where farmers can still earn | http://www.fao.org/3/a-i6641e.pdf | WCR >1.5 is not sensitive, WCR >1 very sensitive (https://www.myaccountingcourse.com/financial-ratios/working-capital-ratio) |

| Sector affected | **Aquaculture** | | | |
|---|---|---|---|---|
| Risk impact chains | Increased fragility of the aquaculture activity due to extreme events | | | |
| Indicator type (4 choices) | **exposure** | | | |
| reference factor(s) in the risk IC | Number of employees | GDP | Size of stock | Value of structures at farm |
| Indicator short name | NEmplA | PGDPA | BDAVE | VFS |
| description of the indicator | Number of employees working in the aquauclture farms | Fraction of GDP produced by aquaculture: Aquaculture production/ (GDP (private consumption + gross investment + government investment + government spending + exports – imports)*100 | Average biomass | Total value of assest in the water, Total value of assest minus depreciation |
| unit | Number of employees | % | $kg/m^3$ | EURO |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Aquaculture operators, National and Regional Statistic Offices or Governmental Aquaculture Organisations | National and Regional Statistic Offices | National and Regional Statistic Offices or Governmental Aquaculture Organisations | Governmental Aquaculture Organisations and directly from aquaculture operators |
| Supplementary information | https://search.proquest.com/openview/c8d55e04f853cdbb11632d75c28db503/1?pq-origsite=gscholar&cbl=237326 | https://onlinelibrary.wiley.com/doi/pdf/10.1111/faf.12186 | http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1516-35982012000600001 | http://edepot.wur.nl/287820 |

| | |
|---|---|
| Sector affected | **Aquaculture** |
| Risk impact chains | Change in production due to changes in temperature |
| Indicator type (4 choices) | **hazard** |
| reference factor(s) in the risk IC | Sea surface water temperature |
| Indicator short name | NSSTX |
| description of the indicator | Number of days with average SST above maximum temperature for the fish species |
| unit | number of days |
| Indicator classification (3 choices) | CCI: Climate Change I |
| sources of information (general categories) | CNEMS, Mercator, MedCORDEX, MedHYMAP and climate models |
| Supplementary information | Temperature range of fish for optimal growth<br>See extra tab (different per species) for values. Useful refs:<br>https://www.researchgate.net/publication/274139996_Impact_of_global_climate_change_on_fish_growth_digestion_and_physiological_status_Developing_a_hypothesis_for_cause_and_effect_relationships ;<br>https://www.google.com/search?q=sea+surface+temperature+as+an+indicator+in+aquaculture&ie=utf-8&oe=utf-8&client=firefox-b |

| Sector affected | **Aquaculture** | |
|---|---|---|
| Risk impact chains | Change in production due to changes in temperature | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| reference factor(s) in the risk IC | Physiological sensitivity of species - Mortality | Physiological sensitivity of species -Specific Growth Rate |
| Indicator short name | MRT | SGR |
| description of the indicator | Number of mortalities per year as percentage of total number of fish in produced | Decrease in growth rate as function of increase in temperature |
| unit | % | % |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I |
| sources of information (general categories) | aquaculture operators | literature/experts/research institutes |
| Supplementary information | | SGR decrease by more than 10% will negatively Affect the income for the farmers. Growth model for SGR: the growth rate per unit weight of the fish as % weight increase/unit time (days) done for different temperatures. Ref:http://www.haparanda.se/download/18.786ab49113d008f9ee5fdd/1362143818794/Growth-+and+Bioenergetic+Models+and+their+Applications+in+Aquaculture+of+Perch.pdf |

| Sector affected | Aquaculture | | | |
|---|---|---|---|---|
| Risk impact chains | Change in production due to changes in temperature | | | |
| Indicator type (4 choices) | vulnerability (adapative capacity) | | | |
| reference factor(s) in the risk IC | Capacity to change species | Early warning systems | Treating diseases/parasites | Financial health of business |
| Indicator short name | CCS | BWS | TDP | WCR |
| description of the indicator | Number of species suitable for the farm | Boolean Variable (YES or NO) denoting existence and efficiency of an early warning system to detect temperature, DO, algae blooms etc. | Amount for treatments or prevention measures applied as a fraction of total costs of the farm | Working capital ratio, Currets assets/current liabilities |
| unit | Number | presence or absence (Boolean variable) | % | dimensionless |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Aquaculture operators | Aquaculture operators | Aquaculture operators | farmers |
| reference tresholds (description and values ) | | http://www.fao.org/3/a-i6641e.pdf | https://sci-hub.tw/https://www.ncbi.nlm.nih.gov/pubmed/20580904 | WCR >1: giving potential liquidity problems so more sensitive. WCR in the range 1.5-2 means that company has solid financial grouns and is thus less sensitive https://www.myaccountingcourse.com/financial-ratios/working-capital-ratio |

