PRACTICAL CLIMATE CHANGE ADAPTATION SOLUTIONS FOR PORTS

PEEL PORTS GROUP

BRITISH PORTS ASSOCIATION

UKMPG

Maritime UK

Agenda

Keynote presentation: Robin Mortimer, Chief Executive Officer, Port of London Authority, UK

Climate change challenges and adaptation experience from Europe and the Middle East

-Joaquim Cortés, Head of Air Quality, Port of Barcelona, Spain
-Marc Eisma, Environmental Management Advisor, Port of Rotterdam
-Piotr Konopka, Senior Manager, Energy & Decarbonisation Programmes, DP World, Dubai

Panel discussion

Short break

Adaptation in practice

-Captain Karuppiah Subramaniam, General Manager of Port Klang Authority, Malaysia; President, International Association of Ports and Harbors
-Marika Calfas, Chief Executive Officer, NSW Ports, Australia
-Regina Asariotis, Chief, Policy and Legislation Section, UNCTAD
-Jan Brooke, Marine Environment Advisor, Peel Ports Group; Chair PIANC Permanent Task Group on Climate Change

Panel discussion

Closing remarks

PORT OF LONDON AUTHORITY

Practical Climate Change Adaptation
London Experience

Robin Mortimer

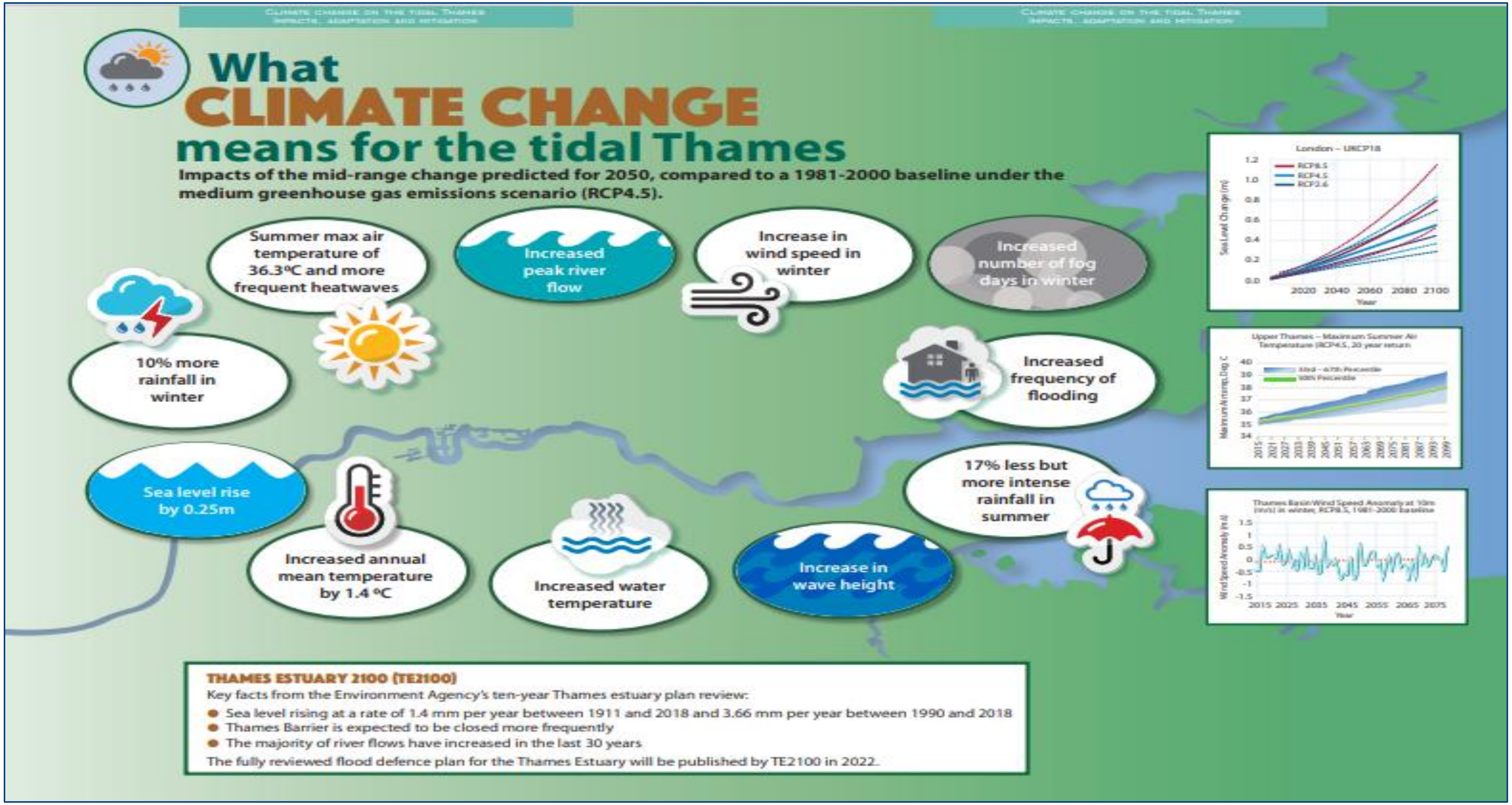
Key elements of Port of London Approach

- **Top Down Commitment**
  - Board level support
  - Organisation Wide Process
  - Adequate Resources and Analytical capability
  - Integrated into risk management systems, ISO standards, BAU

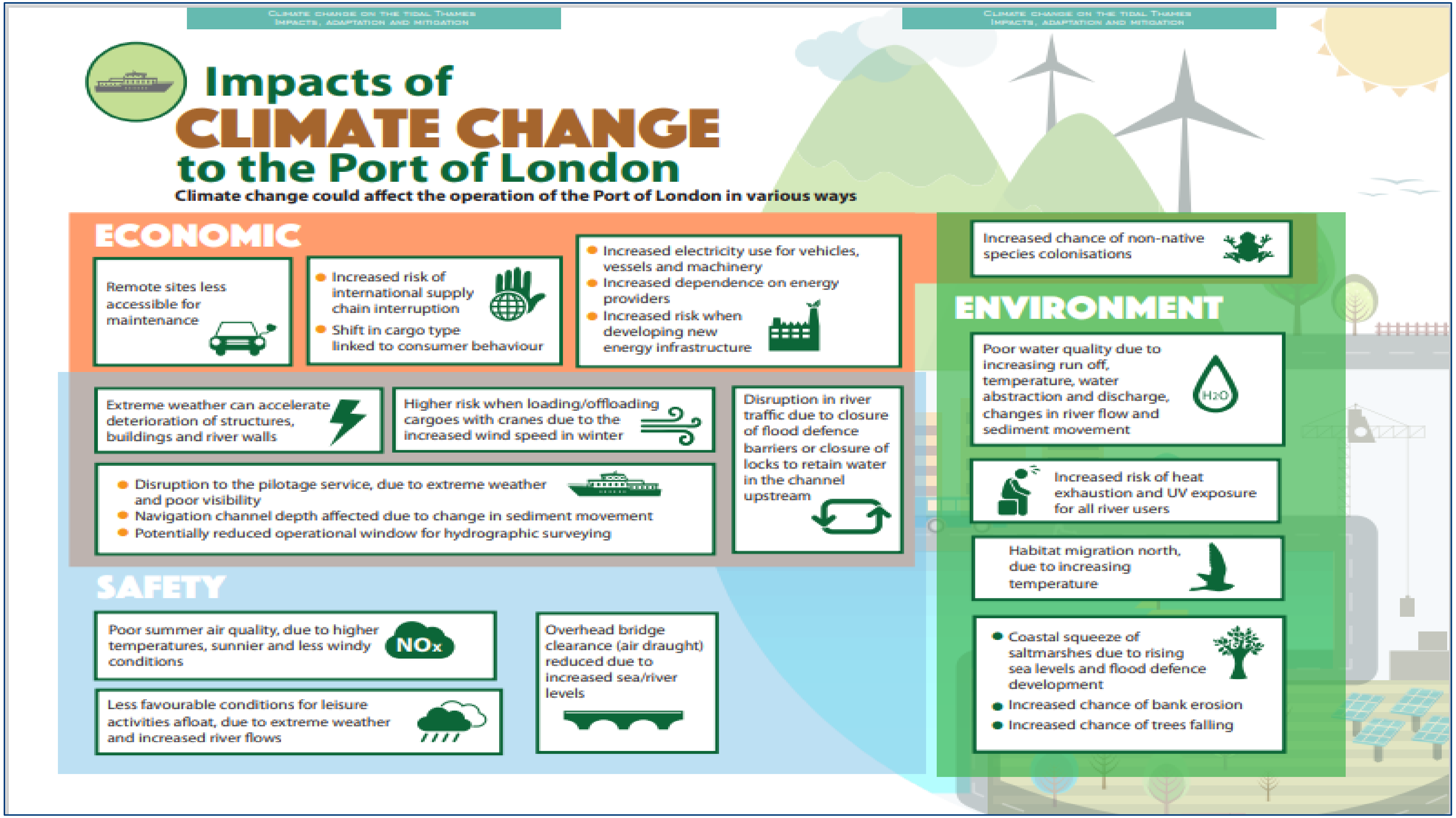
- **External Partnerships and Communication**
  - Environment Agency (Thames Estuary 2100)
  - Thames Resilience Forum
  - Integrated into wider stakeholder communications

PORT OF LONDON AUTHORITY

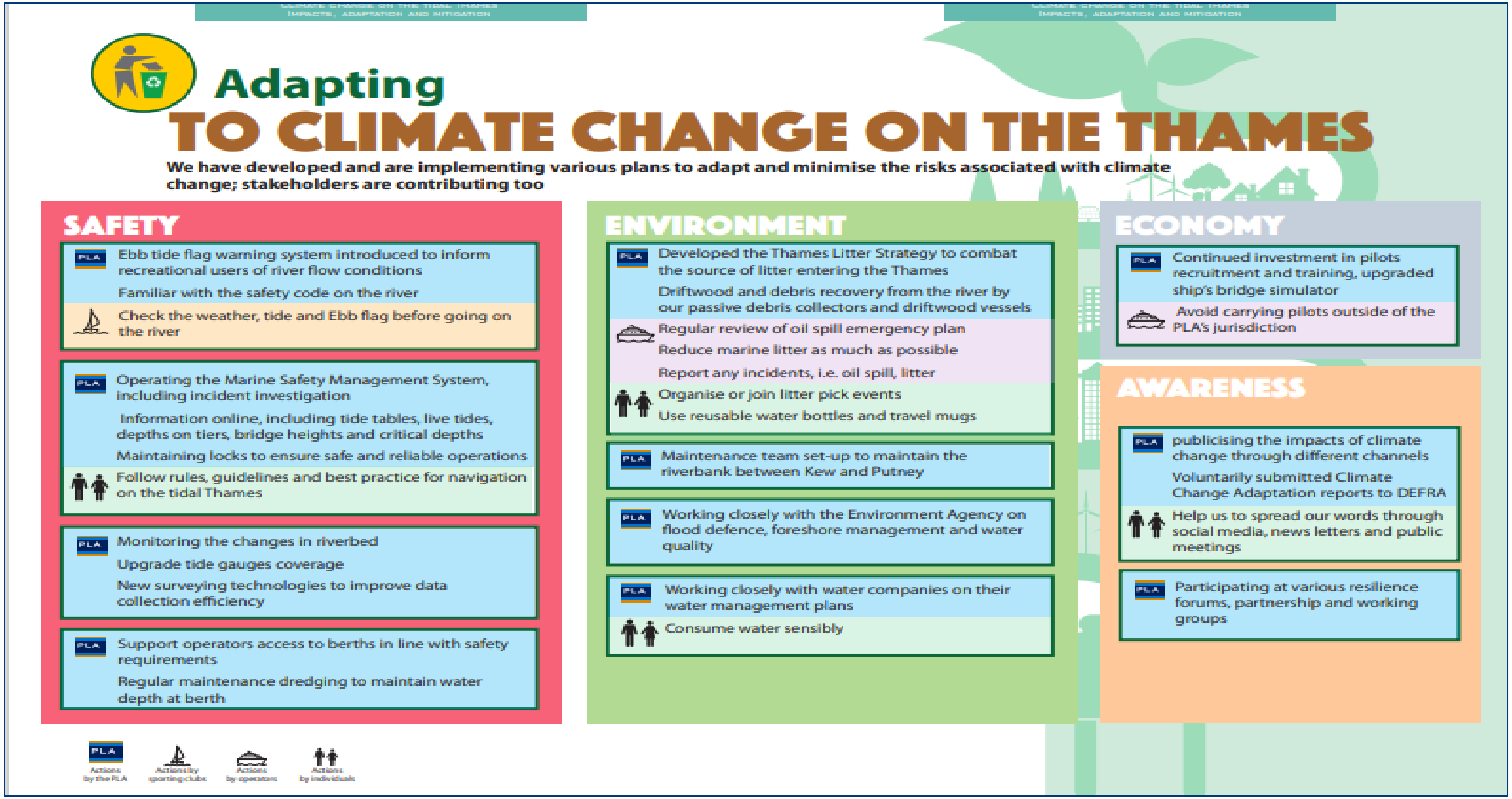
Step 1: Climate Analysis



Step 2: Impact and Risk Analysis



Step 3: Adaptation Plan - Actions Now & Adaptive Pathways



Climate Resilience – Low Winter Flows Over Teddington Weir

Climate Resilience – Usual Winter Flows Over Teddington Weir

PORT OF LONDON AUTHORITY

Climate Resilience – 10 February 2014…

Climate Resilience – Flag Warnings at Richmond Lock

Ports & National Adaptation Response

- **Ports need to be active in engaging with wider national resilience planning**

- **Thames Estuary 2100**

  Future Location of Thames barrier

  Development of Wider Estuary Flood Defences

- **Potential Port Impacts**

  Impact on shipping – size and number of vessels passing through barrier

  Impact on Berth Designs and cargo handling

  Economic costs and benefits

- **Work closely with Environment Agency…**

PORT OF LONDON AUTHORITY

Towards an emissions neutral port

Joaquim Cortes

Air Quality Manager
Environment Department

COP 26
Climate change challenges
and adaptation experience

Port de Barcelona

Overview

Port de Barcelona actions in relation to Climate Change:

Global: Reduction of causes of CC

Actions to reduce Green House Gas emissions of the logistic chain

Ports are key actors: opportunity to influence in all sectors of transport of goods and persons: maritime, road, rail

Local: Actions to minimize local effects of CC

Measures for Adaptation and Mitigation in the Port

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1. Decarbonization

Port of Barcelona Fourth Strategic Plan 2021-2025

Port Vision 2040

MISSION

TO GENERATE PROSPERITY IN OUR COMMUNITY, INCREASING THE COMPETITIVENESS OF OUR COSTUMERS BY PROVIDING EFFICIENT AND **SUSTAINABLE LOGISTICS** AND TRANSPORT SERVICES

VISION

SMART LOGISTICS HUB

The SMARTest logistics hub in the MED

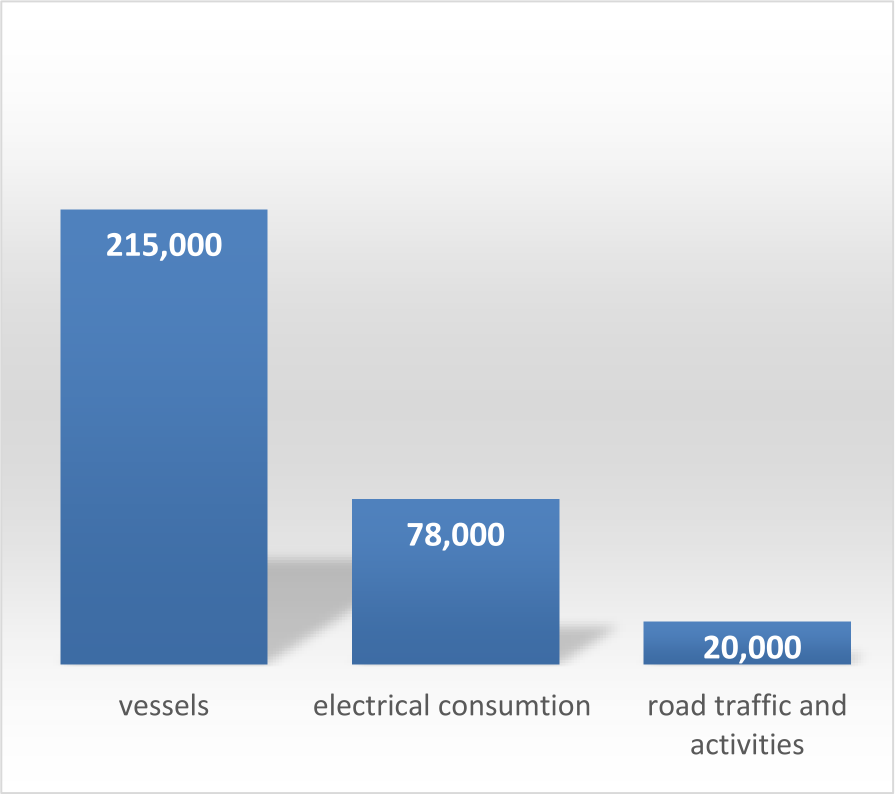
S	M	A	R	T
Sustainable	Multimodal	Agile	Resilient	Transparent

THE GENERAL STRATEGIC OBJECTIVE FOR 2025 CAN BE SUMMARISED IN THE FIGURES 70/50/40

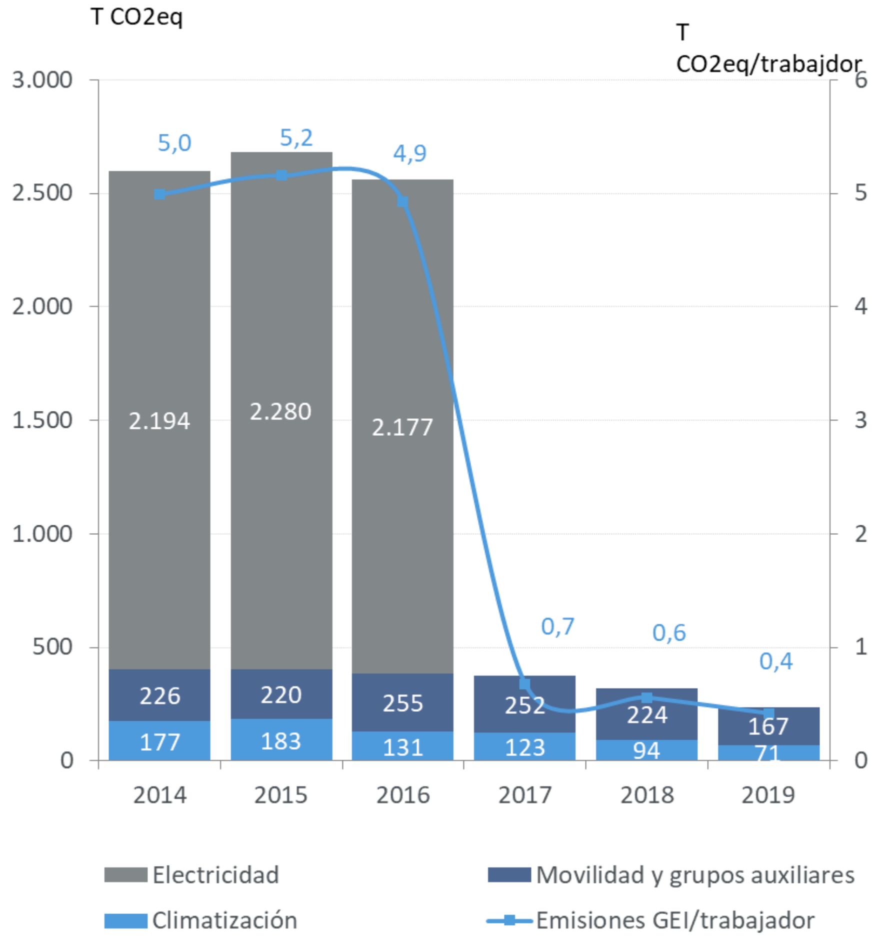
Economic sustainability	Environmental sustainability	Social sustainability
€70 billion in foreign trade value	50% electrified container and ro-ro wharves	40,000 people working at the Port

1. Decarbonization

GHG emissions from all the Port (in tons of CO2 eq)



GHG emissions of Port Authority (in tons of CO2 eq)



1. Decarbonization

Source: McKinnon (2019) 'Decarbonizing Logistics'

LOGISTICS:

10-11% Global GHG emissions

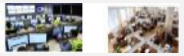
MARITIME TRANSPORT:

3% Global GHG emissions

Freight transport: 8%

Warehousing & terminals: 1-2%

Administration / IT:?



