Interreg Sudoe

EUROPEAN UNION

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ECCLIPSE

assEssment of CLImate change in Ports of Southwest Europe

Towards a Resilient Port Network. Adaptation of ports to the effects of climate change

Budget:
1,045,253.00 €

Consortium:

FUNDACIÓN VALENCIAPORT · HIDROMOD · Cerema · fic · valenciaport Autoridad Portuaria de Valencia · BORDEAUX PORT ATLANTIQUE · Porto de Aveiro · Puertos del Estado

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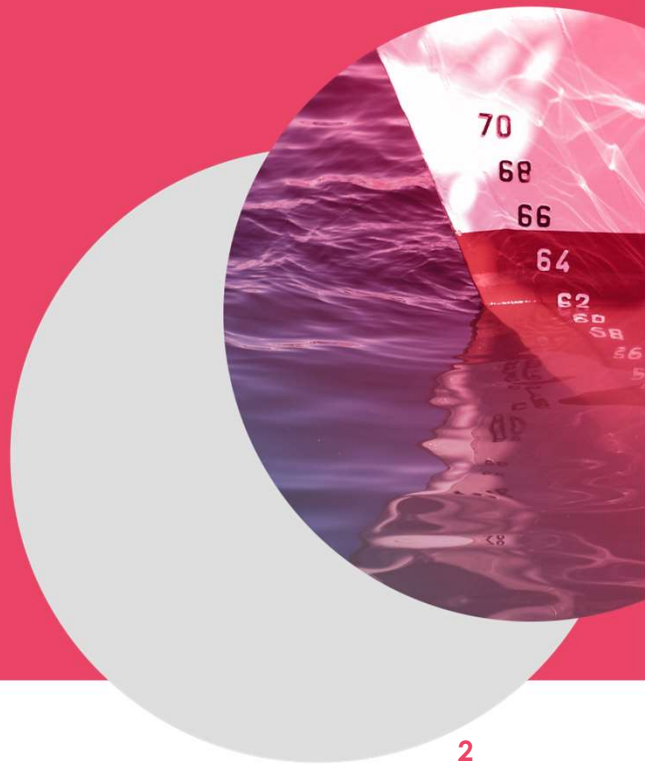


ECCLIPSE project

General overview

The objective of ECCLIPSE is to develop a **common framework for assessing the impacts associated with climate change** and the adaptation to such impacts of ports in the SUDOE space.

Port Resilience. Need for an adaptation strategy

An appropriate and effective climate change adaptation strategy will:

- Reduce the incidence of **structural damage or failure**;
- Reduce **downtime, disruptions and operational delays**;
- Prevent **damage to personnel, equipment and/or the environment**.

Port and waterway managers must act urgently to strengthen resilience and adapt critical assets, operations and systems.

Vessels aground. El Saler

Vessel aground. Algeciras

Need for an adaptation strategy

- 2019, the World Economic Forum's Global Risks report identified the lack of climate change adaptation strategies as one of the most serious short- and medium-term threats to be addressed globally.
- The United Nations Conference on Trade and Development [UNCTAD, 2018] specifically highlighted the urgent need for ports to adapt, along with vital connecting transport infrastructure and global supply chain networks, if significant trade disruption is to be avoided.
- In 2018, the European Joint Research Centre [JRC, 2018] published two studies highlighting an unprecedented risk of coastal flooding unless urgent climate change adaptation measures are taken.