| Sector affected | Aquaculture | | | |
|---|---|---|---|---|
| Risk impact chains | Change in production due to changes in temperature | | | |
| Indicator type (4 choices) | exposure | | | |
| reference factor(s) in the risk IC | Number of employees | Size of stock | Annual production | GDP |
| Indicator name with (optional) short name | NEmplA | Btot | VPATot | PGDPA |
| description of the indicator | annual number of employees working in the aquauclture farms | annual total biomass in stocks | Economic value of total Aquaculture production per year | percentage of regional Gross Domestic Product produced by Aquaculture in each year |
| unit | Number of employees | kg | Eur | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Aquauclture operators, National and Regional Statistic Offices or Governmental Aquaculture Organisations | National and Regional Statistic Offices or Governmental Aquaculture Organisations | National Statistics Office | National and Regional Statistic Offices |
| Supplementary Information | https://search.proquest.com/openview/c8d55e04f853cdbb11632d75c28db503/1?pq-origsite=gscholar&cbl=237326 | | https://onlinelibrary.wiley.com/doi/pdf/10.1111/faf.12186 | https://onlinelibrary.wiley.com/doi/pdf/10.1111/faf.12186 |

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# Marine Energy

| Sector affected | **Marine energy** | | |
|---|---|---|---|
| Risk impact chains | Risk of changes in power generation due to long term climate change and variability | | |
| Indicator type (4 choices) | **hazard** | | |
| Reference factor(s) in the risk IC | Extreme events | average Wind | Solar radiation |
| Indicator short name | WiX98p | Wiave | Srave |
| Description of the indicator | Windstorm max intensity: annual value of the 98th percentile daily of the daily wind speed maximum | monthly average wind speed | Monthly average downward solar radiation at the surface |
| unit (text) | m/s | m/s | $kWh/m^2$ |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| Sources of information (general categories) | Observations and models | Observations and models | Observations and models |
| Supplementary Information | Related to: Decreased renewable energy generation due to extreme events.<br>European Environment Agency Indicators – Wind storms https://www.eea.europa.eu/data-and-maps/indicators/storms-2/assessment | Related to: Decreased renewable energy generation due to resource changes, Changes in average windspeed and in windspeed variability. Cut-in speed (speed at which the wind turbine begins to generate power; tipically 3 m/s) and cut-out speed (speed at which the wind turbine is shut down to avoid damages due to too strong winds; tipically 25 m/s) | Related to: Decreased renewable energy generation due to resource changes ,Changes in average surface solar radiation and in surface solar radiation variability |

| Sector affected | Marine energy | | |
|---|---|---|---|
| Risk impact chains | Risk of changes in power generation due to long term climate change and variability | Risk of changes in power generation due to long term climate change and variability | Risk of changes in power generation due to long term climate change and variability |
| Indicator type (4 choices) | vulnerability (sensitivity) | | |
| Reference factor(s) in the risk IC | Variability in renewable power generation | Variability in renewable power generation | Share of renewable energy |
| Indicator short name | PWPV | PSPV | PREn |
| Description of the indicator | Wind power variability: Coefficient of variation (Wind variability affects the power output of turbines).Computed as standard deviation divided by mean value | Solar PV power variability: Coefficient of variation (increase in clouds and aerosols decreases solar radiation). Higher temperatures decreases efficiency of PV systems. Computed as standard deviation divided by mean value | Percentage of renewable energy in gross final energy consumption. Vulnerability of energy production to extreme events will depend on the share of renewable energy |
| Unit | % | % | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Observations and models | Observations and models | Administrative data |
| Supplememtary Information | Related to: Decreased renewable energy generation due to resource changes | Related to: Decreased renewable energy generation due to resource changes. Gutierrez, C., Gaertner, M. Á., Perpiñán, O., Gallardo, C., & Sánchez, E. (2017). A multi-step scheme for spatial analysis of solar and photovoltaic production variability and complementarity. Solar Energy, 158, 100-116. | Related to: Decreased renewable energy generation due to extreme events. European Environment Agency Indicators - Share of RE in gross final energy consumption https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-4/assessment-2 |