Port of Barcelona GHG emissions

Objective 2030: 50% reduction

Before 2050: Carbon-neutral port

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2. Energy transition

Strengthening of energy saving and efficiency

Promotion of renewable energies

Electricity consumption sharing and storage

Smart grid

2. Energy transition

Promotion of renewable energies

Potential of photovoltaic power generation on surfaces and roofs in the port area: 92 MWp installed and 120 GWh of annual electricity production

Currently: 4.6 MWp on warehouse roofs

2. Energy transition

Encourage shared consumption and storage: Energy Community Project at the Fisherman's Wharf (CREATORS Project. Funding by Program H2020)

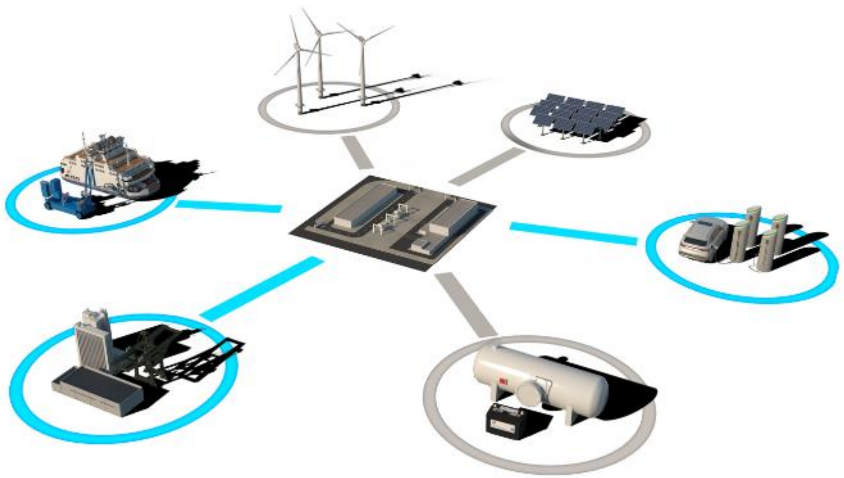
- 6 transformation stations
- Annual consumption of 682 MWh

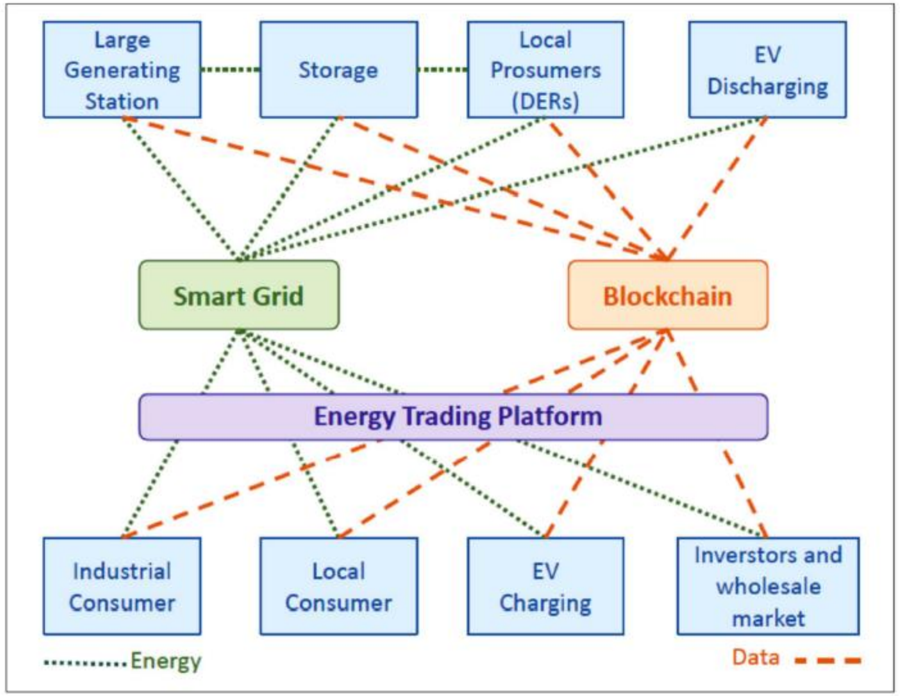
- 4 photovoltaic installations 967 kWp
- Batteries storage: 530 kWh
- 92% electricity saving
- Total investment: 1.22 M€

2. Energy transition

Smart grid

Future new demands and new energy sources require future management of the electricity grid. Technology must be smart to always optimize use to reduce the cost of kWh and ensure the most sustainable combination





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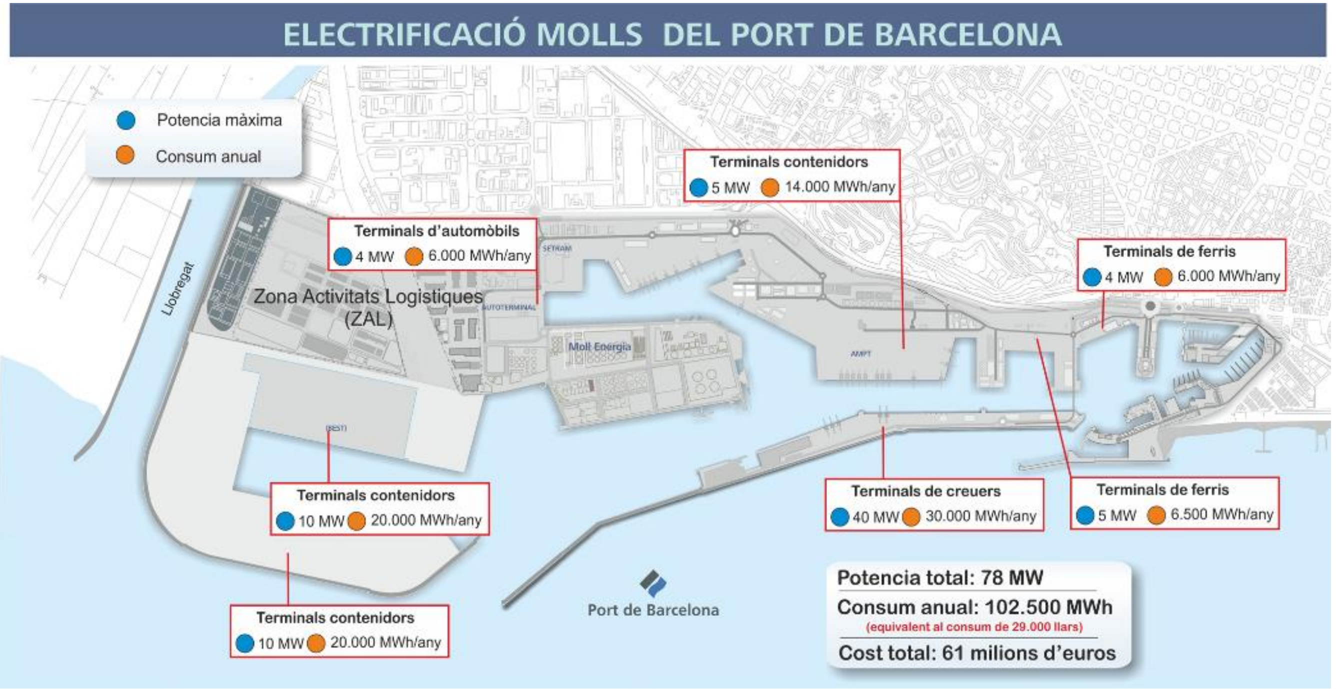
3. OPS

On-shore Power Supply (OPS) infrastructure requires 80 MW capacity for maximum peak demand.
Electricity must be provided from High Voltage general grid 220kV.



GEG emissions reduction: 60 Tons CO2eq

3. OPS

By 2030 there will be OPS infrastructure available at the main docks.

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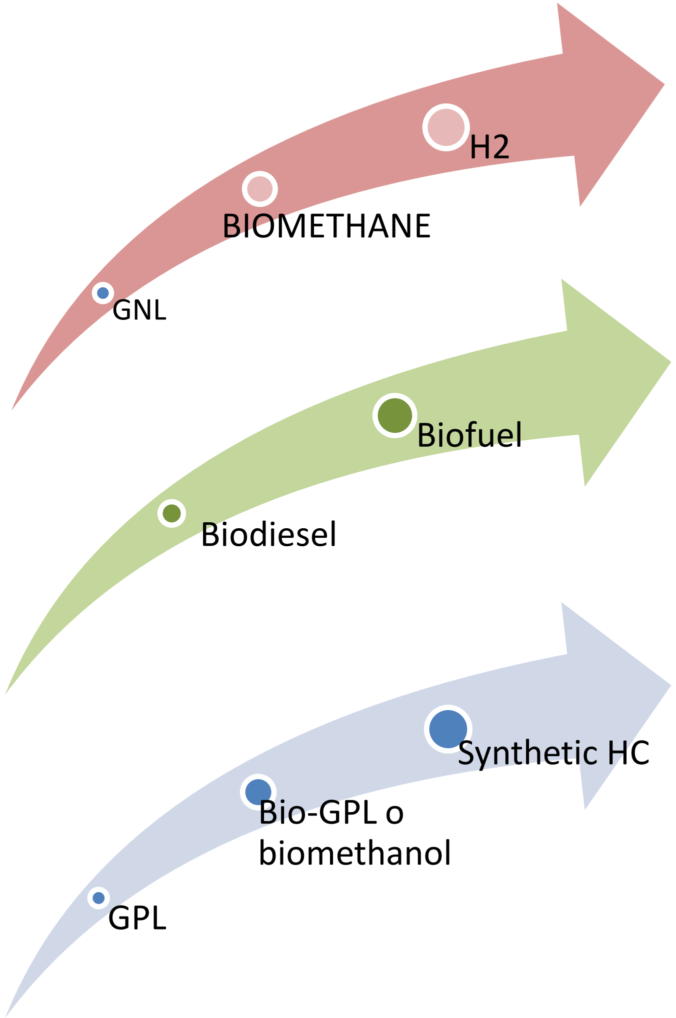
1. Decarbonization targets
2. Energy transition
3. OPS
4. **Promotion of new clean fuels**
5. Adaptation / mitigation

4. Promotion of new clean fuels



From natural gas to H2

From biodiesel to 2nd and 3rd generation biofuel

Of synthetic hydrocarbons

Vessel redesign due to lower energy per volume: Increased storage

Electric or diesel-electric drives

4. Promotion of new clean fuels

Ports are key on the path to new fuels because they are a crossing point for transport chains and modal shift.

In the future, various fuels for ships will coexist:

- OPS
- AMMONIUM, BIOMETHANOL AND H2
- BIOFUELS
- SYNTHETICS, BIOMETHANE

Supply infrastructure for various fuels

Generation of renewable energy to produce renewable fuels

Incentives program for ships and other transport modes

Regulation and control of supply operations

4. Promotion of new clean fuels

Project to accelerate the change towards a clean fuels economy

- Create demand. Demonstrations and pilots
- Securing the value chain: stable framework

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5. Adaptation / mitigation

Expected main effects of Climate Change at the Port of Barcelona

Severe Weather Events: More frequent and stronger

❖ **Winds: strong winds, storms**

- Stay at berth: Risk of damage of bollards and defenses

- Safety of navigation during maneuvering and mooring operations: risk of collision ship-dock or ship-ship

- Safety for loading-unloading operations in port terminals

5. Adaptation / mitigation

Expected main effects of Climate Change at the Port of Barcelona

Severe Weather Events: More frequent and stronger

- **Waves: Seawall overtopping. Sea Level Rise makes it worst.**

- Reduction of the availability of the infrastructure

- Risk of damage of buildings and equipment existing on dock

- Risk of damage of moored boats: yatch marina

5. Adaptation / mitigation

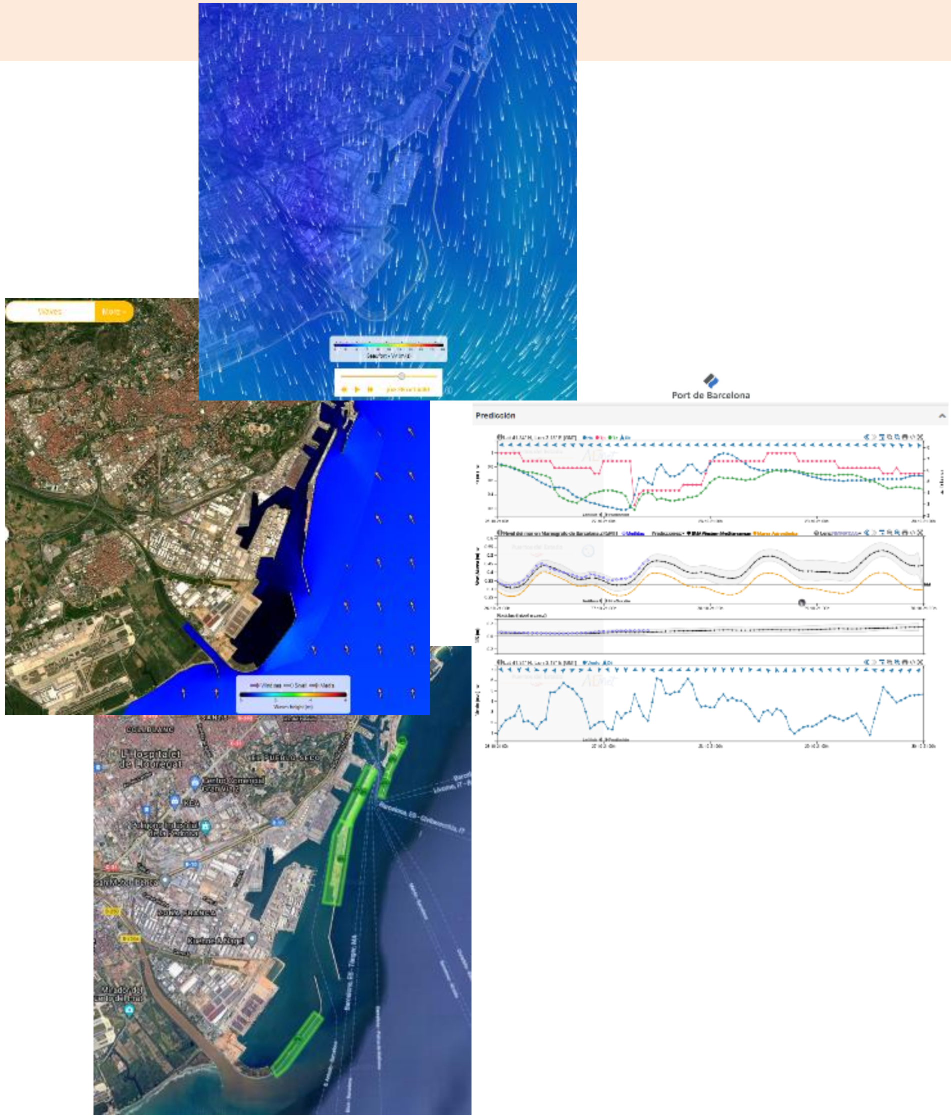
Port response:

- ❑ Information:

More accurate Weather Forecasts and communication to port managers, terminal operators, vessels

- 72h forecasts, run every 12hours
- Meteo HARMONIE model
- Waves WAM model
- Overtopping SAPO model: Verification of forecast with VI-IR cameras

- Early warning system, referenced to operational thresholds
- Planning of activities and operations



5. Adaptation / mitigation

Port response:

- ❑ Regulations on operative limits: for land and sea activities
- Revision of safety protocols:
  - Revision of decision taking criteria depending on activity: WiS, WiD, Hs, WaD
  - Update warning thresholds
  - Revision of operative conditions: p.ex. Number of tugs

- ❑ Strengthen the infrastructure:
  - Increase height of seawalls
  - Strengthen bollards

www.portdebarcelona.cat

Thanks for your attention!

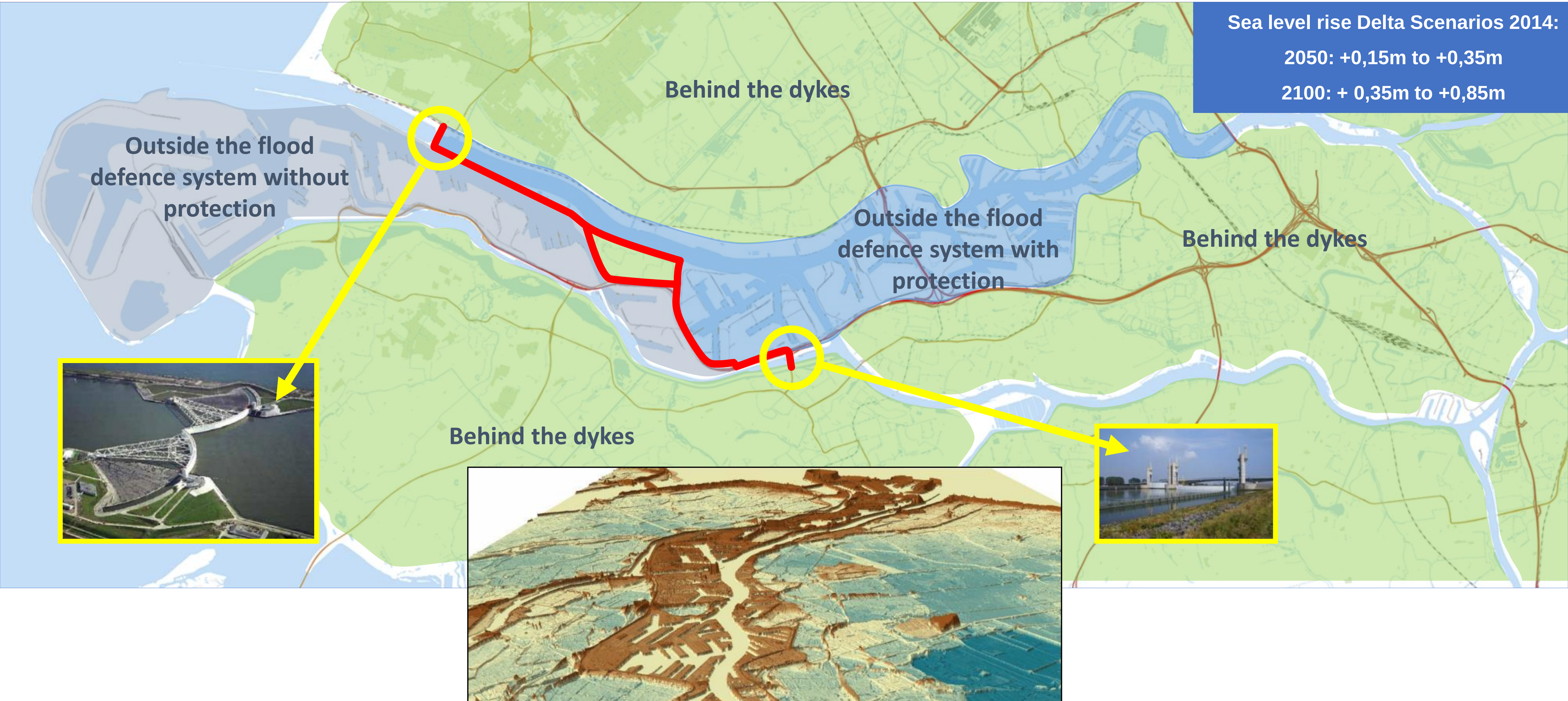
FLOOD RISK MANAGEMENT IN PARTNERSHIP

Marc Eisma

Practical Climate Change Adaptation Solutions for Ports, Glasgow, 2-3 November 2021

Port of Rotterdam at present climate proof

Port located outside the flood defence system, but RAISED

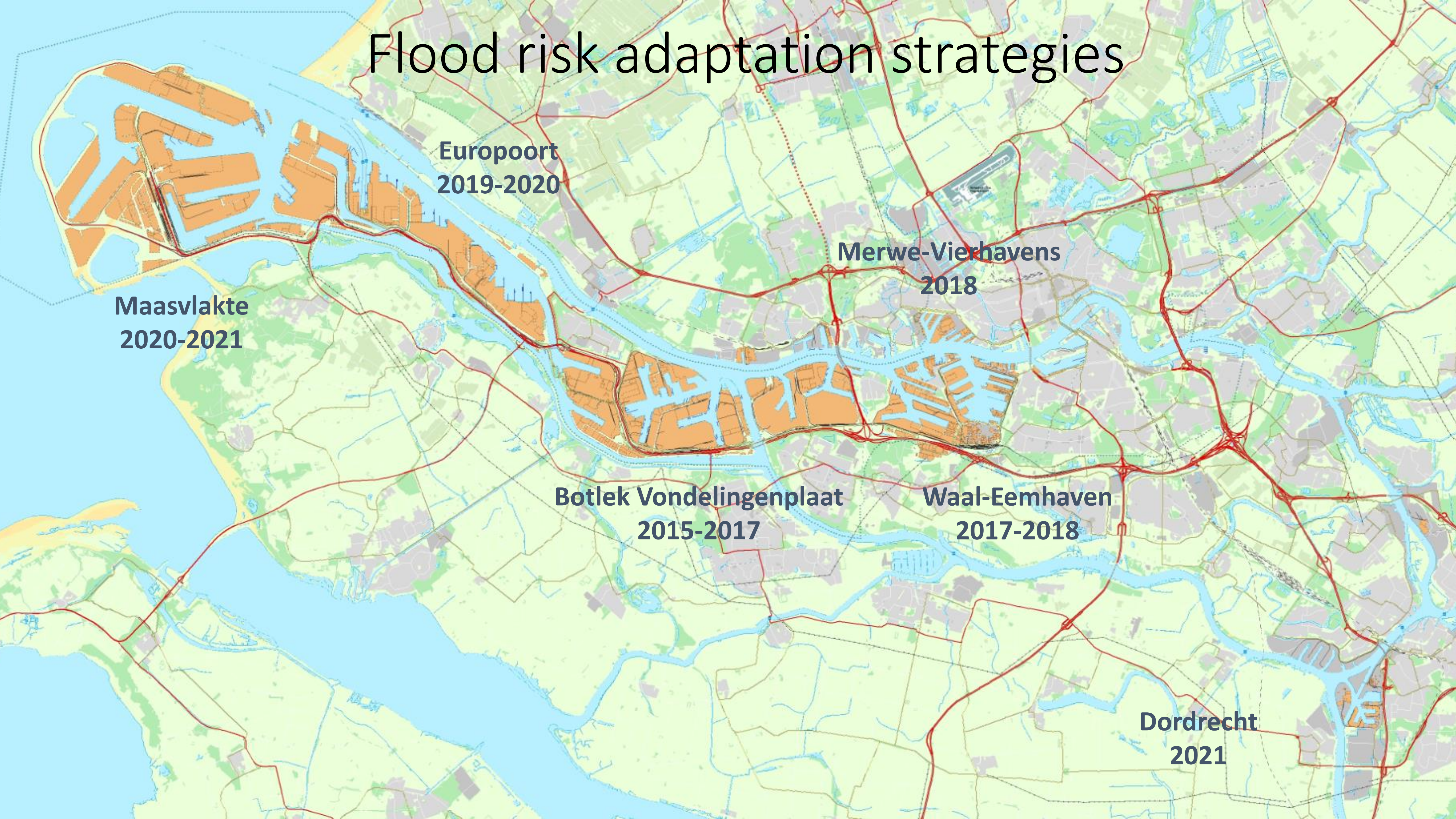


Sea level rise Delta Scenarios 2014:

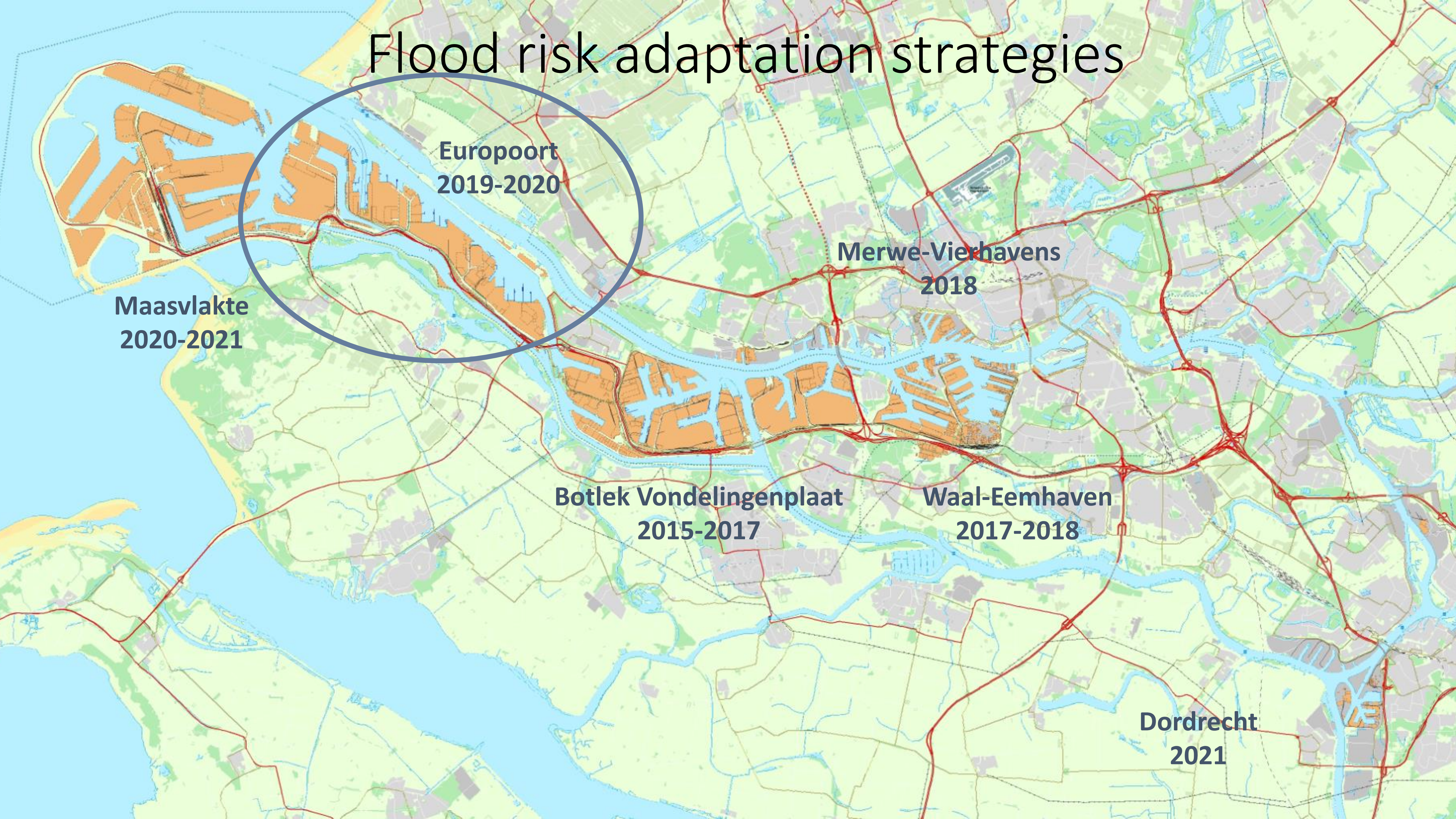
2050: +0,15m to +0,35m

2100: + 0,35m to +0,85m

Flood risk adaptation strategies



Flood risk adaptation strategies

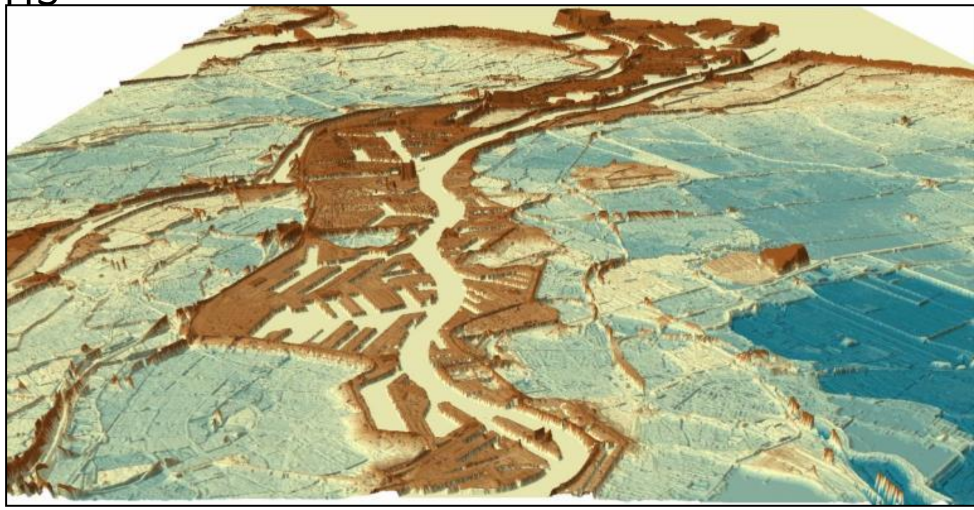


Approach and steps

- in partnership with companies and public organisations -

Approach:

- Creating awareness
- Information sharing + visualisation
- Joint Fact Finding
- Create common language and commitment!



Sea level rise Delta Scenarios 2014:

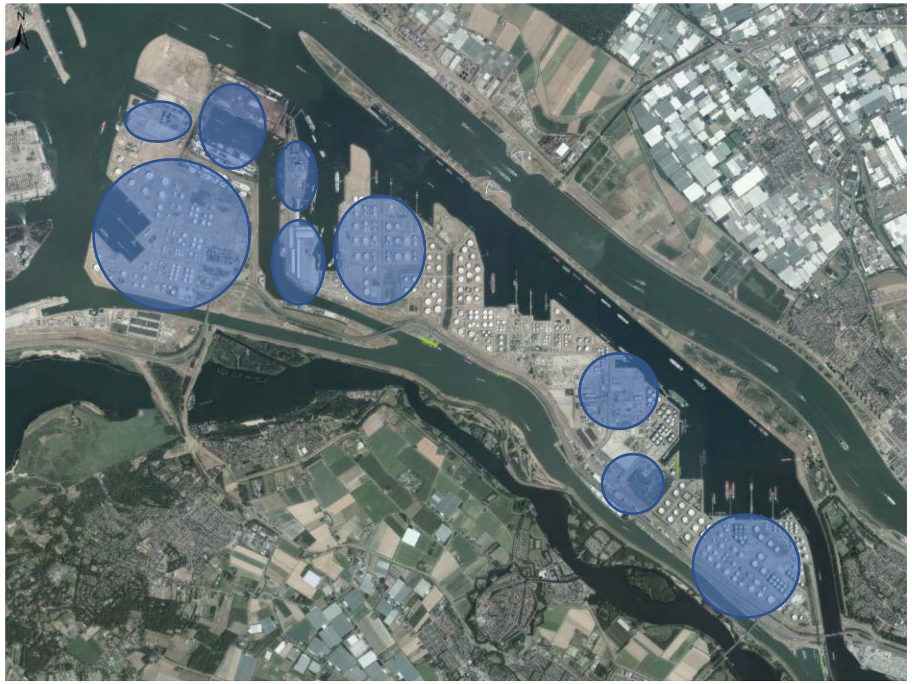
2050: +0,15m to +0,35m

2100: + 0,35m to +0,85m

- **Steps:**
- Flood risk analysis
- Impact assessment (*workshop 1 with stakeholders*) + applying flood risk assessment framework
- Jointly building a flood risk adaptation strategy (*workshop 2 with stakeholders*)

Stakeholder involvement right from the start

- Companies
  - Chemical industry
  - Refineries
  - Tank terminals
  - Distribution centres
  - Dry bulk terminals
  - Break bulk terminals
  - Power plants
  - etc.

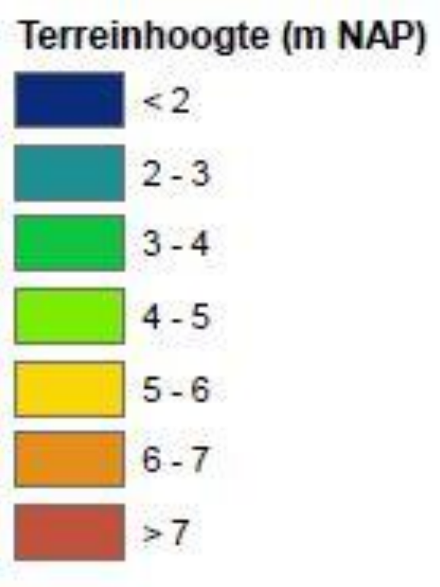


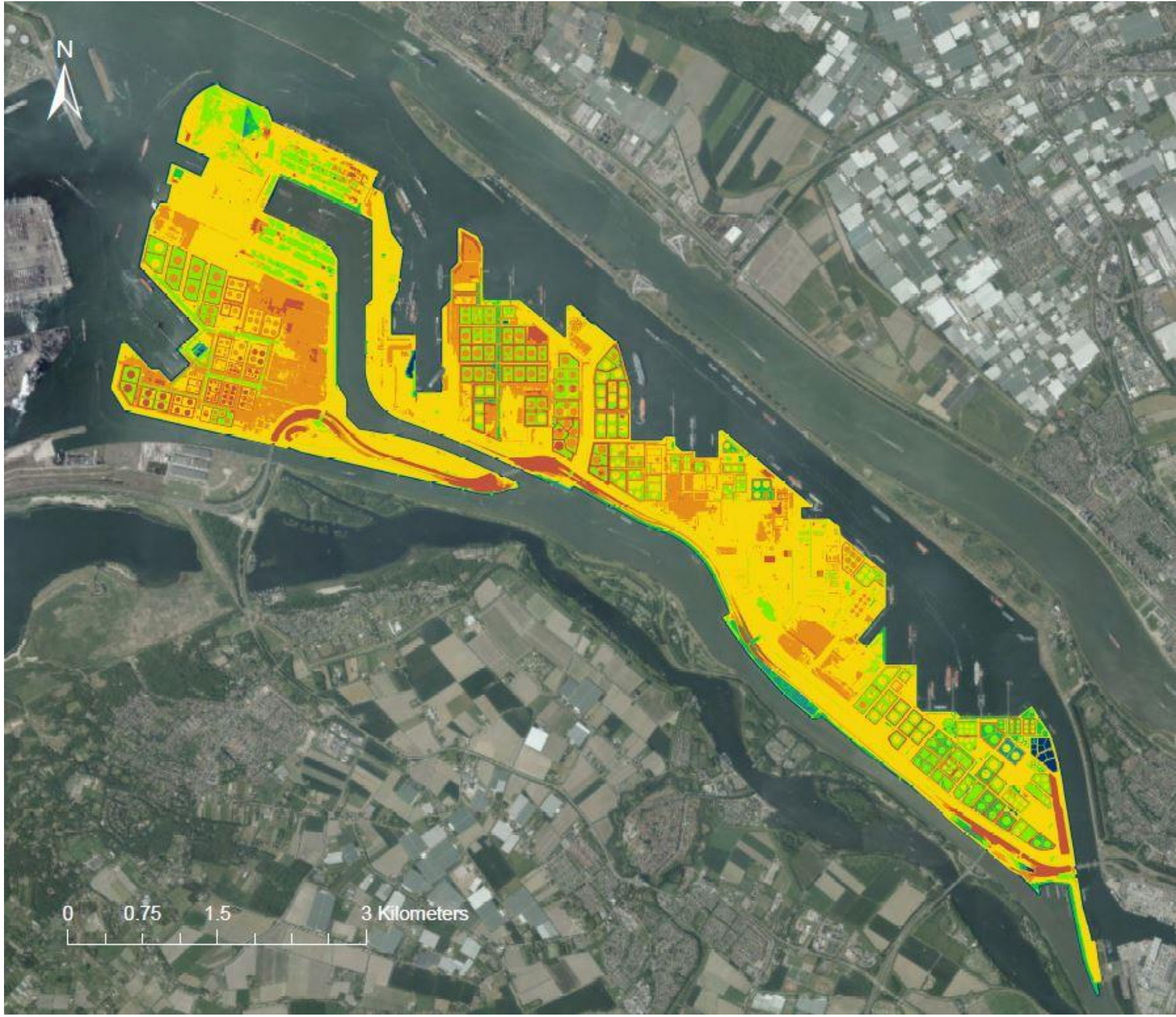
- Public organisations:
  - Municipality of Rotterdam
  - Rotterdam-Rijnmond Safety Region
  - Environmental Protection Agency
  - Ministry of Water Management
  - Rail and road authorities

- Utility owners
  - Electricity
  - Gas
  - Water

ELEVATION MAP

Average height: +5,5m

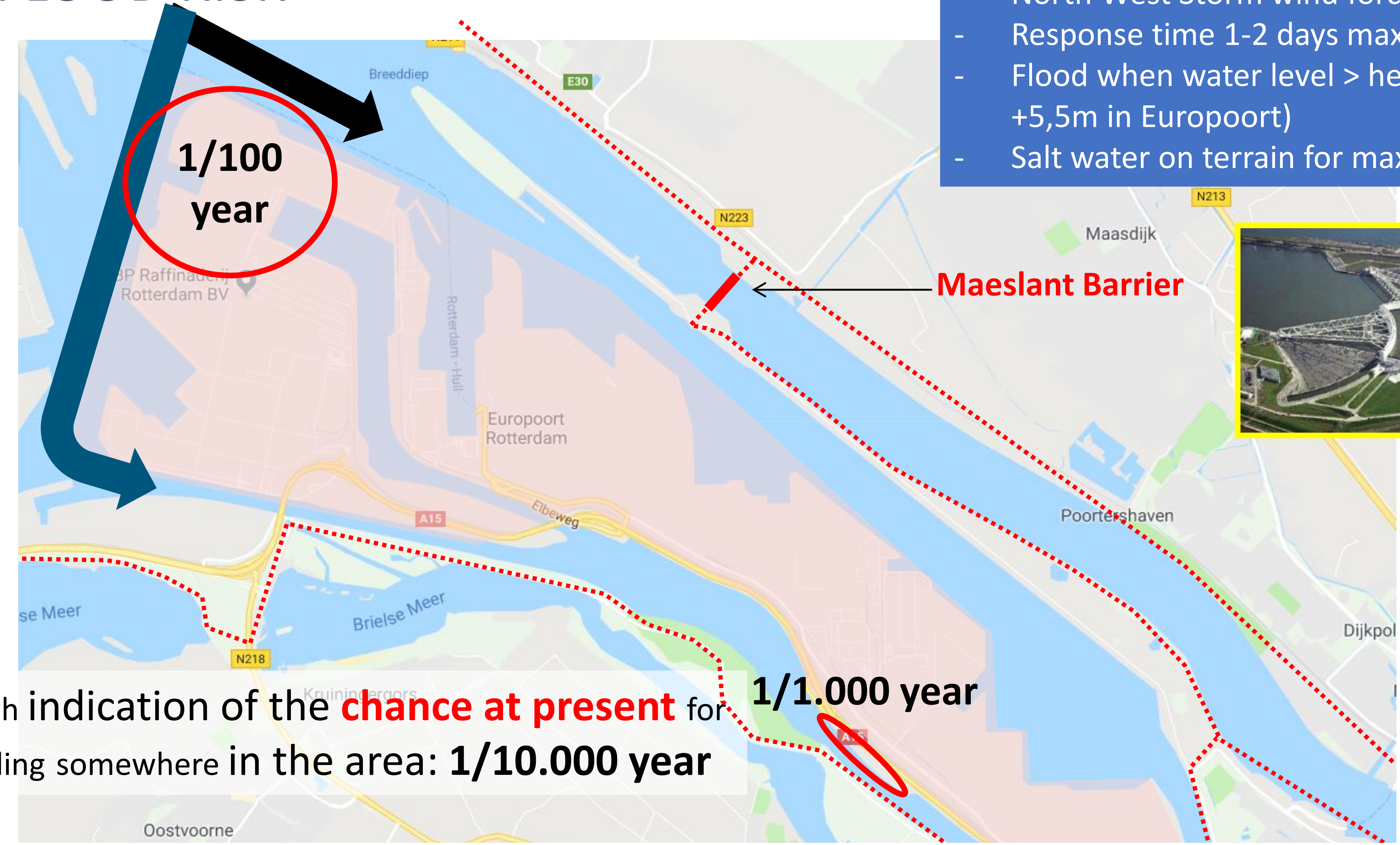




FLOOD RISK

Course of a flood:

- North West Storm wind force Beaufort 11-12
- Response time 1-2 days max
- Flood when water level > height of terrain (average +5,5m in Europoort)
- Salt water on terrain for max 1 - 2 days



Maeslant Barrier

Rough indication of the **chance at present** for flooding somewhere in the area: **1/10.000 year**

Europoort area

Flood from sea

defence system

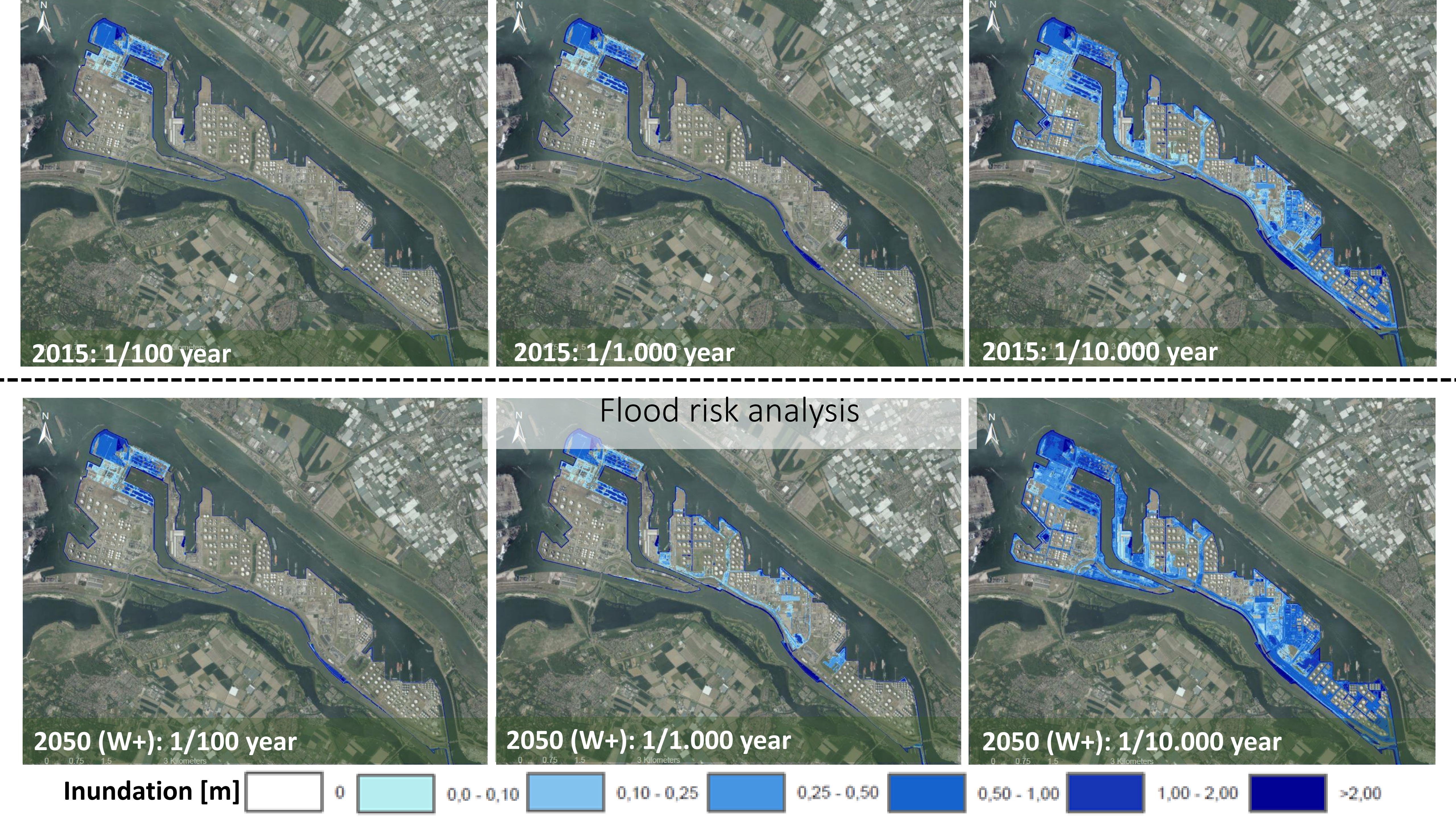
Flood risk analysis

- Water depth 2015 (1/1.000 year storm)*

Water Depth [m]