ECCLIPSE project
General overview

Climate change

3 CASES OF STUDY

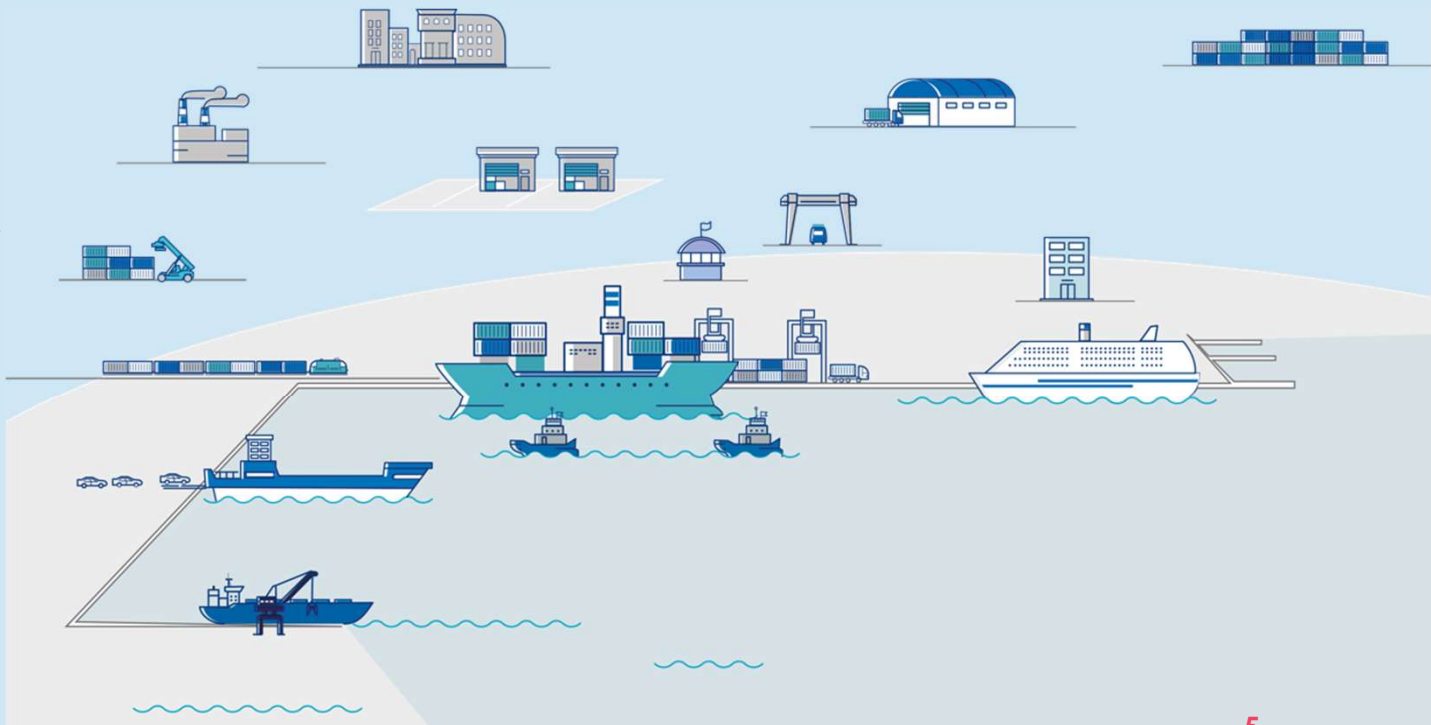
CLIMATE AREA			CRITICAL PARAMETERS
Mediterranean	Port of Valencia	Large European Port	· Heat waves · Extreme rainfall · Storm surges · Seawater temperature
Atlantic	Port of Aveiro	Influence of Estuary	· Currents · Wave Height
Golf of Gascogne	Port of Bordeaux	Inland Port-Estuary	· Submergence · Lower Upstream Flow · Heat Waves · Salinity

Start date:01/10/2019
End date: 30/4/2023

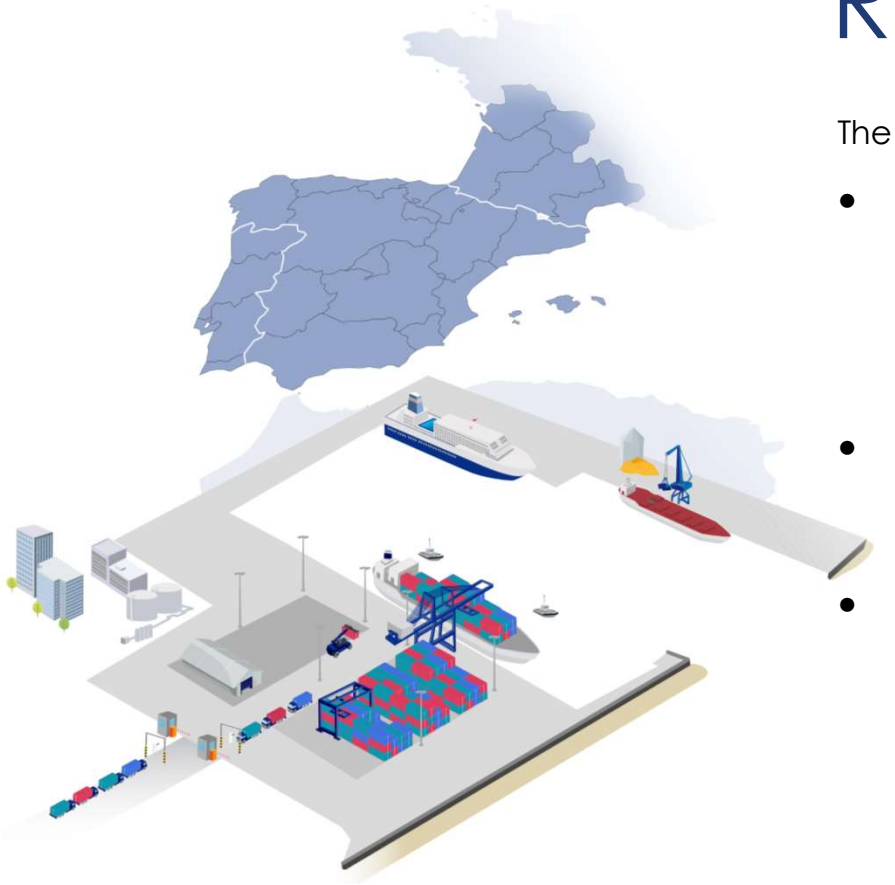
Climate change

Ports are crucial to a national economy, and their importance will increase due to the expected rise in international trade. However, ports are also susceptible to the effects of climate change, including variations in waves, sea level rise, and heatwaves. Consequently, ports face a common challenge of adapting to these climate change impacts to avoid disruptions in their operations. Considering the prevalent just-in-time production models, the closure, whether total or partial, of ports would significantly affect industries and freight distribution centres.

Therefore, it is essential for ports to implement effective climate change adaptation strategies. Such strategies require tools that provide a comprehensive understanding of the localised impacts of climate change. Current models, which are global in nature and cover extensive timeframes, are insufficient for effective decision-making.