| Sector affected | Marine energy | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of changes in power generation due to long term climate change and variability | | | |
| Indicator type (4 choices) | vulnerability (adaptive capacity) | | | |
| Reference factor(s) in the risk IC | Energy mix | Share of renewable energy | Distributed Generation | Distributed Generation |
| Indicator with (optional) short name | ABU | PWSE | NCN | PPS |
| Description of the indicator | Available back-up generation and storage. Increased variation in RES generation will need additional storage capacity to guarantee quality and security of power supply | Percentage of wind and solar energy in gross final energy consumption. Wind and solar energy generators have a shorter lifetime than conventional energy plants, which makes them more adaptable in the long term, less technological lock-in, more | Degree of decentralization .given by the number of consumption nodes per number of power plants | Degree of decentralization .given by the average size of power plants |
| Unit | % | % | dimensionless | MW |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data | Administrative data | Administrative data |
| Supplementary Information | Related to: Decreased renewable energy generation due to resource changes and extreme events. Ref:Blanco, H., & Faaij, A. (2018). A review at the role of storage in energy systems with a focus on Power to Gas and long-term storage. Renewable and Sustainable Energy Reviews, 81, 1049-1086. | Related to: Decreased renewable energy generation due to resource changes and extreme events Adaptation measures include relocation or generation technology improvements (e.g. repowering for wind turbines). Ref:Schaeffer, R., Szklo, A. S., de Lucena, A. F. P., Borba, B. S. M. C., Nogueira, L. P. P., Fleming, F. P., ... & Boulahya, M. S. (2012). Energy sector vulnerability to climate change: a review. Energy, 38(1), 1-12. | Related to: Decreased renewable energy generation due to resource changes and extreme events. REF:Alanne, K., & Saari, A. (2006). Distributed energy generation and sustainable development. Renewable and sustainable energy reviews, 10(6), 539-558. | Related to: Decreased renewable energy generation due to resource changes and extreme events. REF:Alanne, K., & Saari, A. (2006). Distributed energy generation and sustainable development. Renewable and sustainable energy reviews, 10(6), 539-558. |

| | | |
|---|---|---|
| Sector affected | **Marine energy** | |
| Risk impact chains | Risk of changes in power generation due to long term climate change and variability | |
| Indicator type (4 choices) | **exposure** | |
| Reference factor(s) in the risk IC | Type and number of power generators | Type and number of power generators |
| Indicator with (optional) short name | WWi | WSPv |
| Description of the indicator | Wind power capacity: Installed wind energy capacity (onshore and offshore) | Installed sSolar photovoltaic capacity |
| Unit | MW | MW |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data |
| Supplementary Information | Related to: Decreased renewable energy generation due to resource changes and extreme events | Related to: Decreased renewable energy generation due to resource changes and extreme events |

| Sector affected | **Marine energy** | |
|---|---|---|
| Risk impact chains | Risk of changes in energy demand due to changes in precipitations and temperatures | |
| Indicator type (4 choices) | **hazard** | |
| Reference factor(s) in the risk IC | Temperature | Precipitation |
| Indicator name with (optional) short name | CDD | SPI |
| Description of the indicator | Cooling degree days: accumulated temperature difference above a threshold value (18ºC) in a year calculated usingaverage daily temperature values | Standardised precipitation index: the SPI is obtained transforming the monthly precipitation time series into a standardized normal distribution |
| Unit | ºC | dimensionless |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I |
| Sources of information (general categories) | Observations and models | Observations and models |
| Supplementary Information | This indicator is related to increased energy demand due to increased cooling demand. Ref: Jakubcionis, M., & Carlsson, J. (2017). Estimation of European Union residential sector space cooling potential. Energy Policy, 101, 225-235. | This indicator is related to increased energy demand due to increased desalination/pumping needs, Refs: Lloyd-Hughes, B., and M. A. Saunders, 2002: A drought climatology for Europe. Int. J. Climatol., 22, 1571–1592 |