- 0
- 0,0 - 0,10
- 0,10 - 0,25
- 0,25 - 0,50
- 0,50 - 1,00
- 1,00 - 2,00
- >2,00

- * Dutch Flood event 1953: 1/300 year storm



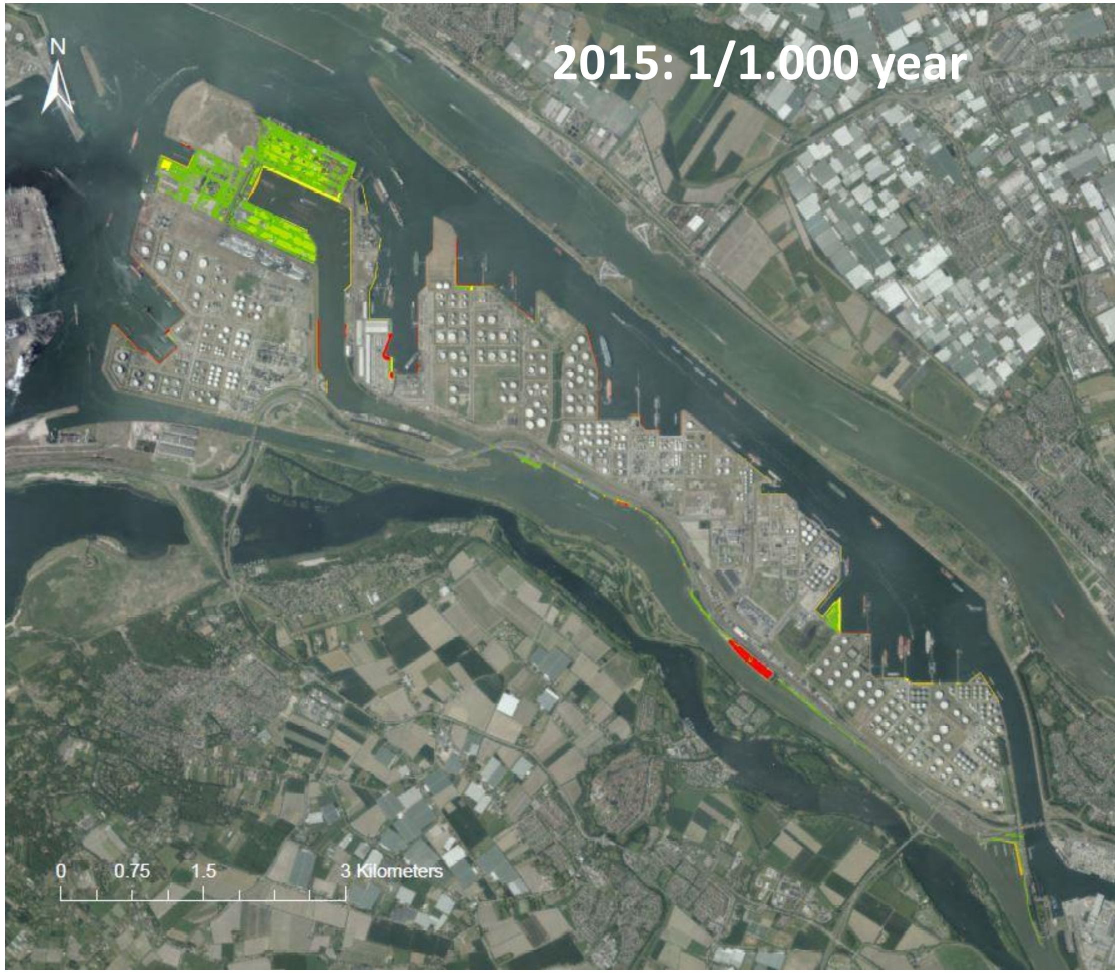
Flood risk analysis
2015: 1/100 year
2015: 1/1.000 year
2015: 1/10.000 year
2050 (W+): 1/100 year
2050 (W+): 1/1.000 year
2050 (W+): 1/10.000 year
Inundation [m]
0
0,0 - 0,10
0,10 - 0,25
0,25 - 0,50
0,50 - 1,00
1,00 - 2,00
>2,00

Impact assessment
(workshop 1)

- Assessment of impact on:
  - (Deadly) casualties
  - Economy (direct and indirect)
  - Environment (air, water, soil)

Social disruption

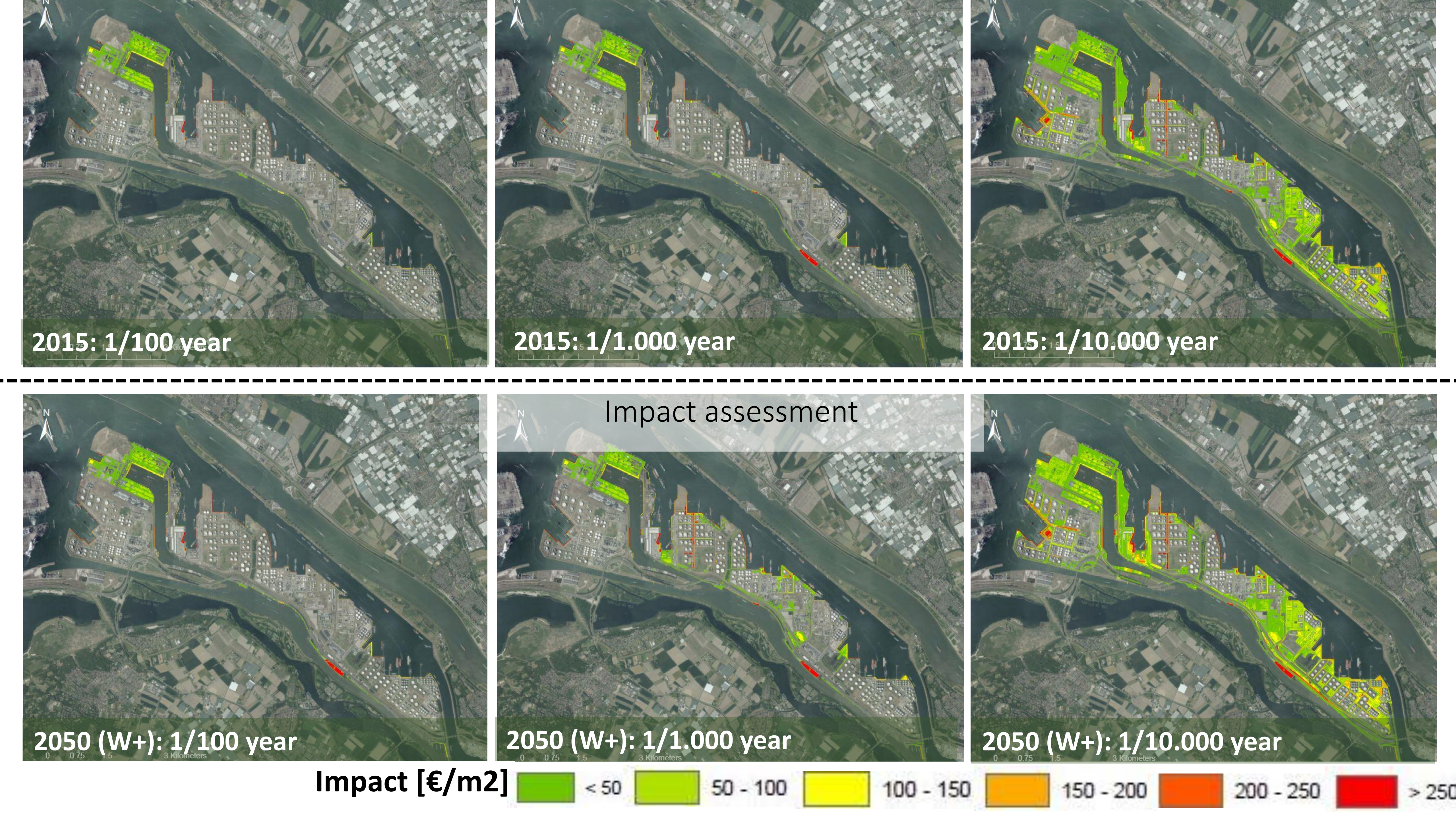
- Quantitative approach (modelling of direct and indirect economical impact)
- Qualitative approach (workshops and interviews with stakeholders)



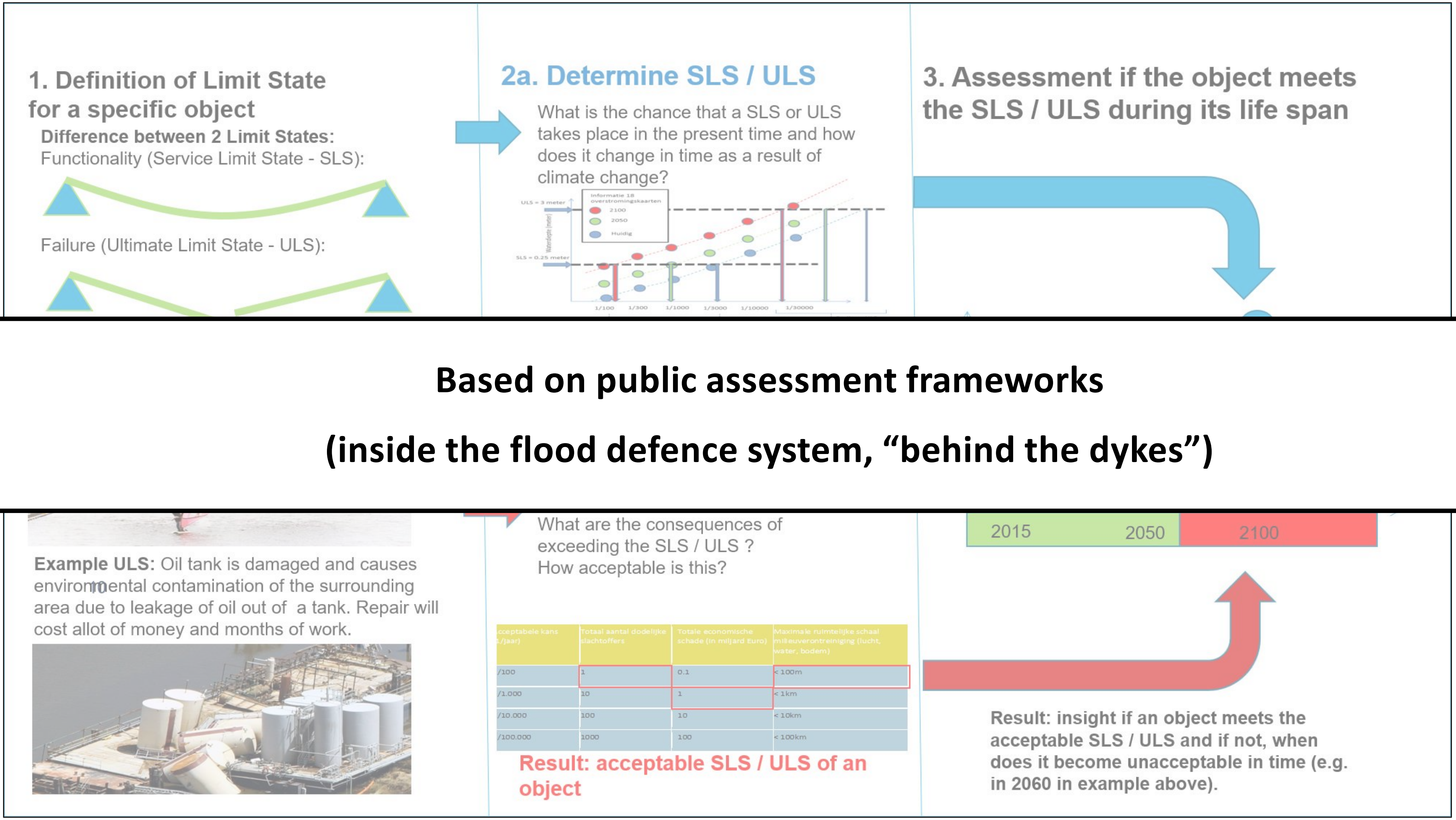

Direct effect [mln €]


Total effect [mln €]

Impact [€/m2] < 50 | 50 - 100 | 100 - 150 | 150 - 200 | 200 - 250 | > 250


Impact assessment
2015: 1/100 year
2015: 1/1.000 year
2015: 1/10.000 year
2050 (W+): 1/100 year
2050 (W+): 1/1.000 year
2050 (W+): 1/10.000 year
Impact [€/m2]
< 50
50 - 100
100 - 150
150 - 200
200 - 250
> 250

Flood risk assessment framework

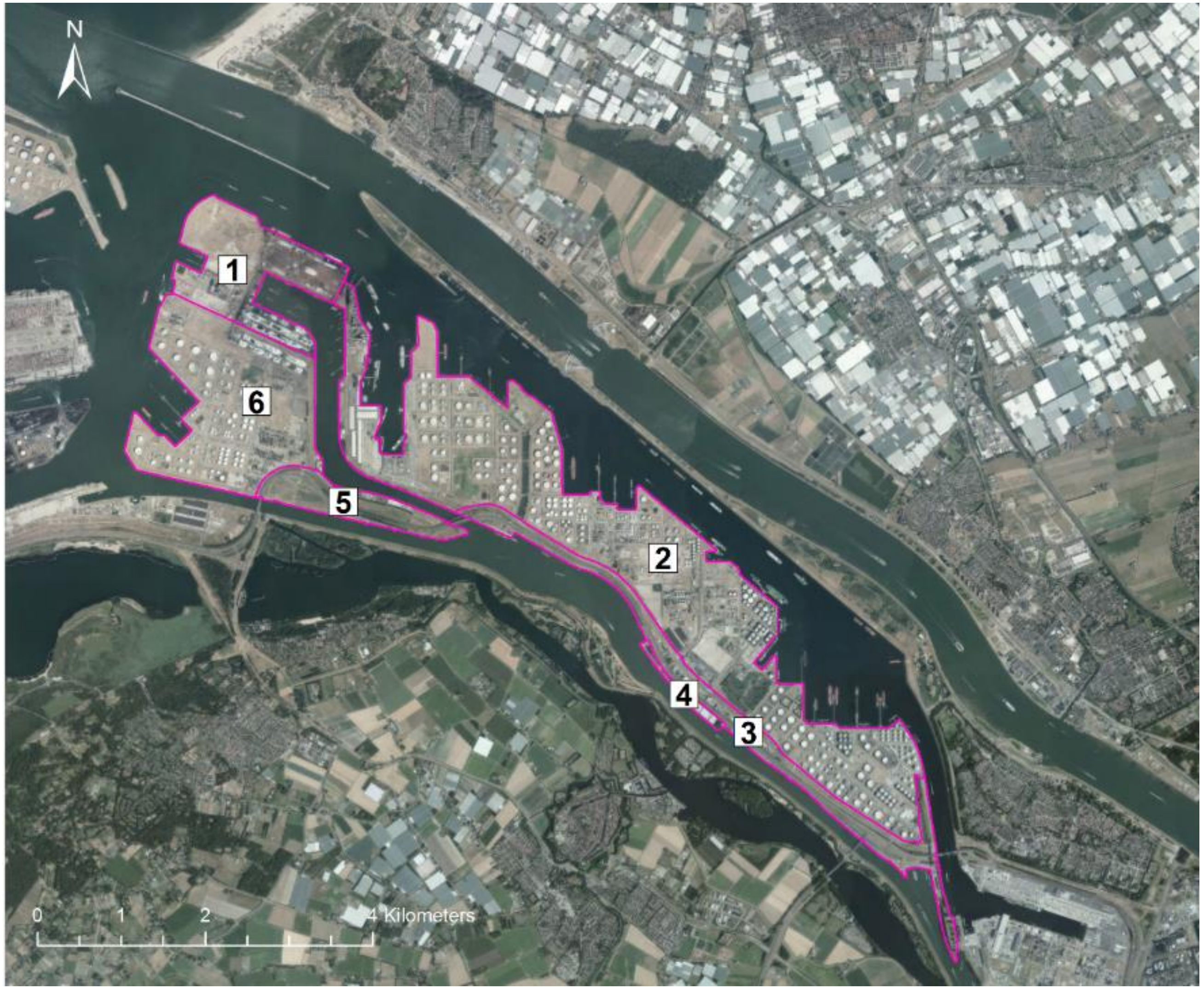


cceptabele kans 1/jaar)	Totaal aantal dodelijke slachtoffers	Totale economische schade (in miljard Euro)	Maximale ruimtelijke schaal milieuverontreiniging (lucht, water, bodem)
/100	1	0.1	< 100m
/1.000	10	1	< 1km
/10.000	100	10	< 10km
/100.000	1000	100	< 100km

Based on public assessment frameworks

(inside the flood defence system, “behind the dykes”)