Climate change

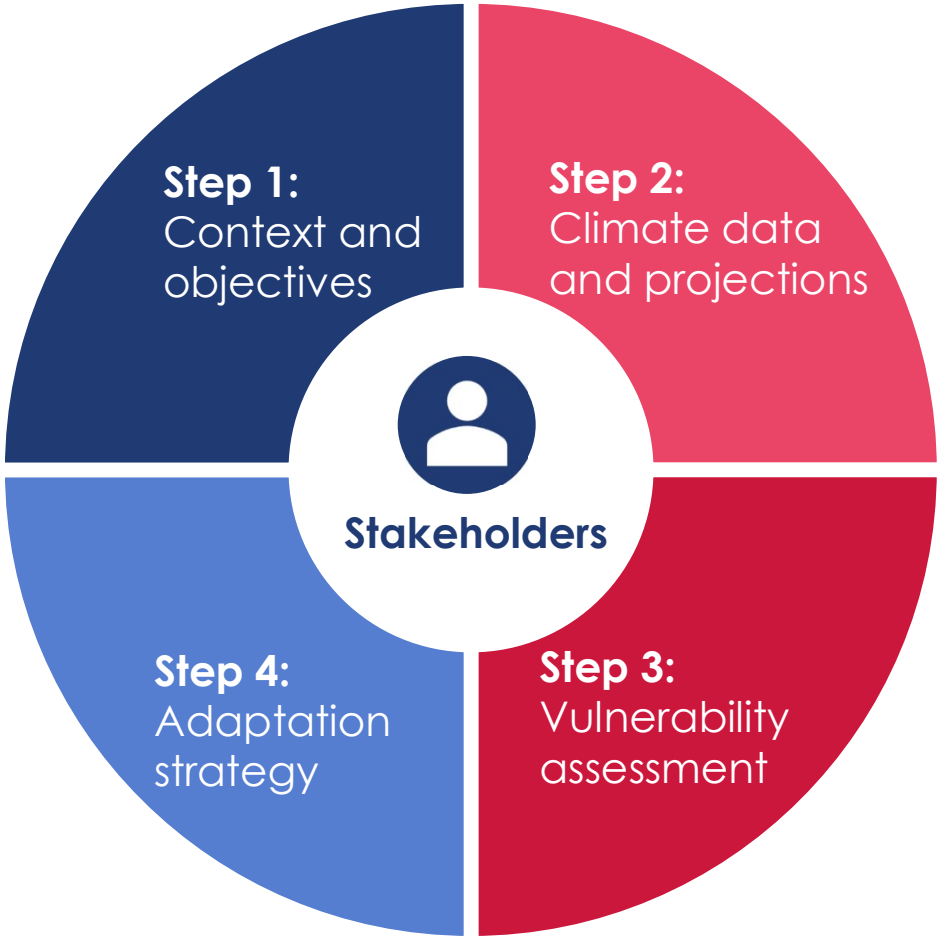


Results

The main project results are:

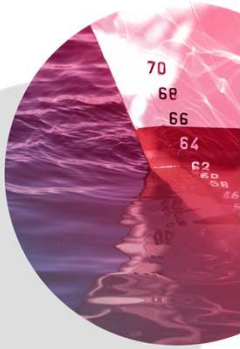
- The development and implementation of a **common methodology** make it possible to assure the consistency of the results to be obtained for each port by using the **same scientific and technical criteria** so that the conclusions drawn for the entire port network are consistent. This also makes it easier to extend the application to other European ports.
- ECCLIPSE provides the **mechanisms for designing and implementing the measures to adapt ports** to climate change. These measures have a common scientific basis for the whole European port network.
- Finally, the results of the **climate projections are stored in a climate database/observatory by port**, which will allow the study of the evolution of the climate change impact in specific locations when planning and designing new port infrastructures.

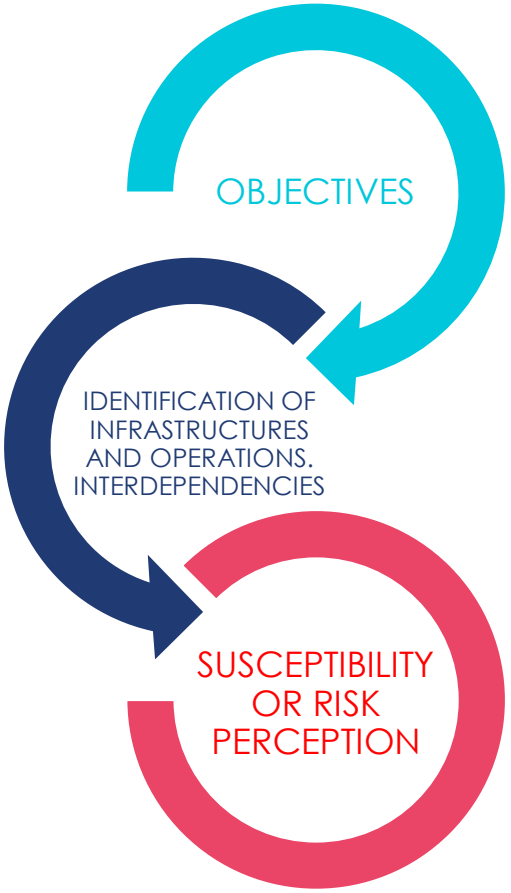
Methodology



Step 1: Context and objectives

Port of Valencia: Make the port fully resilient to the impacts of climate change by 2025 and ensure that it remains one of the safest port cities in the world