| Sector affected | **Marine energy** | |
|---|---|---|
| Risk impact chains | Risk of changes in energy demand due to changes in precipitations and temperatures | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| Reference factor(s) in the risk IC | Comfort requirements | Irrigation needs |
| Indicator name with (optional) short name | CED | DED |
| Description of the indicator | Change of cooling energy demand per unit change of CDD | Change of desalination and pumping energy demand per unit change of SPI |
| Unit | kWh per CDD | kWh per unit change of SPI |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data |
| Supplementary Information | Related to: Increased energy demand due to increased cooling demand | Related to: Increased energy demand due to increased desalination/pumping needs |

| Sector affected | Marine energy | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of changes in energy demand due to changes in precipitations and temperatures | | | |
| Indicator type (4 choices) | vulnerability (adaptive capacity) | | | |
| Reference factor(s) in the risk IC | Crop choices and irrigation needs | Comfort requirements | Energy demand control | Energy demand control |
| Indicator short name | LCrCho | PP | DSM | PEE |
| Description of the indicator | Lickert scale based on expert estimate on crop choices and irrigation needs assessing flexibility to switch to more resistant crops | Purchasing power : Capacity of local residents and industry, and of tourists, to assume increased energy bills | Demand side management: Adaptation of demand to power generation: non-critical deferrable loads could be postponed to adjust power demand to variable RES power generation | Percentage of buildings (properties) with a certificated energy efficiency class higher than D: Increased energy efficiency of buildings and AC systems can reduce the final cooling electricity demand |
| Unit | Lickert variable (1-10) | Per capita GDP | MWh | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data | Administrative data | Administrative data |
| Reference tresholds (description and values) | | | | |
| Supplementary Information | Related to: Increased energy demand due to increased desalination/pumping needs | Related to: Increased energy demand due to increased cooling demand | Related to: Increased energy demand due to increased cooling demand | Related to: Increased energy demand due to increased cooling demand |

| Sector affected | Marine energy | | | | |
|---|---|---|---|---|---|
| Risk impact chains | Risk of changes in energy demand due to changes in precipitations and temperatures | | | | |
| Indicator type (4 choices) | exposure | | | | |
| Reference factor(s) in the risk IC | Population density | Tourism flows and seasonality | Economic activity: agriculture, industries | Population density | Population density and economic activity |
| Indicator short name | NResP | NTouP | GDPEDA | PCPR | PDW |
| Description of the indicator | Island residents population: number of permanent residents. The energy and water demand will be proportional to the number of residents | Number of tourists: total annual number of visitors reaching the island . Tourism is the main economic activity in islands, and the number of tourists affect energy and water demand in a different way than residents population. | Value-added by energy demanding economic activities. The bigger the service and industry activity of the island, the higher the total energy demand | Cooling penetration rate: potential percentage of households using AC as a function of CDD value of an island | percentage of desalinated water with respect to the total water for domestic consumption |
| Unit | Number of persons | Number of persons | € | % | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data | Administrative data | Model or administrative data | Administrative data |
| Supplementary Information | Related to: Increased energy demand due to increased cooling demand / Increased energy demand due to increased desalination/pumping needs | Related to: Increased energy demand due to increased cooling demand / Increased energy demand due to increased desalination/pumping needs | Related to: Increased energy demand due to increased cooling demand | Related to: Increased energy demand due to increased cooling demand Jakubcionis, M., & Carlsson, J. (2017). Estimation of European Union residential sector space cooling potential. Energy Policy, 101, 225-235. | Related to: Increased energy demand due to increased desalination/pumping needs |

| | |
|---|---|
| Sector affected | **Marine energy** |
| Risk impact chains | Risk of damages to transmission grids due to extreme events |
| Indicator type (4 choices) | **hazard** |
| Reference factor(s) in the risk IC | Extreme Meteorological Events |
| Indicator name with (optional) short name | NEME |
| Description of the indicator | total annual number of extreme meteorological events (such as high winds, floods, high temperatures) that can damage transmission lines and substations |
| Unit | number/year |
| Indicator classification (3 choices) | CCI: Climate Change I |
| Sources of information (general categories) | Observations and models |
| Supplementary Information | High air temperatures are included because they may force to reduce the electrical current passing through transmission lines and power transformers (de-rating), to avoid overheating of the equipment. This process may become significant with rising demand associated to high temperatures. |