APPLICATION OF THE ASSESSMENT FRAMEWORK
- COMPARISON OF THE IMPACT WITH THE ACCEPTABLE LEVEL OF RISK -



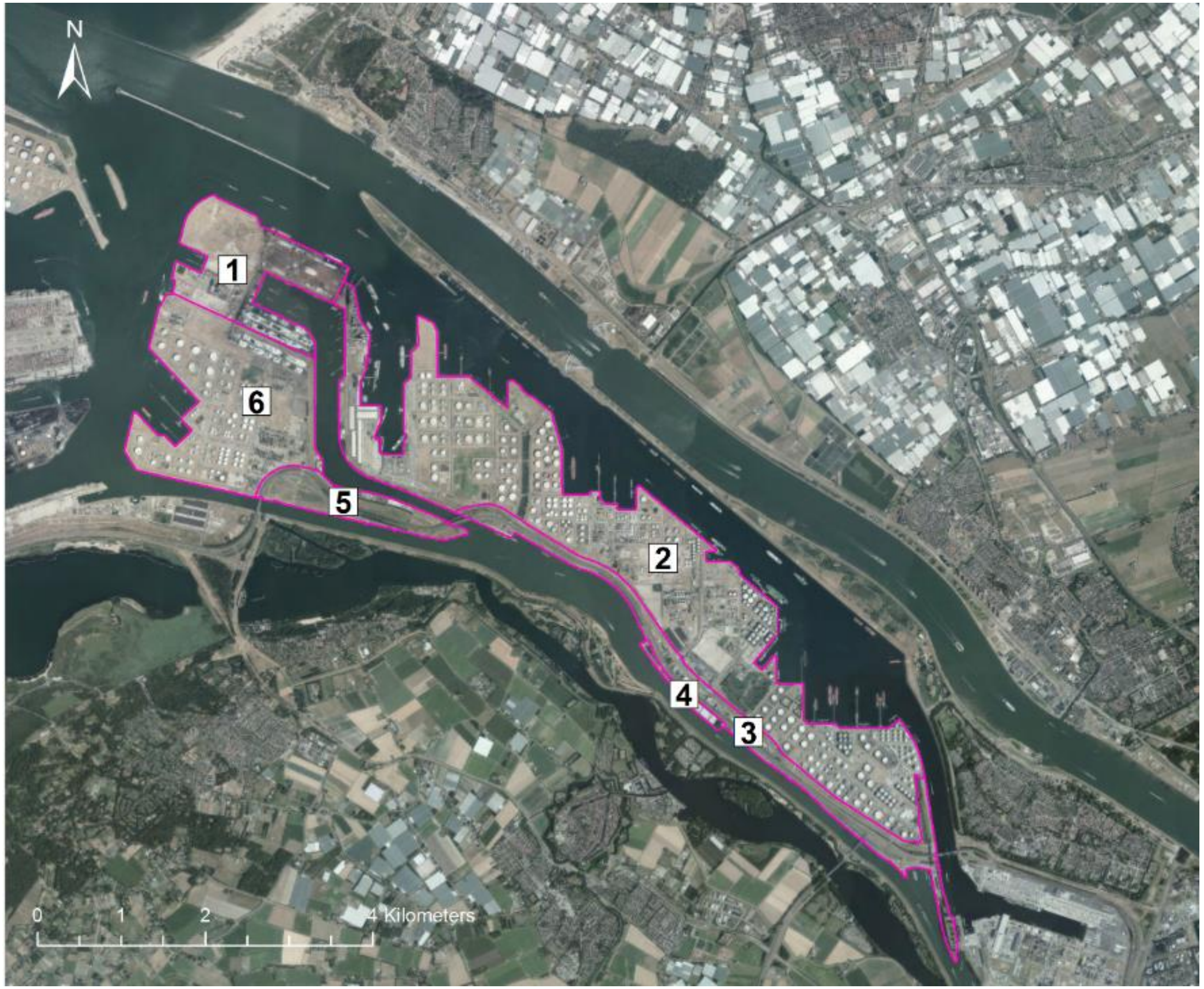
	Grensniveau		
Deelgebieden	**nu**	**2050**	**2100**
Europoort			
Deelgebied 1			
Deelgebied 2			
Deelgebied 3			
Deelgebied 4			
Deelgebied 5			
Deelgebied 6			

impact = still acceptable

impact = close to unacceptable

impact = unacceptable

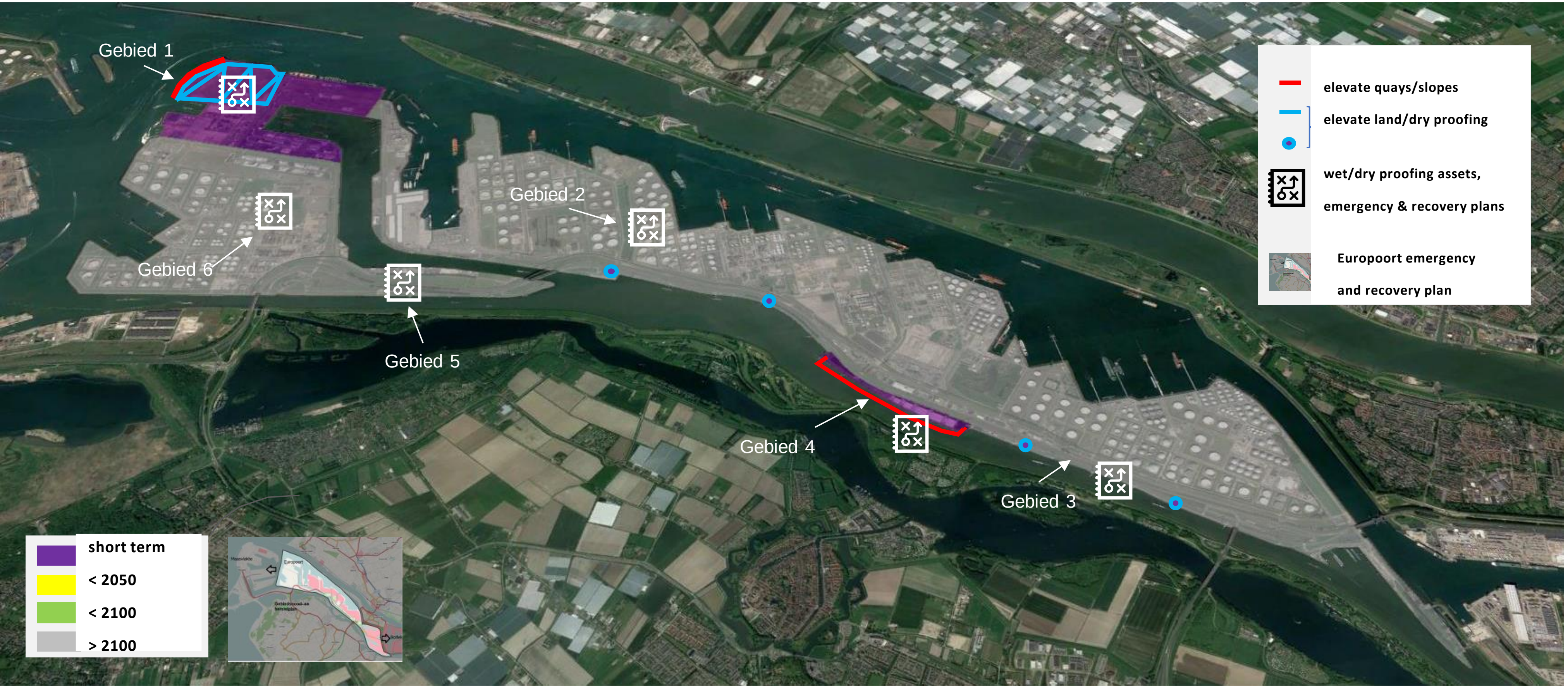
FEASIBILITY MEASURES + JOINTLY BUILDING STRATEGY (WORKSHOP 2)

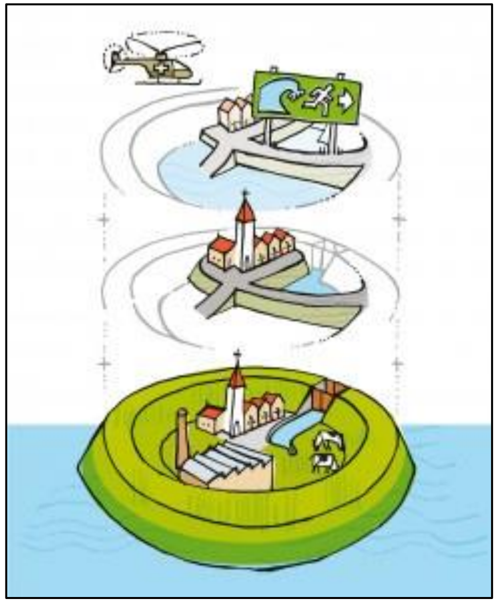


"Risk dialogue"

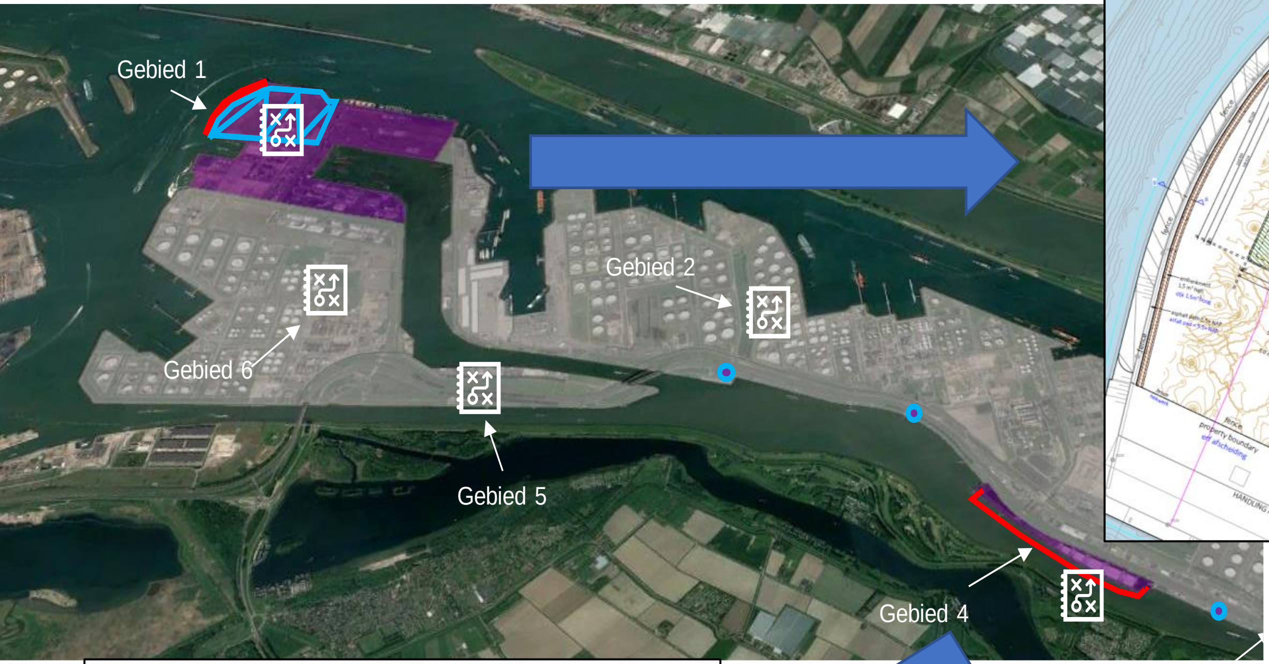
- Combining preventive measures with spatial adaptation and emergency response.
- Cost-benefit analysis
- Gives insight in necessity of collaborative approach.
- Commitment and first steps to jointly follow up on the strategy.

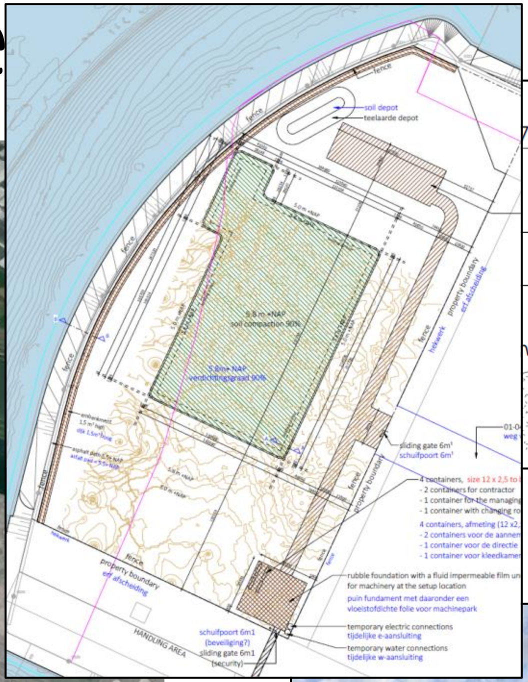
Europoort flood risk adaptation strategy

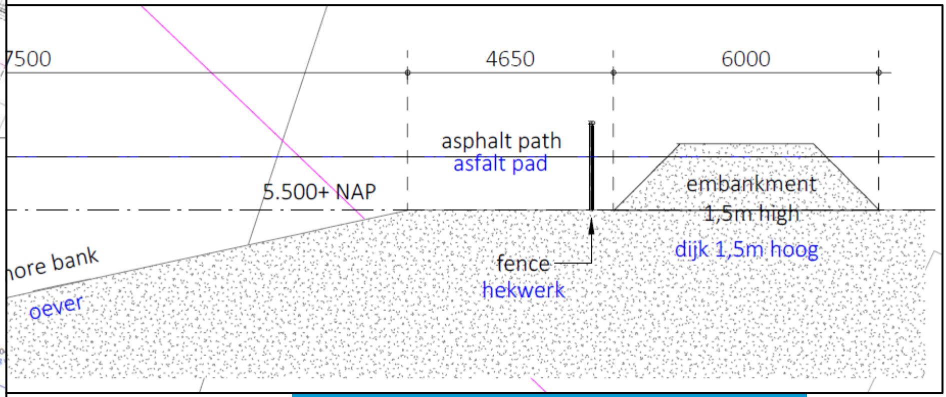




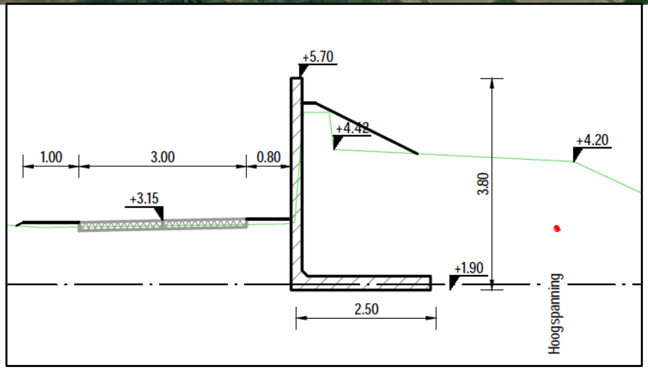
Measures in progre







- **new embankment**



elevated quay

A safe port, now and in the future!

DP WORLD

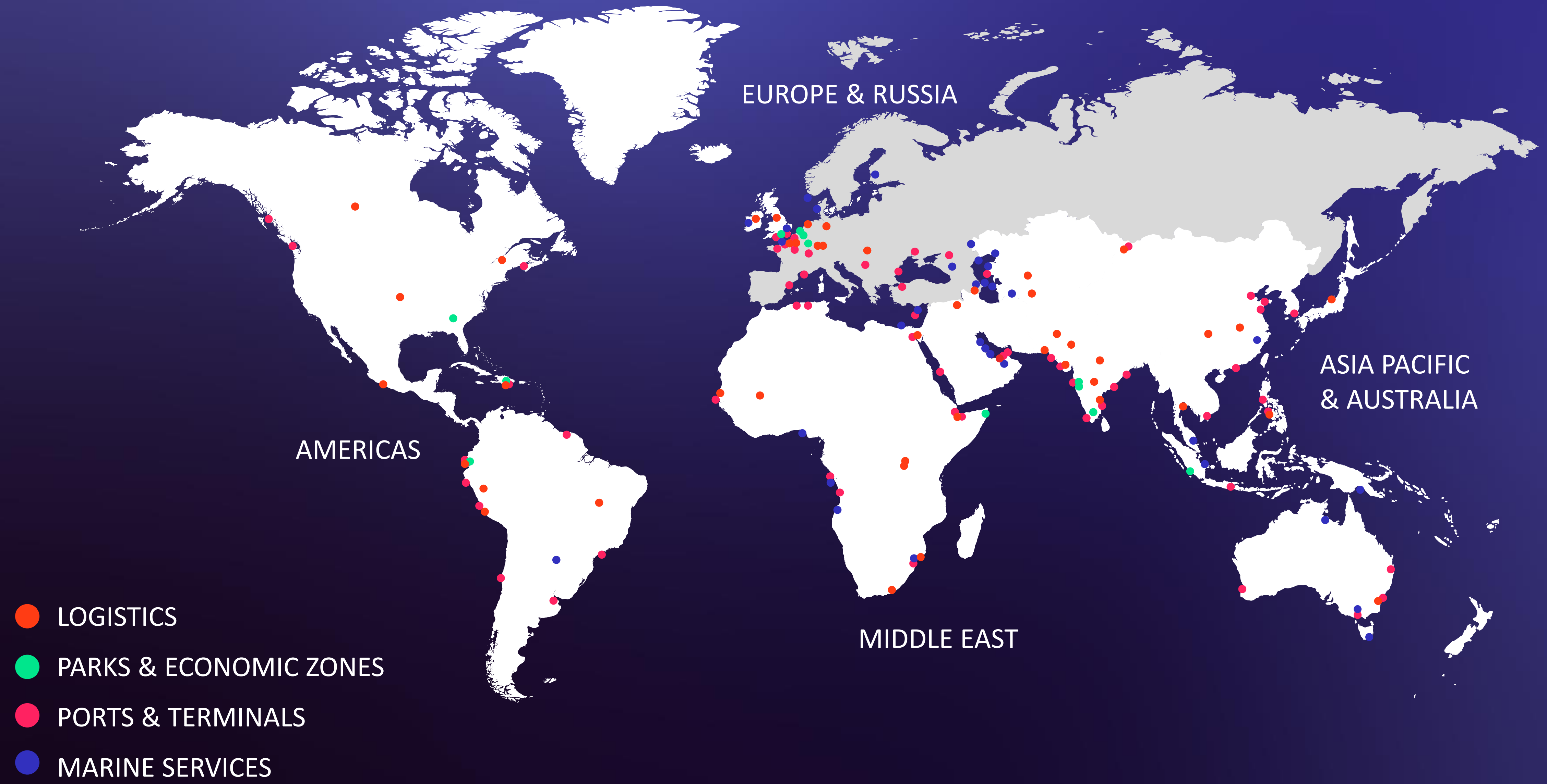
DP WORLD

PRACTICAL CLIMATE CHANGE ADAPTATION CHALLENGES AND GOOD PRACTICE SOLUTIONS FOR PORTS

International Maritime Hub, COP 26

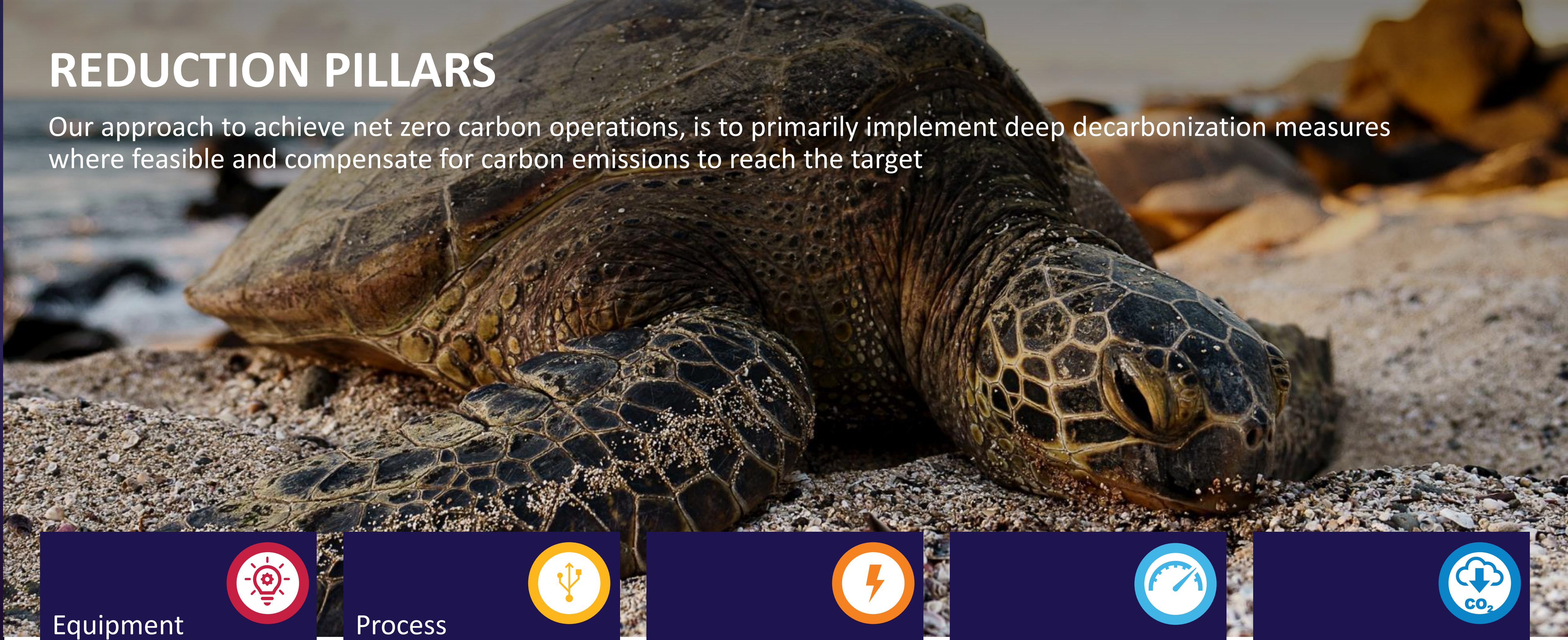
3rd November 2021

WHAT WE DO AND WHERE WE OPERATE



REDUCTION PILLARS

Our approach to achieve net zero carbon operations, is to primarily implement deep decarbonization measures where feasible and compensate for carbon emissions to reach the target



- Equipment Electrification & Efficiency
- Process Efficiency & Digitalization
- Renewable Energy Supply
- Low Carbon Fuel Supply
- Carbon Compensation

CLIMATE CHANGE MITIGATION ASSESSMENT

We have created a tool to assess the resiliency of our ports & terminals across 3 criteria

#1:

Rising sea levels and flooding

#2:

Increased adverse weather events

#3:

Rising temperatures

CLIMATE CHANGE MITIGATION ASSESSMENT

Key findings

15

sites assessed

Future Sea Level

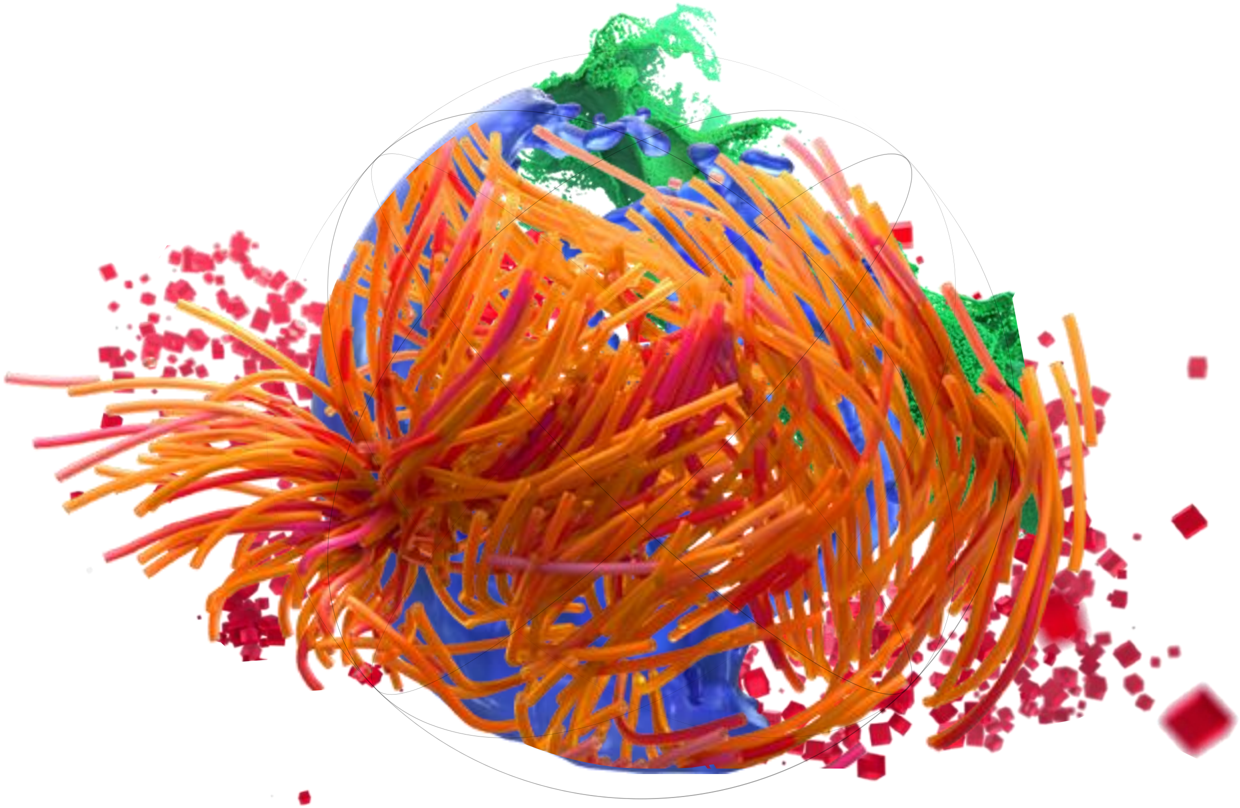
in many locations is not monitored by local agencies to inform the assessment

Adverse weather events

are not expected to severely impact equipment operation

Rising temperatures

and the impact on workforce was not a widely considered criterion



Motivation for assessment

longevity of investments

Capacity building

is required, particularly in developing countries where impacts may be worst

Operational excellence

As the low-hanging fruit in climate change resiliency

Way forward?