- High level objectives
- Medium long term

- Identification of port infrastructures
- Identification of all port operations
- Responsible for each of the infrastructures and operations
- Interdependencies between them

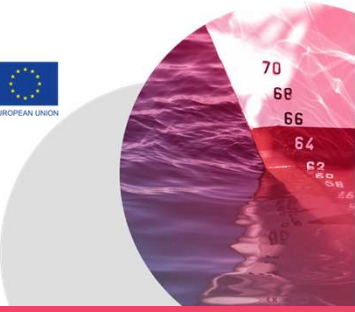
- Criticality: their disruption or destruction would have a significant adverse impact on the continued operation of the port.
- Which critical infrastructure and operations will be most affected by climate change?

ADAPTATION TO THE CLIMATE CHANGE

Critical infrastructure and/or operations can be affected by structural, mechanical or electrical failures, natural disasters or emergencies, or human error.

- **For what period of time** will port or shipping activity or business continuity be affected as a result of an extreme weather event (e.g. hurricanes)?
- **Health and safety** consequences (e.g. due to heat waves)
- **Strategic implications** (e.g. for the regional or national economy or for aid distribution, either directly or due to interdependencies or network/supply chain connectivity problems)
- Operation of **emergency services**
- **Social, socio-economic or environmental consequences** resulting from the interruption of port operations.

Step 2: Climate data and projections



Impact of climate events in business?

Stakeholders

Operations

Infrastructures

Climate variable projections

Steps to perform an evaluation of possible impacts of future climate on ports

Identify sensible assets and activities that can be impacted by metocean related processes

a.Operation window
b.Downtime
c.Structural suitability/Design criteria

Identify the relevant metocean variables

- Operation window

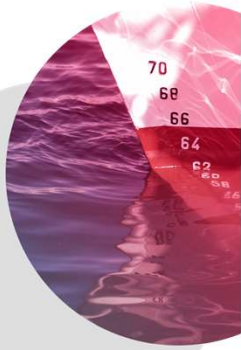
Determine the degree of complexity of the information needed to be analysed for each process

- Strong background on the meteorological and hydrodynamics of the region

The type of analysis to be performed depends on the process itself and to the type of asset/activity it is impacting upon

a.Port operations: Operational threshold:
i.Frequency of occurrence of events above threshold.
ii.Time scale (duration) of the events.
b.Port infrastructures: Extreme wave analysis. Mean and extreme values tend are significant for infrastructural purposes.
i.An increase on the expected extreme waves in the future due to climate change may result on changes in the design of new structures as well as an adaptation of the existing ones.

Step 2: Climate data and projections



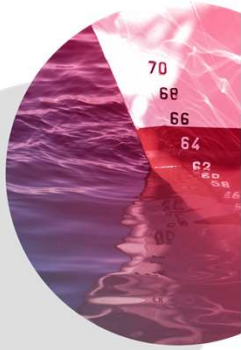
Main hazards that can affect the different ports are the following ones:
Relationship between hazard and climate parameters

Hazard	Sea level rise	Storm surge	Currents	Waves	Wind	Precipitation	Fog	Air temp
Overwhelmed drainage systems	X	X				X		
Flooding	X	X				X		
Wave overtopping	X	X		X	X			
High current velocities	X			X	X			
Changes in bathymetry	X		X	X				
Reduced visibility							X	X
Port agitation				X				
Ship manoeuvres				X	X			
Changes in wind speed/direction					X			
Heat/Cold waves								X
Damages in infrastructures	X	X	X	X	X	X		

MDJM0

Diapositiva 11

MDJM0 Esta es la relación entre cada impacto y la variable climática que lo causa
Mercedes De Juan Muñoyerro; 2023-01-30T09:09:15.076



Step 2: Climate data and projections

PORT	CLIMATE VARIABLE	WORKING PROJECTIONS FOR ADAPTION PLANNING
VALENCIA	Temperature	+4,5 °C in 2100 (RCP 8,5)- Temp Max
		+6 °C in 2100 (RCP 8,5)- Temp Max in summer
	Heat Wave	+ 5ºC in 2100 (RCP 8,5) , max. 3-4 heatwaves per year;
	Precipitation (RP100)	Historical- 160 mm ; 300 mm in 2040; 360 mm in 2070 and 335 mm in 2100
	Fog	- (10%-20%) for the period 2040-2060 and - (15%-25%) for the period 2080-2100)
	Wind and wind gust	Steady
	Sea Level	+0,29 cm in 2050 (RCP 8,5) and +0,39 cm in 2100 (RCP 4,5)
	Total sea level (RP100)	+0,91 cm in 2050 (RCP 8,5) and +1,00 cm in 2100 (RCP 4,5)
	Significant wave heigh	-9% for the annual average. Decrease concentrated in autumn-winter (-20%).
	Wave direction	Small variation in the direction of origin of the swell, turning a little to the south, although no substantial change is observed
	Storm surges	- (31%-18%) for the period 2040-2060 and - (29%-24%) for the period 2080-2100)
		Less storms with higher energy and more duration
	Port Closures	- (12%-41%) for the period 2040-2060 and - (18%-23%) for the period 2080-2100)