| Sector affected | **Marine energy** | |
|---|---|---|
| Risk impact chains | Risk of damages to transmission grids due to extreme events | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| Reference factor(s) in the risk IC | Damage to transmission lines and substations | Damage to transmission lines and substations |
| Indicator name with (optional) short name | CTLRep | PCU |
| Description of the indicator | Specific cost of repairing transmission lines and substations (asaconsequence of an extreme event) | Percentage of consumption units affected by power outages (blackouts) resulting from damages to power lines (per extreme event) |
| Unit | € | % |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Observations | Observations |
| Supplementary information | This cost will depend on geographical circumstances of the grid equipment (e.g. lines in mountainous areas will have a higher repair cost) | |

| Sector affected | Marine energy | | |
|---|---|---|---|
| Risk impact chains | Risk of damages to transmission grids due to extreme events | | |
| Indicator type (4 choices) | vulnerability (adaptive capacity) | | |
| Reference factor(s) in the risk IC | Interconnections with mainland | Distributed Generation | Distributed Generation |
| Indicator name with (optional) short name | IM | NCN | PPS |
| Description of the indicator | Interconnections with mainland: power Capacity of existing submarine cables interconnecting the island electrical system to a continental grid | Degree of decentralization: number of consumption nodes per number of power plants | Average size of power plants |
| Unit | MW | Number | MW |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data | Administrative data |
| Supplementary Information | | Alanne, K., & Saari, A. (2006). Distributed energy generation and sustainable development. Renewable and sustainable energy reviews, 10(6), 539-558. | |

| Sector affected | **Marine energy** | |
|---|---|---|
| Risk impact chains | Risk of damages to transmission grids due to extreme events | |
| Indicator type (4 choices) | **exposure** | |
| Reference factor(s) in the risk IC | Damage to transmission lines and substations | Load characteristics |
| Indicator name with (optional) short name | LTrGr | NtotP |
| Description of the indicator | Size of the grid computed as total length of the transmission grids | Annual number of Inhabitants in the island, both permanent residents, and tourist equivalent |
| Unit | km | Number of persons |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I |
| Sources of information (general categories) | Administrative data | Administrative data |
| Supplementary information | | |

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# Maritime Transport

| Sector affected | **Maritime Transport** | | |
|---|---|---|---|
| Risk impact chains | Risk of damages in port infrastructures | | |
| Indicator type (4 choices) | **hazard** | | |
| reference factor(s) in the risk IC | Rising of sea level | Increased frequency of extreme weather events | Increased frequency of extreme weather events |
| Indicator name with (optional) short name | MSL | NSWHX98p | NWiX98p |
| description of the indicator | Annual Mean Sea level | number of days per year with wave height maximum above the 98percentile of a reference baseline period ( | number of days per year with wind speed maximum above the 98percentile of a reference baseline period |
| unit | meter | number of days | number of days |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | Observations, public administrations' data | Observations, public administrations' data | Observations, public administrations' data |
| Supplementary information | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017. http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx<br><br>http://www.gloss-sealevel.org/ | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017.<br><br>Puertos del Estado - REDCOS http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017. AEMET http://www.aemet.es/es/serviciosclimaticos/datosclimatologicos/efemerides_extremos?w=0&k=coo&datos=det&l=C649I |