Setting up a cross-departmental working group

Thank you

Piotr Konopka

Senior Manager, Energy & Decarbonization Programmes

DP World

Piotr.Konopka@dpworld.com

DP WORLD

PANEL
DISCUSSION

PRACTICAL CLIMATE CHANGE ADAPTATION AND GOOD PRACTICE SOLUTION FOR PORTS

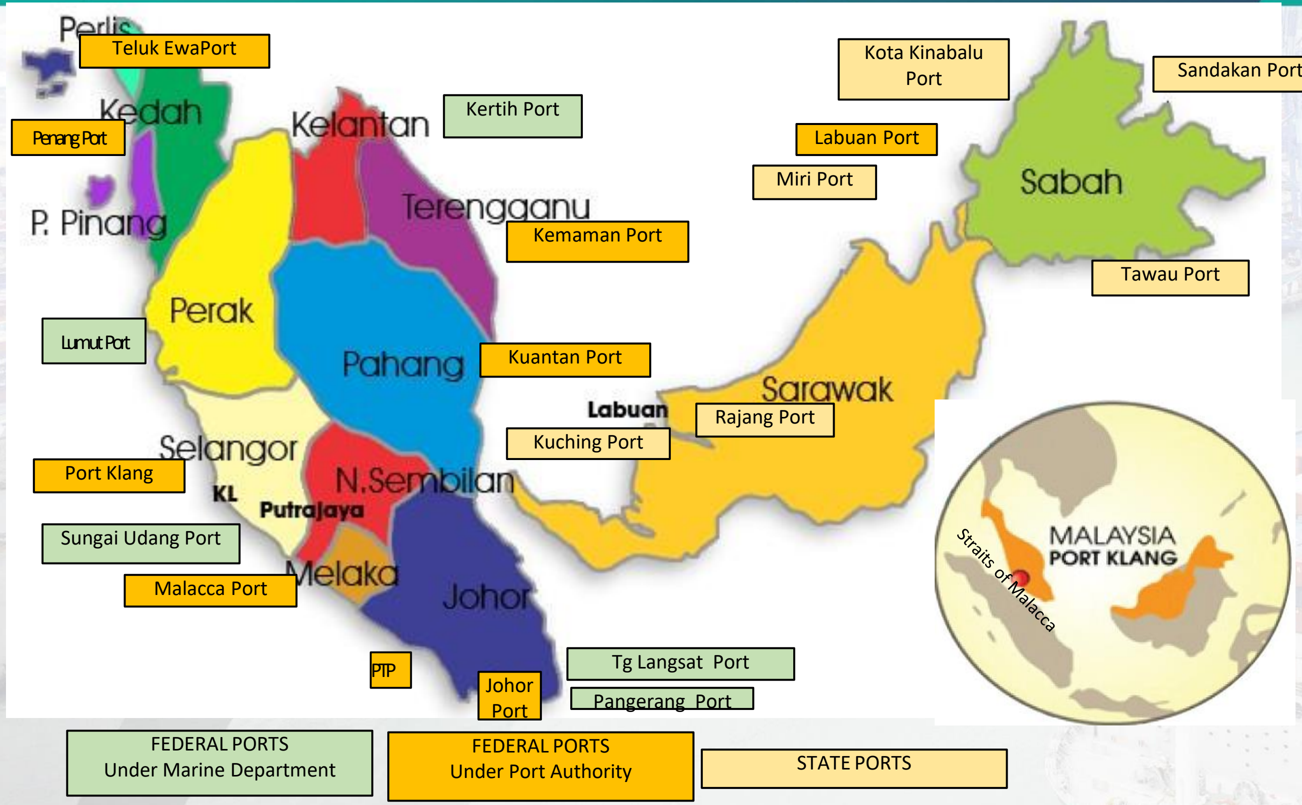
CAPT K. SUBRAMANIAM
General Manager, Port Klang Authority (PKA)
President, International Association of Ports and Harbors (IAPH)

PORT KLANG malaysia

IAPH
International Association of Ports and Harbors

MALAYSIA PORTS

CONTAINER THROUGHPUT 2020



PORT KLANG PERFORMANCE

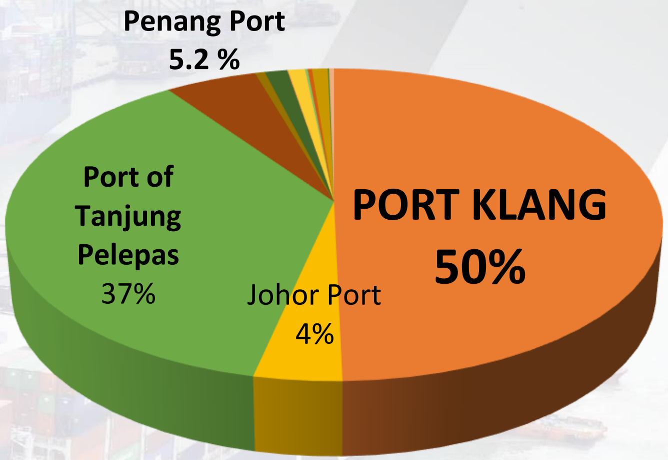
TEUS	2019	2020	2021 (Jan - Sept)
Export	2,485,728	2,564,794	2,007,332
Import	2,548,714	2,556,427	2,007,793
Transhipment	8,546,397	8,123,202	6,419,304
Total	**13,580,839**	**13,244,423**	**10,434,429**

90%
WORLD TRADE IS MARITIME BASED

70%
MARITIME TRADE CONVEYED BY CONTAINER SHIPS

50%
NATIONAL THROUGHPUT VIA PORT KLANG

80,000
VESSELS PASSING THROUGH STRAITS OF MALACCA ANNUALLY



TEUs Handling by Country

	Country	TEUs
1.	China	249.5 m
2.	United States	43.5 m
3.	Singapore	36.9 m
4.	South Korea	27.3 m
5.	**Malaysia**	**26.7 m**

CLIMATE CHANGE IMPACT

ENVIRONMENT

- Higher Temperature
- Widespread Changes in rainfall patterns
- Increased risk of drought
- Ricing ocean levels
- Increased frequency of bad weather
- Erosion of shorelines
- Coral reef bleaching
- Tidal inundation of coastal areas

PORT

- Damage to infrastructure, equipment, road and cargo
- Air and water pollution
- Higher energy consumption for cooling
- Increases health risk for port workers
- Changes to port construction design

MALAYSIA’S GHG TARGET

MALAYSIA’S COMMITMENT

- Reduce GHG emission by 45% by 2030
- Towards netzero GHG emissions as early as 2050

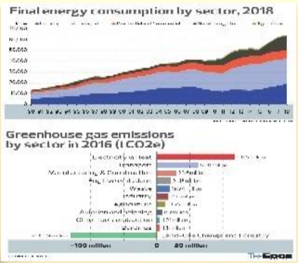
INITIATIVES
(Headed By Ministry Of Environment And Water)

1. Domestic Emissions Trading Scheme (DETS)
   - A scheme that involves the development
   - of a single platform for carbon credit
   - transaction at the domestic level
2. Increase new energy generation, 100% procurement of non- internal combustion engine (ICE) for government vehicles by 2030
3. Retaining at least 50% national forest coverage
4. Encourage zero – waste and recycling
5. Development of low carbon cities through Low Carbon Cities Master Plan
6. To improve on the engineering design for water related infrastructures, to ensure sustainable water management.

SUSTAINABLE PORT DEVELOPMENT

- Digitalisation
- Reduce carbon footprint
- Use of sustainable resource & operational practices

MALAYSIA MARITIME TRANSPORT INITIATIVES



Transport sector

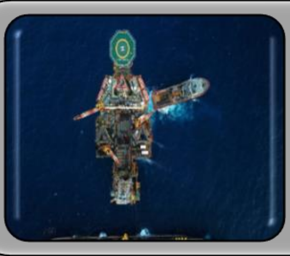
- Utilises 40% of the energy
- Contributes approximately 30% of GHG

Waste Management

- Ballast water management
- Prevention & efficient response to oil and chemical spills
- Reduce / Reuse / Recycle
- Cleaner shipping and logistic industry throughout supply chain
- Water & Affluent Management
- Environmental Compliance

IMO Green Voyage 2050

- Global Partnership
- Commitment towards relevant climate change & energy efficiency goals
- 50 % reduction in GHG emission from International Shipping by 2050



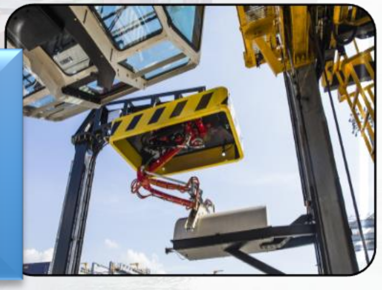
Malaysia Blue Economy

- To focus on port, shipping, marine transport and logistics
- To drive the maritime transport, ports & logistics industry using technological solutions for better stewardship of the environment and natural resources.

Port Safety, Health and Environmental Management System

Energy Management

Energy, electricity & fuel saving, clean shipping



Environmental Initiatives

Green Port Promotion

PORT KLANG'S INITIATIVE

SHAPING A SUSTAINABLE FUTURE THROUGH ASSOCIATIONS

IAPH
International Association of Ports and Harbors

1

Work to resolves common issue and committed to a cleaner, safer and more environmentally-sustainable industry

APEC
Asia-Pacific Economic Cooperation

2

APSN is to promote economically and environmentally sustainable ports by strengthening cooperation, developing best practices and guidelines, enhancing supply chain effectiveness, building capacity and stimulating information and personnel exchange

3

Facilitate the exchange of ideas and learn best practices.

APA

4

Provide a venue for port officials concerned to meet and share experiences that may lead to finding solutions to identified problem areas and emerging issues affecting the port sector

IAPH Technical Committee on Climate and Energy

WORLD PORTS SUSTAINABILITY PROGRAM
www.sustainableworldports.org

1. IAPH – a non government / non profit International Association (port authorities / port terminals / logistics company / government authorities & academia)
2. 230 members from 90 countries
3. Primary objective of promoting port industry and facilitates global trade through sustainable development and harmonised practices
4. IMO MEPC – GHG emission reduction (submissions / interventions / workshops)
5. Coordination of the various initiatives on decarbonizing ports and shipping

Green Voyage 2050

ESI Environmental Ship Index

WPCAP World Ports Climate Action Program

International Taskforce Port Call Optimization

Navigating a Changing Climate

Getting to Zero Coalition

Clean Energy Ministerial – Advancing Clean Energy Together

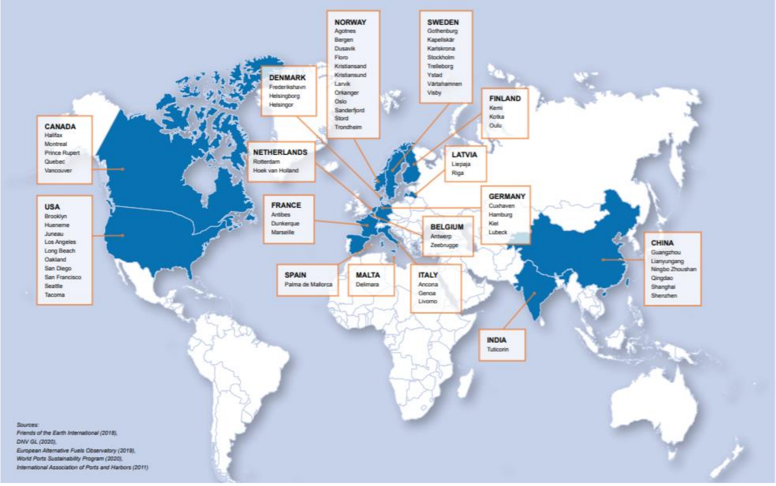
IMO International Maritime Organization

IAPH International Association of Ports and Harbors

Decarbonisation of shipping – Resolution MEPC.323(74)

Voluntary cooperation between ports and shipping on GHG emission reduction from ships

- Onshore Power Supply
- Safe and efficient bunkering of low/zero carbon fuels
- Port incentives
- Port call optimization and JIT



International Taskforce
Port Call Optimization

INTERNATIONAL MARITIME ORGANIZATION

GreenVoyage 2050

IAPH
International Association of Ports and Harbors

WPSP Port projects database

Port of San Diego – ECOncrete Coastalock Blue Economy Pilot Project

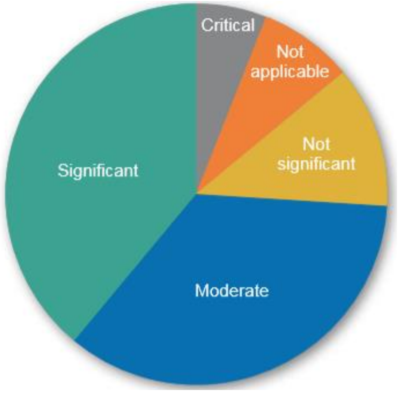
Port of Valencia – Increasing resilience to climate change

Maryland Port Administration – Climate Change Adaptation & Stormwater Treatment

- Limited examples of Climate Adaptation projects - Call for additional contributions

https://sustainableworldports.org/portfolio/type/port-projects/

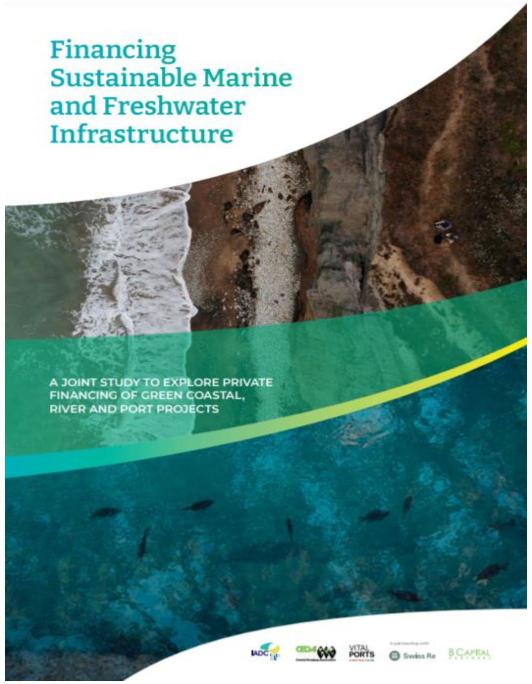
Joint initiative - Navigating a Changing Climate



- PIANC led initiative on climate change mitigation and adaptation
- 2019 Survey on the impact of extreme weather events on port operations

https://sustainableworldports.org/pianc-navigating-a-changing-climate/

Climate adaptation in the ports' context



Adapting Port Infrastructure

- Factoring in climate adaptation in new development projects
- Business case may be of challenge as recent report demonstrates

Impact on Port Operations

- Work closely with Pilots, Harbour masters, terminal operators to define challenges and adjust as needed

CONCLUSION

1 Fast action needed to tackle environment issues

2 Strategies to face future climate challenges & disruption using digital technology in every aspect of the industry

3 Commitment to reduce emission & GHG to protect the environment towards developing a sustainable industry for the future

4 Climate Adaptation/Resilience is being addressed as part of the work programme of the IAPH Technical Committee on Risk and Resilience

5 IAPH is an active partner at the NaCC Initiative that is expected t have an increased focus on adaptation in the years to come.

6 More work is needed and IAPH is willing to work with relevant stakeholders on further initiatives targeting both infrastructure and operations

WORLD PORTS SUSTAINABILITY PROGRAM
www.sustainableworldports.org

Thank you for your attention!

iaphworldports.org / sustainableworldports.org / worldportsconference.com

PORT KLANG malaysia

www.pka.gov.my /pkamalaysia /myportklang

IAPH International Association of Ports and Harbors

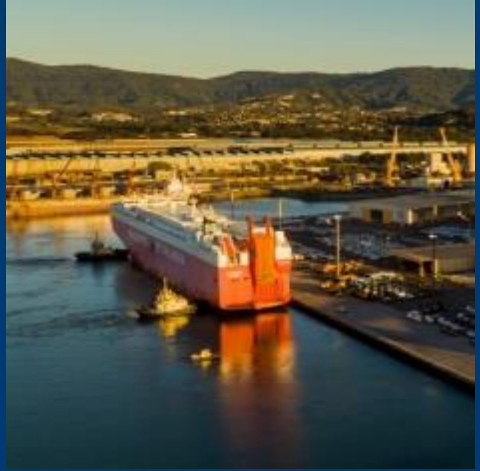
Adaptation in Practice

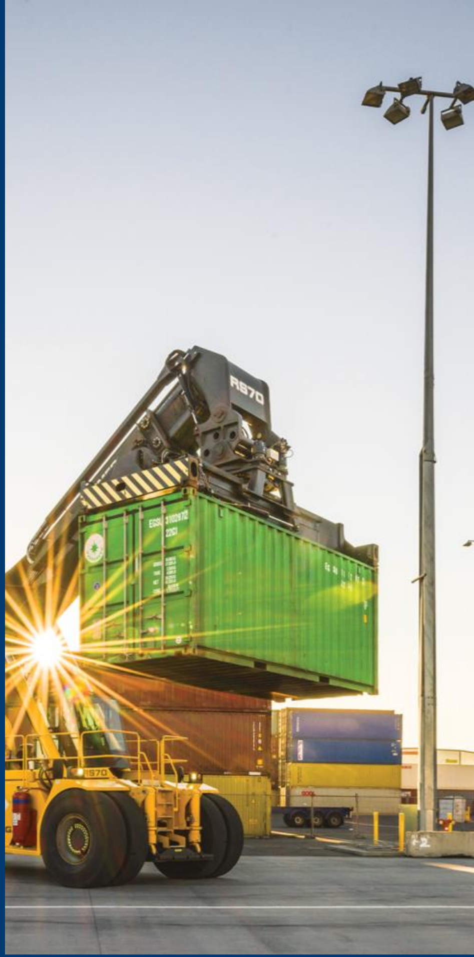
Practical climate change adaptation challenges and good practice solutions for ports

Presentation at COP26 International Maritime Hub

Marika Calfas

3 November 2021





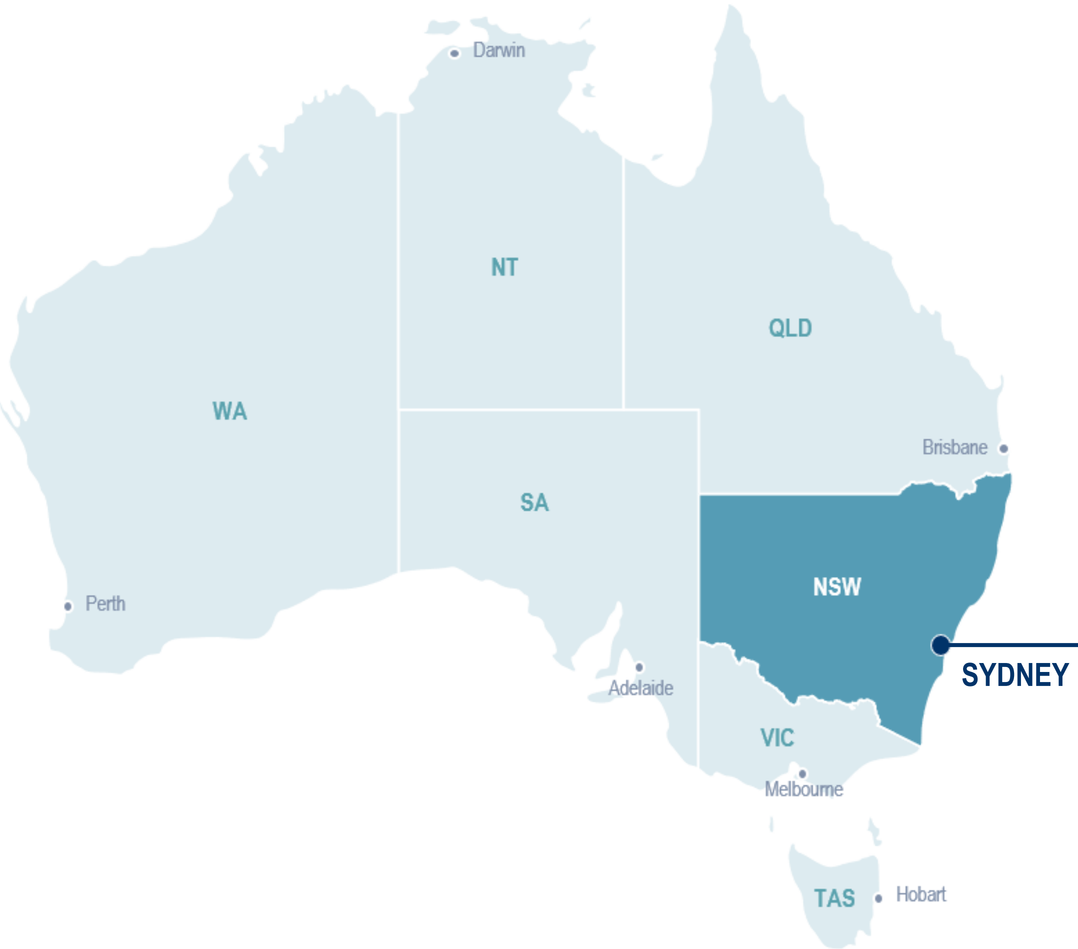
Who is NSW Ports?