RCP .Representative Concentration Pathway
RP. Return period

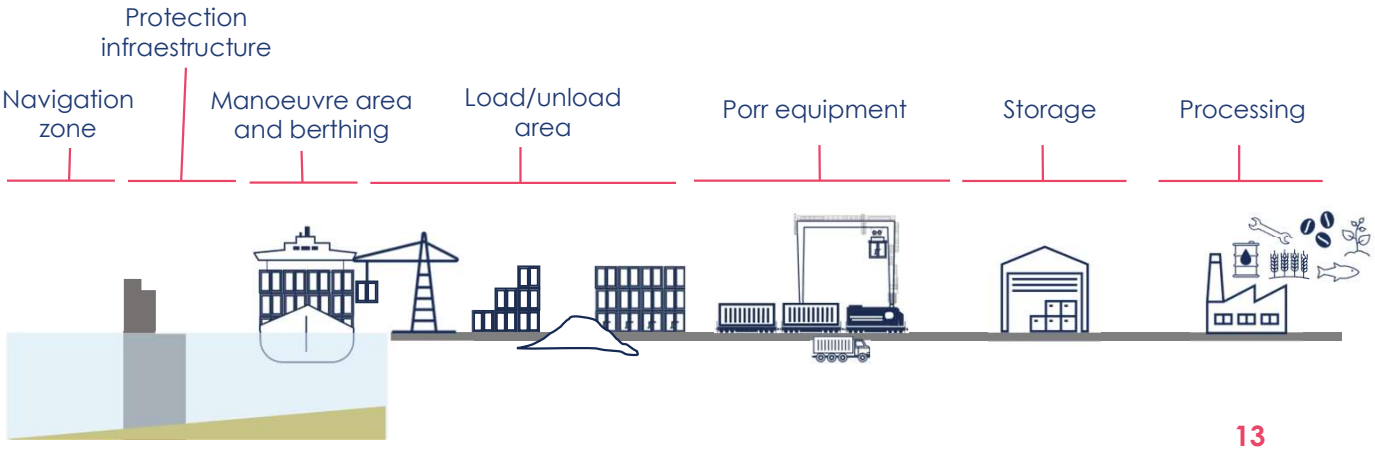
Step 3: Vulnerability assessment

Once we know how climate change will affect the climatic variables that affect each port, then it is time to see how the evolution of these variables affects port infrastructures and operations. To this end, surveys have been carried out in the port community asking how these variables have affected them in the past.

The analysis has been carried out considering four main areas:

- Approach of the ship to port
- Maneuvering area
- Loading and unloading area
- Storage area

The most critical vulnerabilities have been determined on the basis of a risk analysis, which has quantified the sensitivity (economic, social, environmental and reputational impact caused by climate change) and the likelihood of a given climate event occurring more frequently.



Diapositiva 13

MDJM0 Una vez que sabes como va a afectar el cambio climático a las variables climáticas que afectan a cada puerto (unas mejoraran, otras empeoraran y otras se quedaran como están) entonces es el momento de ver como afecta la evolución de esas variables a las infraestructuras y operaciones portuarias. Para ello se han realizado encuestas a la comunidad portuaria preguntando como se han visto afectado en el pasado

Mercedes De Juan Muñoyerro; 2023-01-30T09:18:39.901

Step 3: Vulnerability assessment

CLIMATE VARIABLE	HAZARD	LEVEL	PORT AREA	CASCADE EFFECT
HEAT WAVES/EXTREME TEMPERATURES	Decrease efficiency of electrical and electronic systems	Operations/Infrastructures	Energy supply Container terminals	Energy black-out
			Harbour Master	Port call application and port state control inspection
	Electrical and thermal engines need to increase the refrigeration. Cooling systems upgraded	Operations/Infrastructures	Container terminals Dry bulk terminals	
	Increase of the energy consumption (air conditioning, reefers)	Operations/Infrastructures	Whole port Container terminals Refrigerated cargo Buildings	Energy black-out
	Health problems	Operations	Outdoor port staff Passenger terminals	Low productivity and increase of sick leaves
	Port closed to navigation for waterplanes operation in wild fires	Operations	Whole port Port sheltered waters	
	Worsening of passenger comfort	Operations	Passenger terminals	Passenger complains
	Handling and storage of dangerous goods	Operations	Container terminals Ro-ro terminals Liquid bulk terminals	
	Low visibility Aids to Navigation due to the wildfires smoke	Operations	Port external waters	
	Increased bulk traffics as a consequence of crop failures.	Operations	Dry bulk terminals	