| Sector affected | Maritime Transport | | |
|---|---|---|---|
| Risk impact chains | Risk of damages in port infrastructures | | |
| Indicator type (4 choices) | vulnerability (sensitivity) | | |
| reference factor(s) in the risk IC | Adaptation of harbours to changing environmental conditions | Knowledge and training | Existence and efficiency of an early coastal warning system |
| Indicator short name | NSPCCA | NTrCoRM | NOcSta |
| description of the indicator | No. of strategic plans which include a climate change adaptation approach (Review of the port authorities' strategic plans to determine which of them include actions related to climate change adaptation). | No. of specialized training courses in risk management (Continuous training in specific emergencies for port employees, port communities, general public and police.) | No. of active ocenographic stations (support systems for measuring and forecasting the marine environment withthe objective to provide the essential oceanographic and meteorological data for design and exploitation, which reduces costs and increases efficiency, sustainability and security of port operations) |
| unit | number of Strategic plans | number of Training courses | number of Ocenographic stations |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I | ESI: Environmental Services I |
| sources of information (general categories) | Port authorities | internet | internet |
| supplementary information | | http://www.puertos.es/es-es/Paginas/Formaci%C3%B3n.aspx<br><br>http://www.gobiernodecanarias.org/academia/scripts/default.asp | http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx |

| Sector affected | **Maritime Transport** | |
|---|---|---|
| Risk impact chains | Risk of damages in port infrastructures | |
| Indicator type (4 choices) | **vulnerability (sensitivity)** | |
| reference factor(s) in the risk IC | Presence of dikes/moles | Quality of infrastructures and equipments (height, drainage system) |
| Indicator name with (optional) short name | NNOpP | NAgeP |
| description of the indicator | No. of ports that cannot operate during extreme storms, when waves or sea level are above the threshold. | No. of ports with critical infrastructures not renovated since 1993 |
| unit | number | Year |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I |
| sources of information (general categories) | Port authorities | Port authorities |
| Supplementary information | | ROM 1.0-09, Breakwaters Recommendations (Part I: Calculation and Project Factors. Climatic Agents) http://www.puertos.es/es-es/BibliotecaV2/ROM%201.0-09%20(EN).pdf 2.8 RECOMMENDED VALUES FOR BREAKWATER CONSTRUCTION AND DEFENSE |

| Sector affected | Maritime Transport | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of damages in port infrastructures | | | |
| Indicator type (4 choices) | exposure | | | |
| reference factor(s) in the risk IC | Location of ports (incl. marinas nearby) | Location of ports (incl. marinas nearby) | Nature of the transport | Nature of the transport |
| Indicator name with (optional) short name | Npo | NTotP | Npax | VGTSTot |
| description of the indicator | Number of Existing port infrastructures on the islands. | Population | Total number of passengers transported every year by ships docked at the islands' ports. | Value of goods transported by ships. |
| unit | Port infrastructures | Number of inhabitants | Number/Years | Euros/Year |
| Indicator classification (3 choices) | ESI: Environmental Services I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | Port authorities, local/regional governments | internet | internet | internet |
| supplementary information | AP Las Palmas<br>http://www.palmasport.es/web/guest/puerto-de-las-palmas<br><br>AP Santa Cruz de Tenerife<br>https://www.puertosdetenerife.org/index.php/es/tf-infraestructuras<br><br>Puertos Canarios<br>https://puertoscanarios.es/ | | | |

| | | |
|---|---|---|
| Sector affected | **Maritime Transport** | |
| Risk impact chains | Risk of damages to ships on route | |
| Indicator type (4 choices) | **hazard** | |
| reference factor(s) in the risk IC | Increased frequency of extreme weather events | Increased frequency of extreme weather events |
| Indicator short name | NSWHX98p | NWiX98p |
| description of the indicator | number of days per year with wave height maximum above the 98percentile of a reference baseline period | number of days per year with wind speed maximum above the 98percentile of a reference baseline period |
| unit | number of days | number of days |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | Observations, public administrations' data | Observations, public administrations' data |
| supplementary information | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017. Puertos del Estado - REDCOS http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017.AEMET http://www.aemet.es/es/serviciosclimaticos/datosclimatologicos/efemerides_extremos?w=0&k=coo&datos=det&l=C649I |

| | |
|---|---|
| Sector affected | **Maritime Transport** |
| Risk impact chains | Risk of damages to ships on route |
| Indicator type (4 choices) | **vulnerability (sensitivity)** |
| reference factor(s) in the risk IC | Quality of the ship |
| Indicator short name | NSHDL |
| description of the indicator | No. of ships on Paris MOU detenntion list. Paris MoU's mission is to eliminate the operation of sub-standard ships through a harmonized system of port State control. 27 participating national maritime Administrations covers the waters of the European coastal States and the North Atlantic basin from North America to Europe. |
| unit | number |
| Indicator classification (3 choices) | ESI: Environmental Services I |
| sources of information (general categories) | Paris MoU detention list database https://www.parismou.org/detentions-banning/monthly-detentions/detentionlists-2018 |
| Supplementary Information | |