SUSTAINABLE DEVELOPMENT GOALS

NAVIGATING A CHANGING CLIMATE

WPSP
WORLD PORTS SUSTAINABILITY PROGRAM

NSW GOVERNMENT | Planning & Environment
Sustainability Advantage Bronze



Key trades handled for NSW:

Port Botany

Containers
(2.7m TEU)

Refined petroleum
(Fuel - 5B L)

LPG

Bitumen

Bulk chemicals

$4.4 billion
to NSW GSP p.a.

29,400 jobs
Supported by port operations

Port Kembla

Motor Vehicles
(338k)

Agricultural products
Fertiliser, grain

Bulk liquids
Diesel, lubricants, chemicals

Project cargo
Large machinery

Construction Materials
Cement clinker, gypsum, steel

Minerals
Copper, Zinc, Coal, Iron ore

Assessing the climate risk in 2015

2015

Original Scope

- Port Botany and Port Kembla.
- Identifying and assessing risks that a changing climate may pose to current & future developments for NSW Ports.
- Determining the adaptation planning approaches that can be implemented to minimise climate change associated risks.
- Based on IPCC 2007 data and in line with the AS:5334 Climate Change Adaptation for Settlements and Infrastructure.

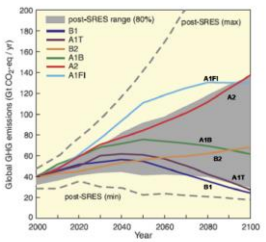


Figure 2 Greenhouse gas emissions scenarios (IPCC, 2007)

Key climate risk insights identified in 2015

NSWPorts

KEY HAZARDS

- Intensive rainfall storm events
- Increase in average temperatures & extreme heat events
- Increased wind events/average wind speed
- Climate change policy affecting import/export revenue

RELATED RISKS

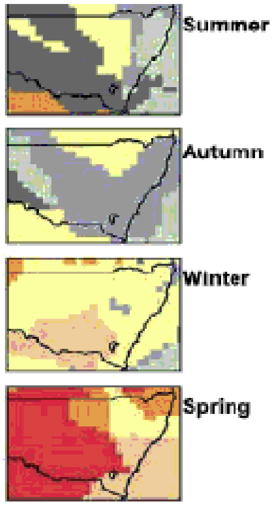
Mostly focused on condition and capacity of infrastructure:

1. Damage to road surfaces and yard pavements
2. Drainage system capacities exceeded
3. HVAC failure for buildings and offices – extreme heat

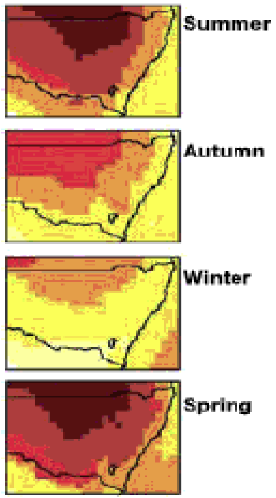
Some operational and commercial risks identified:

4. Wind and swell impacts on ship movements, mooring security and cargo handling
5. Potential reductions in trade volumes for climate sensitive and emissions intensive cargoes (e.g. grain, coal)

CONCLUSION: *Anticipated effects of climate change on NSW Ports should be "manageable" with current engineering and asset management practices combined with some adaptive practices…"*



Rainfall



Temperature

Actions following 2015 risk assessment

- **Active monitoring and recording of adverse weather conditions** that lead to suspensions of pilotage, port closures, etc.
- **Strengthened our Port Kembla breakwaters and seawall** in response to weather events. 4-year monitoring program, including above water and below water surveys quantify changes to the breakwater structure, and allows for targeted maintenance.
- **Analysed the limiting wind conditions** in which the capacity of the existing mooring infrastructure at various berths can safely hold the vessel fleet using those berths.
- **Dynamic Under Keel Clearance technology for Port Botany** has helped to ensures transit safety by integrating real-time data and AI enhanced forecasts into navigational decision making. This contributes to port resilience in the face of more frequent extreme weather events.

Assessing climate risk today

NSW Ports

2021

What's different?

- Scope now expanded to also include:
  - NSW Ports intermodal terminals
  - All maritime & landside activities and assets.
  - Vulnerability of key connecting freight routes (road and rail) and utilities (e.g. electricity, pipelines)
- Uses National & State data aligned to IPCC 2013 modelling.
- Review the effectiveness of existing control measures and systems, recommending improvements to optimise resilience and adaptive capacity.
- Increased awareness of weather-related impacts on port operations and assets.

Climate change projections for NSW Ports

Hazard type	Data availability	Key data point and source
Sea level rise/coastal inundation	GOOD	Under RCP8.5, current day 100 year extreme sea level event to occur once every 5 years by 2050, and 10 times per year by 2100 (RCP8.5; CMSI).
Extreme winds/storms	DATA DEFICIENT	5-30% reduction in number of East Coast Lows by 2050, but shifting southward with more severe events (IAG & CMSI).
Swells/wave action	DATA DEFICIENT	Changes likely, localised effects require additional research (CMSI).
Extreme rainfall	FAIR	Increased peak rainfall intensity, Australian Rainfall & Runoff Guidelines 2019 assumes 5% per degree of warming (AR&R).
Extreme heat	GOOD	On average across all sites, annual days over 35°C more than tripling by 2065 (NARCliM 1.5).
Bushfire (indirect)	GOOD	Days per year with extreme fire danger conditions increasing 20% per degree of warming (CMSI).
Large hail	FAIR	"Marked increasing trend in east and south-east Australia in frequency of hail events exceeding 2cm in diameter"; southward shift of areas at greatest risk (IAG & NCAR).

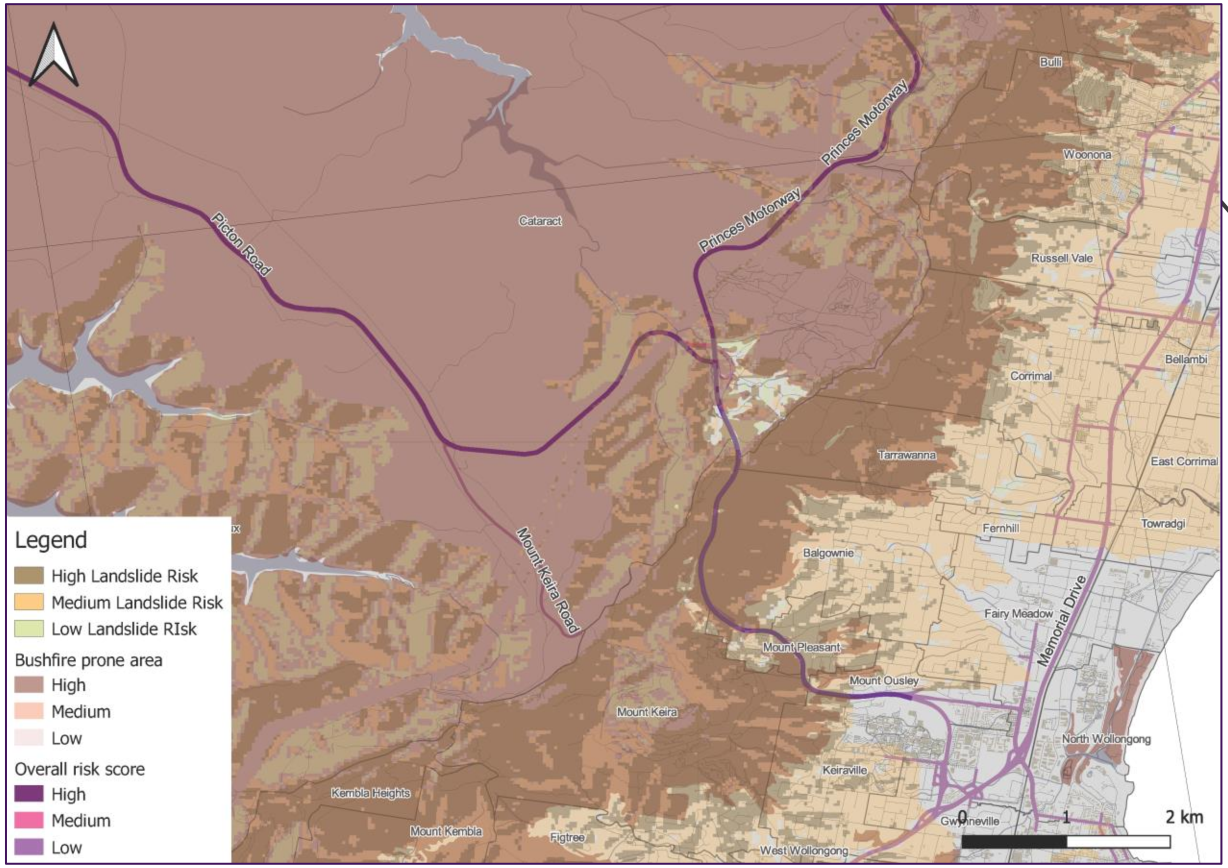
2021 Assessment - Summary of key climate change risks

	Risk	2035	Δ*	2065	Δ*
EXISTING	Swell disrupts pilotage and ship movements	Significant	↑	Significant	↑
	Wind disrupts ship movements, mooring and cargo handling	Moderate	↑	Significant	↑
	Wave damage to breakwaters and revetments	Moderate	↑	Significant	↑
	Disruption due to overloading stormwater system and overland flooding	Moderate	-	Significant	↑
	Extreme heat impacts on power supply, building HVAC systems & equipment	Low	-	Moderate	-
	Road surface and yard pavement damage due to extreme heat	Low	↓	Low	↓
NEW	Long-period waves disrupts mooring (some Port Kembla berths)	Moderate	New	Significant	New
	Hail impacts on cargo (e.g. vehicles) and yard equipment	Significant	New	Significant	New
	Health impacts from exposure to bushfire smoke	Significant	New	Significant	New
	Incursion of new marine pests – subtropical and tropical species	Moderate	New	Significant	New
	Supply chain disruptions due to flooding, bushfire, landslip	Various	New	Various	New

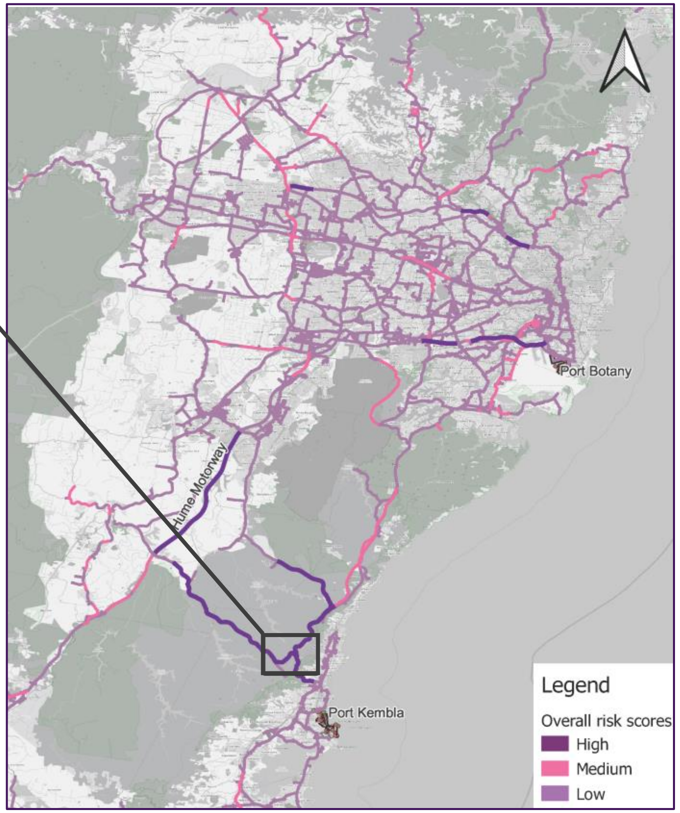
Δ* - change relative to 2015 risk assessment

Example of supply chain infrastructure risk exposure mapping

Analysis by WSP



Road freight exposure to climate related hazards



Future Direction of 2021 Climate Risk Report

- Study will be complete in December 2021, but early indications suggest organisational focus on:
  - Building greater understanding and partnership with port and supply chain infrastructure operators / managers.
  - Further analysis of key hazards and assets, especially those impacted by extreme weather events i.e. breakwaters, stormwater systems
  - Assembling long term local data sets regarding weather-related disruptions
- Engage with supply chain infrastructure owners on risk exposure mapping outcomes.
- Incorporate Climate Change Risk Assessment in the context of NSW Ports' new Sustainability Strategy (2022).

Recent extreme weather events impacting New South Wales

2015 & 2018 dust storms over Sydney
2016 storm damage at Port Kembla
2020 bushfire smoke
2021 Nepean/Hawkesbury River flooding

Thank you

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

UNCTAD

International Maritime Hub at COP 26, Glasgow

Practical climate change adaptation challenges and good practice solutions for ports: Adaptation in practice

3 November 2021

Climate change adaptation for ports in SIDS
- key issues, challenges and approaches

Regina Asariotis
Chief, Policy and Legislation Section, UNCTAD
regina.asariotis@unctad.org
unctad.org/ttl/legal

Seaports are critical for global trade & development but are at risk of climate change

- Over **80% of volume** of world trade carried by sea (port-port)
- **Ports: key nodes** in the network of closely interlinked international **supply chains** - **gateways to global markets and the blue economy**
- **Globalization: interconnectedness/interdependence**

https://www.shipmap.org/

P. Bridge, WMO, ECE EGM April 2016

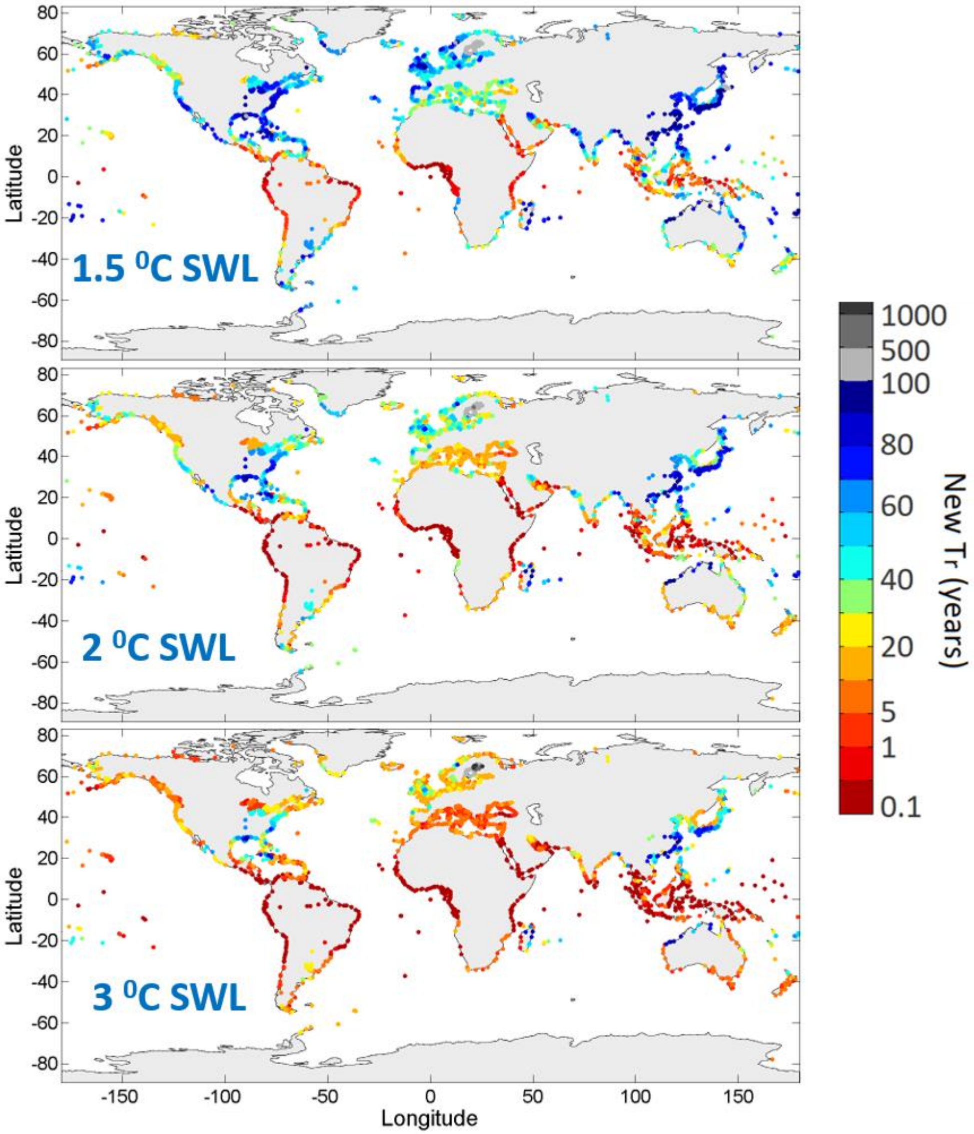
Climate change will have direct and indirect impacts:

Sea-level rise; changes in temperature, humidity, precipitation; extreme storms and floods under climate change likely to:

- affect port infrastructure and operations; hinterland transport; and the broader global supply-chain
  - significant potential for *damage, disruption and delay* – extensive economic/trade related losses
- exacerbate other transport-related challenges, including for SIDS/vulnerable economies; increase energy needs and costs

Climate change adaptation and resilience building for ports is of strategic economic importance – especially in the light of growing hazards (*Climate change impacts on seaports: a growing threat to sustainable trade and development*, UNCTAD2021)

Hazard projections for global ports under CV & C: Extreme sea level (ESL)