Diapositiva 14

MDJM0 Ejemplo, para Valencia, para las olas de calor

Mercedes De Juan Muñoyerro; 2023-01-30T09:41:16.224

Step 3: Vulnerability assessment · Risk assessment

Sensitivity	Impact			
	Death and Injury	Economic	Environmental	Reputation
Low (1)	Low level short term subjective inconvenience or symptoms. No measurable physical effects. No medical treatment.	No shutdown, costs less than €1,000 to repair	No lasting effect. Low-level impacts on biological or physical environment. Limited damage to minimal area of low significance.	Public concern restricted to local complaints. Ongoing scrutiny/ attention from regulator.
Minor (2)	Objective but reversible disability/ impairment and/or medical treatment injuries requiring hospitalization.	No shutdown, costs less than €10,000 to repair.	Minor effects on biological or physical environment. Minor short-term damage to small area of limited significance.	• Minor, adverse local public or media attention and complaints. Significant hardship from regulator. Reputation is adversely affected with a small number of site focused people.
Moderate (3)	Moderate irreversible disability or impairment (< 30%) to one or more persons.	Operations shutdown, loss of day rate for 1-7 days and/or repair costs of up to €100,000.	Moderate effects on biological or physical environment but not affecting ecosystem function. Moderate short-medium term widespread impacts (e.g., oil spill causing impacts on shoreline).	Attention from media and/or heightened concern by local community. Criticism by Non-Governmental Organizations (NGO). Significant difficulties in gaining approvals. Environmental credentials moderately affected.
Major (4)	Single fatality and/or severe irreversible disability or impairment (> 30%) to one or more persons.	Operations shutdown, loss of day rate for 7-28 days and/or repair costs of up to €1,000,000.	Serious environmental effects with some impairment of ecosystem function (e.g., displacement of species) Relatively widespread medium-long term impacts.	Significant adverse national media/ public/NGO attention. May lose license to operate or not gain approval. Environment/ management credentials are significantly tarnished.
Critical (5)	Short or long term health effects leading to multiple fatalities, or significant irreversible health effects to > 50 persons.	Operations shutdown, loss of day rate for more than 28 days and/or repair costs more than €1,000,000.	Very serious effects with impairment of ecosystem function. Long-term widespread effects on significant environment (e.g., unique habitat, National Park).	Serious public or media outcry (international coverage). Damaging NGO campaign. License to operate threatened. Reputation severely tarnished. Share price may be affected.

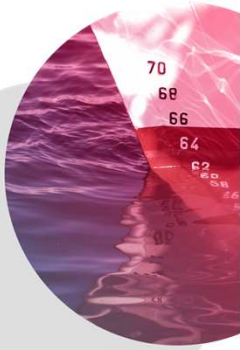
Source: Own elaboration based on American Bureau of Shipping guidelines

Step 3: Vulnerability assessment · Risk assessment

Qualitative description of likelihood	Likelihood rating	
It is **expected that** the climate hazard will occur, that the threshold will be exceeded or there will be another significant impact within the adaptation planning horizon under all climate change scenarios investigated. The effect of climate hazard will increase by 200-500% compared to today	Almost certain	5
It is **likely that** the climate hazard will occur, the threshold will be exceeded or there will be another significant impact within the adaptation planning horizon under some of the climate change scenarios investigated. The effect of climate hazard will increase by 100-200% compared to today.	Likely	4
The climate hazard **may** occur, or the threshold may be exceeded or there may be another significant impact within the adaptation planning horizon under some of the climate change scenarios investigated. The effect of climate hazard will increase by 50-100% compared to today.	Possible	3
The climate hazard **could** occur, or the threshold could be exceeded or there could be another impact within the adaptation planning horizon under one or more of the climate change scenarios investigated. The effect of climate hazard will increase by 20-50% compared to today.	Unlikely	2
The climate hazard (or the exceedance of the threshold or the manifestation of an impact) is **not expected** to occur other than in exceptional circumstances within the adaptation planning horizon under most of the climate change scenarios investigated. The effect of climate hazard will increase by 0-20% compared to today.	Rare	1

Source: Adapted by partners from PIANC. (2020) "Climate change adaptation planning for ports and inland waterways"

Step 3: Vulnerability assessment · Risk assessment



Likelihood → Impact ↓	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost Certain (5)
Catastrophic (5)	5	10	15	20	25
Major (4)	4	8	12	16	20
Moderate (3)	3	6	9	12	15
Minor (2)	2	4	6	8	10
Insignificant (1)	1	2	3	4	5

Source: PIANC. (2020) "Climate change adaptation planning for ports and inland waterways"

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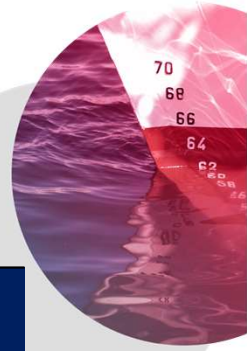


Step 3: Vulnerability assessment · Risk assessment

Climate Variable	Hazard	Sensibility	Likelihood (2040-2060)		Likelihood (2080-2100)		Risk (2040-2060)		Risk (2080-2100)	
			RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
HEAT WAVES/EXTREME TEMPERATURES	Decrease efficiency of electrical and electronic systems	2	3	5	3	5				
	Electrical and thermal engines need to increase the refrigeration. Cooling systems upgraded	4	3	5	3	5				
	Increase of the energy consumption (air conditioning, reefers)	4	3	5	3	5				
	Health problems	3	3	5	3	5				
	Port closed to navigation for waterplanes operation in wild fires	3	3	5	3	5				
	Worsening of passenger comfort	1	3	5	3	5				
	Handling and storage of dangerous goods	5	3	5	3	5				
	Low visibility Aids to Navigation due to the wildfires smoke	3	3	5	3	5				
	Increased bulk traffics as a consequence of crop failures.	5	3	5	3	5				

Diapositiva 18

MDJM0 Finalmente, para cada variable climática se hace un análisis de riesgo para ver cuales son lois impactos mas críticos. En este análisis de riesgos se cruza la sensibilidad (el impacto económico, social, ambiental y en la reputación del puerto que causaría cada riesgo climático) con la probabilidad de que la variable climática aumente en cada escenario climático.