| Sector affected | Maritime Transport | | |
|---|---|---|---|
| Risk impact chains | Risk of damages to ships on route | | |
| Indicator type (4 choices) | vulnerability (adapative capacity) | | |
| reference factor(s) in the risk IC | Knowledge and training | Existence and efficiency of an early coastal warning system | Existence of a risk management plan in the port/city for accidents (people, |
| Indicator short name | NTrCoRM | NOcSta | NCPla |
| description of the indicator | No. of specialized training courses in risk management (Continuous training in specific emergencies for port employees, port communities, general public and police). | No. of active ocenographic stations (support systems for measuring and forecasting the marine environment withthe objective to provide the essential oceanographic and meteorological data for design and exploitation, which reduces costs and increases efficiency, sustainability and security of port operations) | No. of times the contingency plan was triggered (Contingency plan for marine pollution events occuring in ports, maritime terminals for handling goods, marine platforms for exploration or exploitation of natural resources at sea, as well as any other maritime facility located in areas belonging to the country). |
| unit | number of Training courses | Number of Ocenographic stations | Number of Plan activations |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I | ESI: Environmental Services I |
| sources of information (general categories) | internet | internet | internet |
| Supplementary Information | http://www.puertos.es/es-es/Paginas/Formaci%C3%B3n.aspx<br><br>http://www.gobiernodecanarias.org/academia/scripts/default.asp | http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx | http://www.palmasport.es/web/guest/publicaciones<br><br>https://www.puertosdetenerife.org/index.php/es/sostenibilidad |

| Sector affected | **Maritime Transport** | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of damages to ships on route | | | |
| Indicator type (4 choices) | **exposure** | | | |
| reference factor(s) in the risk IC | Routes | Nature of the transport | Nature of the transport | Nature of the transport |
| Indicator short name | PFFS | Npax | VGTSTot | NCS |
| description of the indicator | annual Percentage of Foreign Flag Ships that dock at the islands' port with respect to the total number of ships | Total Number of Passengers transported every year by ships that docks at the islands' ports. | Total annual Value of Goods Transported by Ships that docks at the islands' port | Total Number of Cargo Ships that docks at islands' ports every year. |
| unit | % | Number/Years | Euros/Year | Number/Year |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I |
| sources of information (general categories) | internet | internet | internet | internet |
| Supplementary Information | | | | |

| Sector affected | **Maritime Transport** | | |
|---|---|---|---|
| Risk impact chains | Risk of isolation due to transport disruption | | |
| Indicator type (4 choices) | **hazard** | | |
| reference factor(s) in the risk IC | sea level rise | Increased frequency of extreme weather events | Increased frequency of extreme weather events |
| Indicator short name | MSL | NSWHX98p | NWiX98p |
| description of the indicator | Annual Mean Sea level | frequency of extreme marine storm: number of days per year with wave height maximum above the 98th percentile of a reference baseline period | frequency of extreme high winds: number of days per year with wind speed maximum above the 98th percentile of a reference baseline period |
| unit | meter | number of days | number of days |
| Indicator classification (3 choices) | CCI: Climate Change I | CCI: Climate Change I | CCI: Climate Change I |
| sources of information (general categories) | Observations, public administrations' data, climate models | Observations, public administrations' data, climate modesl | Observations, public administrations' data, climate models |
| Supplementary Information | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017.<br>http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx<br><br>http://www.gloss-sealevel.org/ | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017.<br><br>As long as the probability of exceedance of the value of the predominant agent inducing the failure is negligible for all sea states less than the extreme value, the verification of failure modes assigned to ultimate limit states for extreme or exceptional work conditions will be carried out by applying the extreme regime. Otherwise, for ultimate limit states as well as for serviceability limit states, it is necessary to work with the distribution function of annual over-threshold exceedances and their extension to the useful life of a structure. This distribution can be obtained from a sample of various years at the project site location or from the maximum peak regime combined with an estimate of the generation and damping curves of | This indicator has been used in previous scientific papers as climatic variables of reference (for example Sánchez-Archilla et al 2016; Sierra et al 2017.<br>AEMET<br>http://www.aemet.es/es/serviciosclimaticos/datosclimatologicos/efemerides_extremos?w=0&k=coo&datos=det&l=C649I |