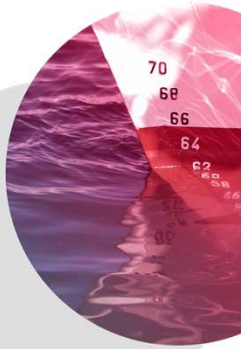
Mercedes De Juan Muñoyerro; 2023-01-30T09:51:42.210

ECCLIPSE

OPPORTUNITIES

VULNERABILITIES

Step 3: Vulnerability assessment

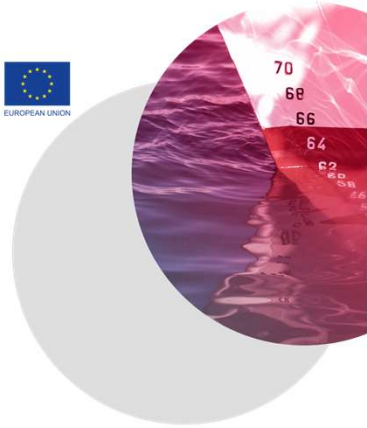


Climate risk	Vulnerabilities	Opportunities
Rise in temperatures, increase in the number of heat waves and their duration. (Valencia, Sagunto y Gandía)	• Reduced efficiency of electrical and electronic equipment. • Adaptation of equipment cooling systems. • Increased energy consumption • Handling of certain hazardous goods • Health problems and increased sick leave. • Closure of the port as a consequence of increased fires ➡ Waterplanes • Poor visibility of navigational aids due to smoke from fires.	• Increase in cereal imports as a result of increased droughts. • Extension of the cruise season

Step 3: Vulnerability assessment

Climate risk	Vulnerabilities	Opportunities
Extreme rainfall (Valencia)	• Flooding of the traffic circle and the underpass providing access to the east dock, cruise ships, etc. • Damage to cargo. Increased insurance costs • Operations slowed down or stopped due to low visibility • Increased traffic accidents • Low visibility aids to navigation • Leakage in the bulk unloading conveyor pit	
Increase of sea surface water temperature	• Adaptation of seawater cooling systems • Increase in water turbidity and fouling	
Decreased wave height and port agitation.	• Crane shutdown due to pantograph flooding • Damage to the breakwater (Gandía) • Breakage of ropes in the Marina Real	
Effects of storms		• Fewer stops per year, but of longer duration • Positive net balance of cruise ship calls

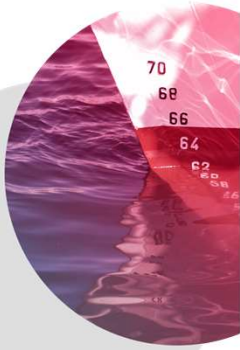
Step 4: Adaptation strategy



The adaptation strategy must meet the following requirements:

- All **adaptation objectives that were initially set out are met,** including the criteria relating to the acceptable level of residual risk.
- There is **no internal incompatibility with other transport infrastructures** or with each other, and
- All **internal and external interdependencies between port and third-party** infrastructure, operations and systems have been addressed.
- The adaptation strategy will consist of **a set of measures aimed at ensuring the port's resilience** to the effects of climate change. These measures must be accompanied by **an adaptation pathway**, which is the point at which a particular measure should be implemented.

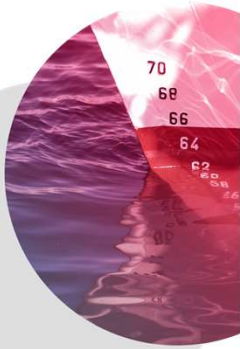
Step 4: Adaptation strategy



Riesgo climático	Medida	Condiciones que desencadenan la acción
Reducción de la eficiencia de los equipos eléctricos y electrónicos.	Monitorizar la evolución de este impacto	< 1 año
	Mejorar los sistemas de refrigeración	En función de la evolución que muestre la monitorización
Pérdida de eficiencia de los equipos de manipulación de mercancías como consecuencia del sobrecalentamiento de los motores.	Monitorizar la evolución de este impacto	< 1 año
	Adaptar los sistemas de refrigeración de los equipos	En función de la evolución que muestre la monitorización

Source: Estrategia de adaptación del Puerto de Valencia frente a los efectos del cambio climático

Step 4: Adaptation strategy



The main objective of the monitoring system is to have data available to assess the impacts of climate change. In this sense, the system must fulfil three fundamental objectives:

1. To **validate the models for predicting the impacts of climate change**. On the one hand, these models have an associated uncertainty in the results, which must be limited by the observations recorded over long periods of time. On the other hand, the predictions have been made under two climate scenarios (RCP4.5 and RCP 8.5). The RCP 4.5 scenario can be considered as the most optimistic of the possible scenarios, while RCP 8.5 is the catastrophic scenario. The data to be collected by the monitoring system will provide information on how **the climate is actually evolving and which projections are the most appropriate**.
2. Traditionally, port infrastructures have been designed taking into account past climate events. As the climate is changing, new **infrastructures and port equipment specifications must be dimensioned for the future climate**. Monitoring provides current data to adjust models for future climate.
3. The tool will also support decision making, in particular **when to undertake the adaptation measures listed in the pathway** described. The climate variables affecting each terminal and port activity have been identified. When an event occurs that stops port operations or causes significant damage to both assets and people, the system will collect these variables for a subsequent analysis of the causes and link them to the climatic variables at the time. In this way, real data will be available both on the evolution of the variables and the impact they have had on port infrastructures and operations.