| Sector affected | **Maritime Transport** | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of isolation due to transport disruption | | | |
| Indicator type (4 choices) | **exposure** | | | |
| reference factor(s) in the risk IC | Location of ports (incl. marinas nearby) | Location of ports (incl. marinas nearby) | Location of ports (incl. marinas nearby) | Number of ports |
| Indicator name with (optional) short name | Npax | NTotP | VGTSTot | Npo |
| description of the indicator | Total number of passengers transported every year by ships docked at the islands' ports. | Total population of the Island (Inhabitants in the island, both permanent residents, and tourist equivalent) | annual economic value of total goods transported by ships per year | Number of existing port infrastructures on the islands. |
| unit | Number/Years | Number of inhabitants | Euros/Year | Port infrastructures |
| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | ESI: Environmental Services I |
| sources of information (general categories) | internet | internet | internet | internet |
| Supplementary Information | AP Las Palmas<br>http://www.palmasport.es/web/guest/puerto-de-las-palmas<br><br>AP Santa Cruz de Tenerife<br>https://www.puertosdetenerife.org/index.php/es/tf-infraestructuras<br><br>Puertos Canarios<br>https://puertoscanarios.es/ | | | |

| Sector affected | Maritime Transport | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of isolation due to transport disruption | | | |
| Indicator type (4 choices) | vulnerability (adapative capacity) | | | |
| reference factor(s) in the risk IC | Ability of the island to be self sustainable | Knowledge and training | Existence and efficiency of an early coastal warning system | Harbour alternatives to avoid island isolation |
| Indicator name with (optional) short name | PenRR | NTrCoRM | NOcSta | Napt |
| description of the indicator | % of energy produced by renewable resources | No. of specialized training courses in risk management : continuous training in specific emergencies for port employees, port communities, general public and police. | No. of active ocenographic stations | No. of airport infrastructures, airports and heliports : Network of public and private airports and heliports existing on the islands. |
| unit | % | Training courses | Ocenographic stations | Airport infrastructures |
| Indicator classification (3 choices) | ESI: Environmental Services I | ESI: Environmental Services I | ESI: Environmental Services I | ESI: Environmental Services I |
| sources of information (general categories) | | internet | internet | internet |
| Supplementary Information | | http://www.puertos.es/es-es/Paginas/Formaci%C3%B3n.aspx<br><br>http://www.gobiernodecanarias.org/academia/scripts/default.asp | Puertos del Estado has developed and supports systems for measuring and forecasting the marine environment. Their objective is to provide the Spanish port system with the essential oceanographic and meteorological data for its design and exploitation, which reduces costs and increases efficiency, sustainability and security of port operations.http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx | http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx |

| Sector affected | Maritime Transport | | | |
|---|---|---|---|---|
| Risk impact chains | Risk of isolation due to transport disruption | | | |
| Indicator type (4 choices) | exposure | | | |
| reference factor(s) in the risk IC | Location of ports (incl. marinas nearby) | Location of ports (incl. marinas nearby) | Location of ports (incl. marinas nearby) | Number of ports |
| Indicator name with (optional) short name | Npax | NTotP | VGTSTot | Npo |
| description of the indicator | Total number of passengers transported every year by ships docked at the islands' ports. | Total population of the Island (Inhabitants in the island, both permanent residents, and tourist equivalent) | annual economic value of total goods transported by ships per year | Number of existing port infrastructures on the islands. |
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| Indicator classification (3 choices) | EVI: Environmental value I | EVI: Environmental value I | EVI: Environmental value I | ESI: Environmental Services I |
| sources of information (general categories) | internet | internet | internet | internet |
| Supplementary Information | AP Las Palmas<br>http://www.palmasport.es/web/guest/puerto-de-las-palmas<br><br>AP Santa Cruz de Tenerife<br>https://www.puertosdetenerife.org/index.php/es/tf-infraestructuras<br><br>Puertos Canarios<br>https://puertoscanarios.es/ | | | |

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