Step 4: Adaptation strategy · Observatory

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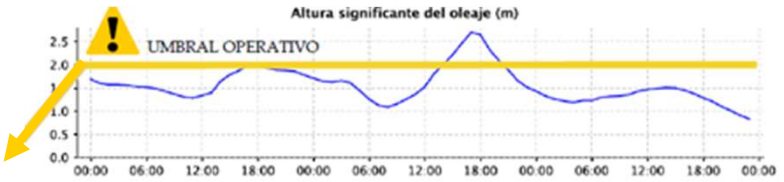
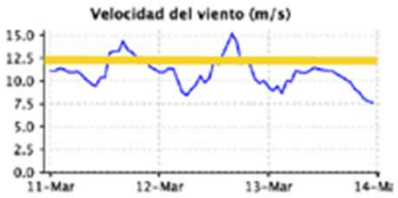


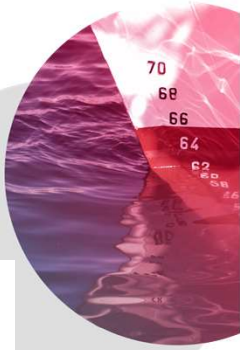


Diapositiva 25

MDJM0 En nuestro caso es muy aventurado realizar una estrategia de adaptación con el esquema que propone PIANC. Por eso se ha decidido monitorizar. Se desarrollará un modulo adicional que formara parte del CMA de SAMOA. Esta por definir, cada terminal reportará un cierre y el sistema recogerá las variables climáticas que hay en ese momento de cierre, para poder analizarla la causa del cierre después. Nos dará información de como van evolucionando las paradas operativas y las vulnerabilidades. Esta información se usará para definir las variables de diseño de las nuevas infraestructuras, y para decidir cuando deben implementarse las medidas de adaptación. ESTA PARTE TODAVIA ESTA EN DESARROLLO

Mercedes De Juan Muñoyerro; 2023-01-30T10:06:25.776

Step 4: Adaptation strategy · Risk indicators



The **adaptation pathway is based on the evolution of risk indicators**. Specific risk indicators have been defined for infrastructures and operations.

The impact of climate change in the port infrastructures is established according to the following indexes:

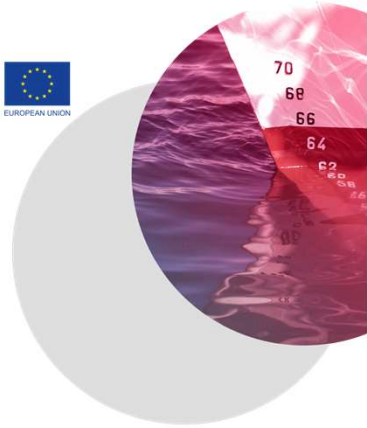
- **Economic Impact Index (EII):** quantitatively assesses the economic repercussions for reconstruction of the work and for the foreseeable cessation of or impact on the activities directly related to it, in the event of destruction or the loss of total operability of the same.
- **Social and Environmental Impact Index (SEII):** This is a qualitative estimate of the social and environmental impact to be expected in the event of the destruction or total loss of operation of the port/terminal, assessing the possibility and extent of: loss of human lives, damage to the environment and to the historical and artistic heritage, and social alarm generated, considering that the failure occurs once the economic activities directly related to the project have been consolidated.

The operational impact of climate change in the port/terminal is established on the basis of the following indexes:

- **Operational Economic Impact Index (OEII):** Quantitatively assesses the costs caused by the operational stoppage of the work section.
- **Operational Social and Environmental Impact Index (OSEII):** Qualitative estimate of the social and environmental impact to be expected in the event of an operational shutdown of the port/terminal operation, assessing the possibility and extent of loss of human lives, damage to the environment and historical and artistic heritage, and social alarm generated.

Conclusions

Monitoring the effect of climate change



1. It is not a proposed methodology but already **implemented in 5 ports.**
   - **Uncertainty and subjectivity** are reduced or even eliminated.
   - Sensitivity analysis. **Surveys.**
2. **Quantitative indicators are proposed** that consider not only economic impact but also social, environmental and reputational damage.
3. The analysis does not depend on users (e.g. terminals) to provide data.
4. The methodology is **applicable to any type of port** (size and type of goods).
5. It is very important to have a **Working Group** at the port that integrates stakeholders for:
   - **Initial identification of vulnerabilities**: port areas, infrastructures, operations, buildings, etc.
   - Initial **identification of risks** (events, climatic variables).
   - The **definition of thresholds** (stops) of the different variables.
   - **Sensitivity analysis**
6. Paradigm shift: **design of infrastructures with future climate not with historical series**.
7. It is necessary to **validate the models** used for projections.
8. The **implementation of a Climate Change Observatory** in ports will allow a better understanding of which **agents/phenomena affect the port** and what are the **thresholds** above which the impact is produced in the areas of climate vulnerability.
9. Climate projections and risk assessment should be **dynamic and updated periodically** or as climate scenarios are updated according to the IPCC.

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