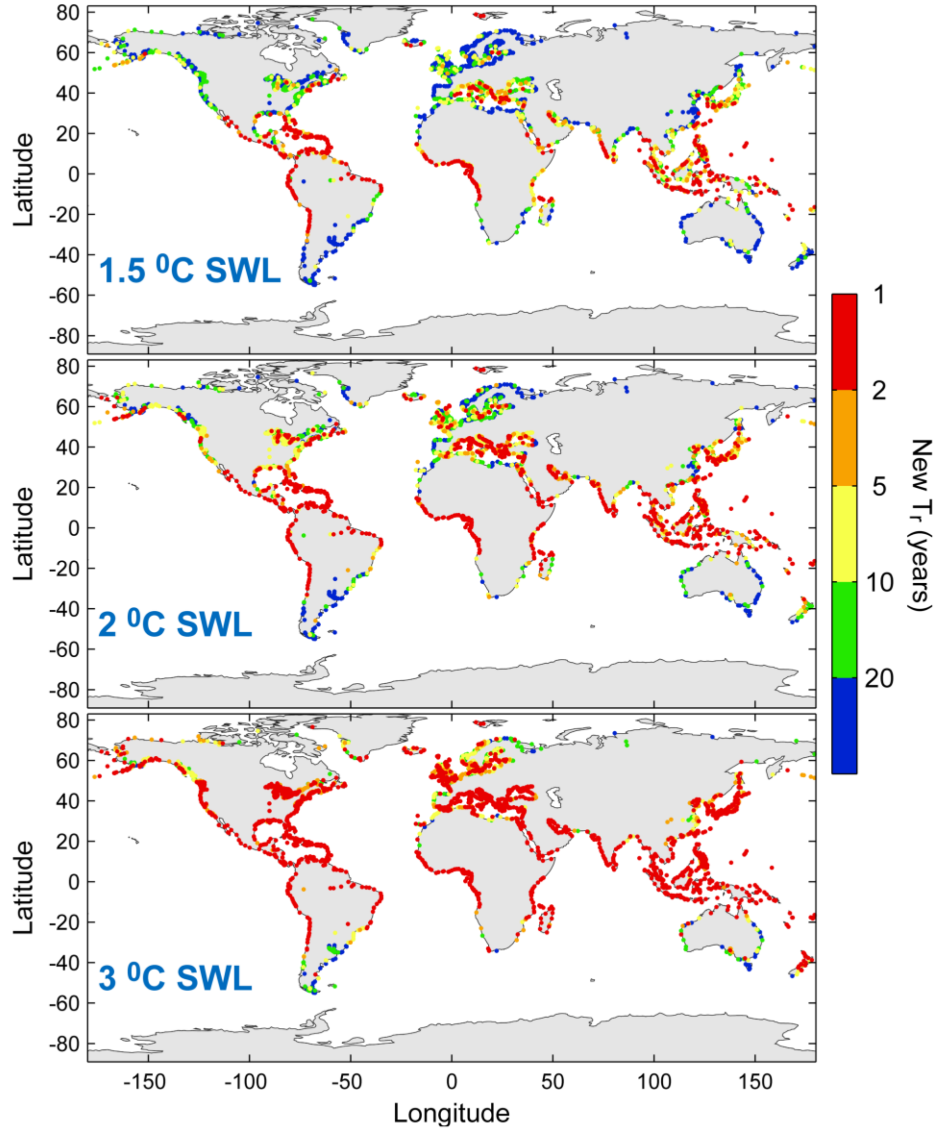
All global ports affected, with effects worsening as the SWL increases

Even under SWL of 1.5 ^{0}C, the return period of the baseline 1-in-100 years ESL will decrease to every 1 to 10 years in many S. American, African, Gulf S. East Asian and Pacific ports

Under a SWL of 3 ^{0}C, many global ports will experience the baseline 1-in-100 years ESL several times per year

Projected changes in the return period of the baseline (mean of 1986-2014)) 1-in-100 years ESL under CV &C for about 3700 global ports. *Key: SWL (Specific Warming Level) in ^{0}C above pre-industrial times. Tr (years) return period. Seaport location from World Port Index 2019 https://msi.nga.mil/Publications/WPI; hazard modelling results from JRC-EC*

Hazard projections for global ports under CV & C: Extreme Heat



<u>All global ports will be affected</u>, with the effects worsening as the SWL increases

<u>Even under a SWL of 1.5 ^{0}C</u>, the return period of the <u>baseline (1976-2005) 1-in-100 years extreme heat event will decrease</u> (down to every 1 to 5 years) <u>in most tropical/subtropical settings</u>

Under a SWL of 3 ^{0}C, <u>most global ports</u> (except some ports in higher latitudes) will experience the <u>baseline 1-in-100 years</u> event <u>at least every 2 years</u>

- Important implications for health & safety; energy needs/costs
- Energy efficiency/renewables/decarbonization: Important co-benefits

Projected changes in the return period baseline (mean of the period 1976-2005) 1-in-100 years extreme heat event at about 3700 global ports*. Key: SWL (Specific Warming Level) in degrees (^{0}C) above pre-industrial times. Tr (years) = return period.*

Port Impacts under Climate Variability and Change (CV & C)

Factor/hazard changes	Impacts on Seaports
Mean sea level rise (SLR)	Permanent inundation risk making ports inoperable without port elevation/coastal protection; changes in port and key transit access (e.g. the Kiel Canal); insurance issues
Increased extreme sea levels (ESLs); changes in wave energy/direction	Increasing frequency/depth of facility flooding and damages; losses due to operational delays; breakwater instability, scouring and overtopping from storm waves; increasing protection costs; wave penetration affecting operations; navigation channel silting-higher dredging requirements; insurance issues
Precipitation: Changes in means and/or in the intensity, type and frequency of extremes causing pluvial/fluvial flooding	Infrastructure flooding and damages; poor manouvrability of locks and vessels from changes in water level and speed; poor visibility from increasing fogs
Temperature: Higher means; heat waves; changes in warm/cool days	Deterioration of paved areas; inoperable cranes; navigational equipment/cargo damages; higher energy consumption for cooling; health/safety issues for personnel/passengers
Reduced arctic snow cover and ice	New arctic shipping routes, longer seasons, lower fuel costs; reductions in snow/ice removal costs; but arctic seaports will face increasing sea storm hazards
Permafrost degradation	Ground subsidence, slope instability,drainage issues, affecting port structural integrity
Wind: Changes in frequency/intensity of exteme events	Damages to terminals and navigation equipment; problems for vessel navigation and port berthing; difficult crane operations above certain wind speeds

How prepared are we?

UNCTAD Port Industry Survey on Climate Change Impacts and Adaptation (2018)

Respondent ports collectively handle more than 16 % of global seaborne trade

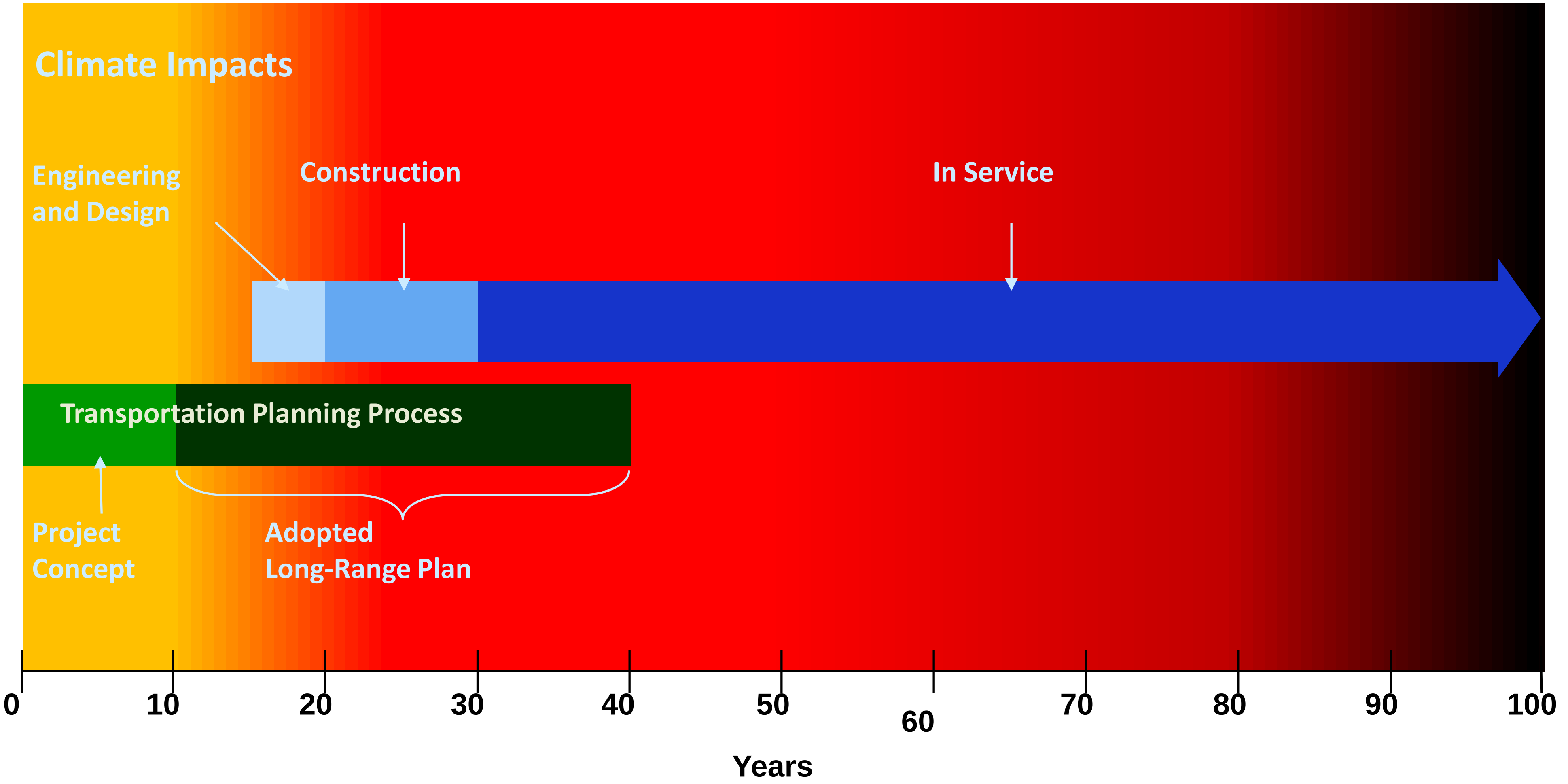
Survey revealed:

- Majority of respondents had been impacted by weather/climate related events, including by extremes
- Important gaps in information available to seaports of all sizes and across regions with implications for effective climate risk assessment/adaptation

Key messages: **Better data/information** needed; **mainstream CC considerations**; **'piggyback' climate resilience** when upgrading infrastructure/operations

Other surveys related to transport/ports provide similar results (e.g UNECE, 2013; NaviCC 2020)

Transportation Infrastructure: Timeframes vs. Climate Impacts



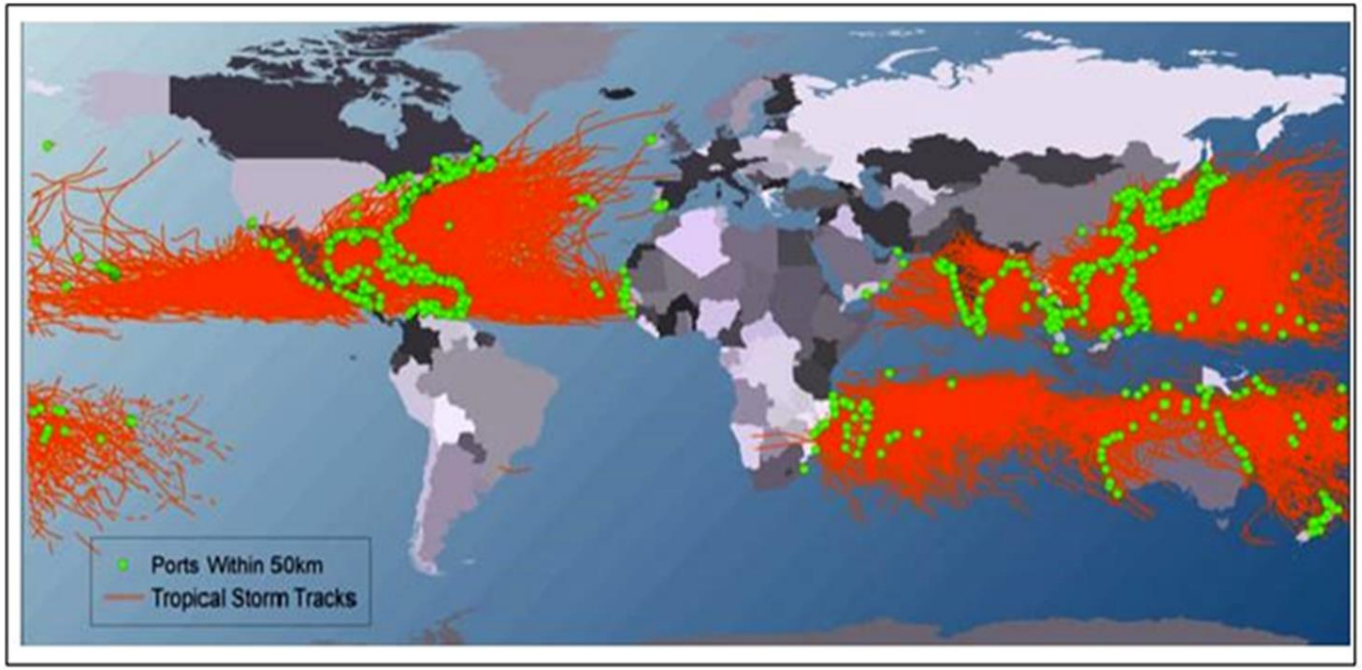
Source: Savonis, 2011

The special case of the SIDS

- Small (land mass/economies/population), remote & highly vulnerable to external shocks; large dependency on imports (i.e. international transport); high transport costs

  Key concerns: connectivity and transport costs (accessibility/affordability)

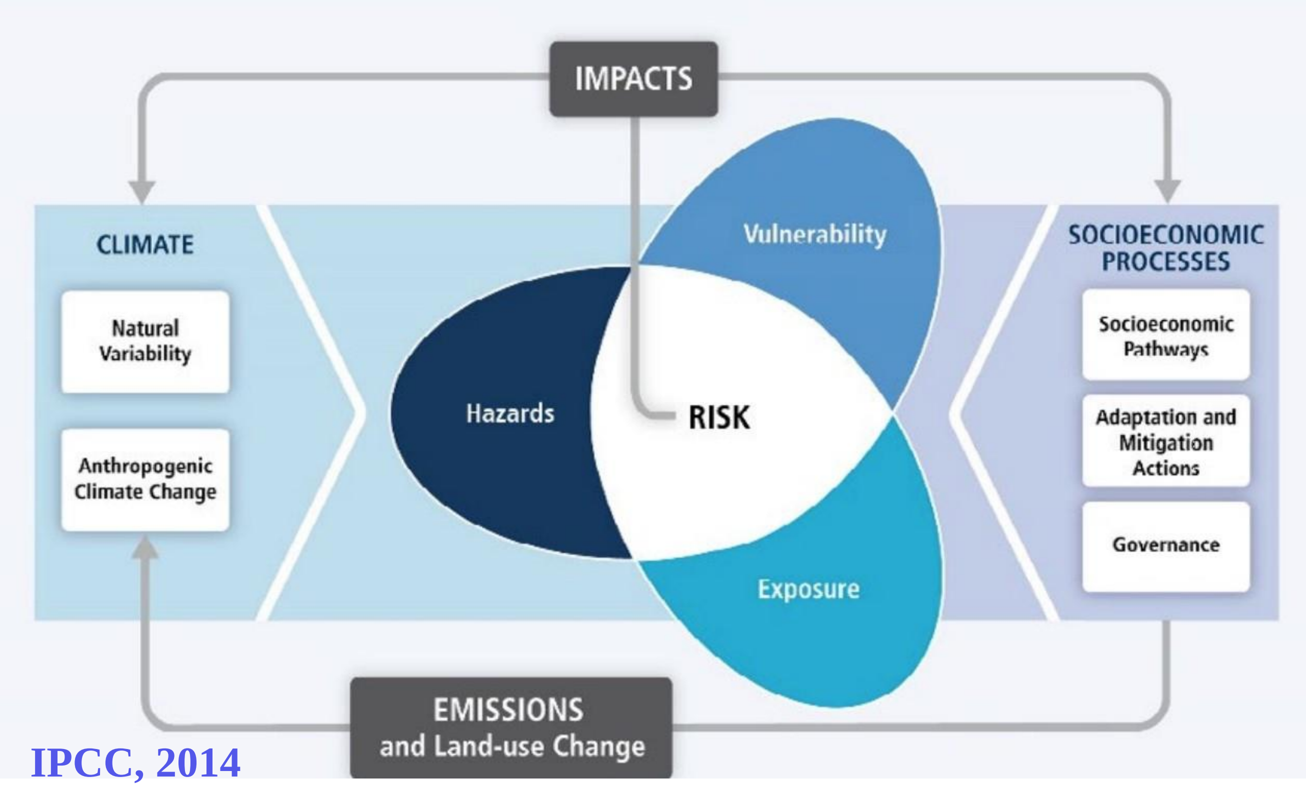
- High exposure to natural disasters and CV & C; low adaptive capacity
- Ports (and coastal airports): critical lifelines for external trade, food, energy, tourism and DRR **-** These assets are threatened by sea level rise and extreme events (storms)



Climate-resilience of ports is vital for the sustainable development of SIDS

Ports within 50 km of tropical sea storm tracks (1960–2010) *Data: Knapp et al. (2010). (Becker et al., 2013)*

Port Risk under Climate Variability and change (CV & C)



IPCC, 2014

Risk of impacts is a function of:

Climatic hazards - changing climatic factors, dependent on climate scenario/ emissions

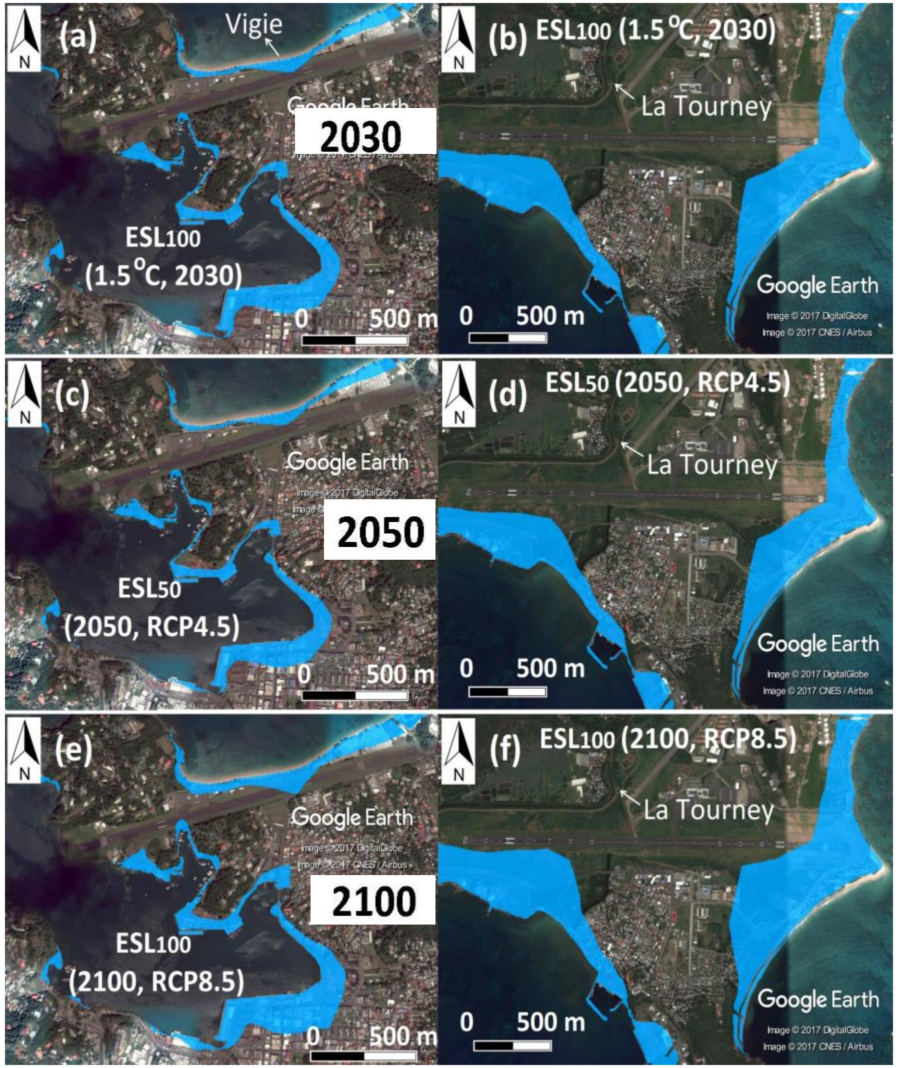
Exposure of port infrastructure /operations to hazards

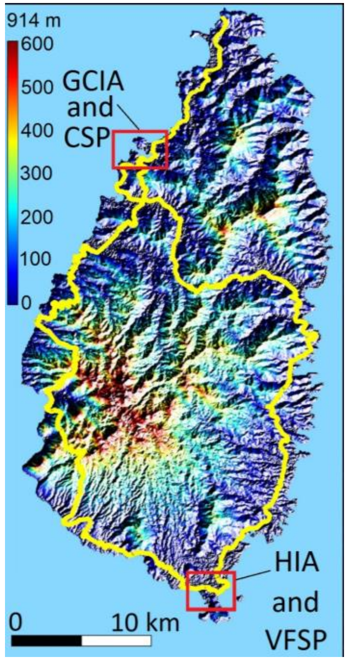
Vulnerability – depends on capacity to respond to factors that make ports prone to damages/losses from hazards, e.g. availability of technologies and materials for port defenses, elevation; human and financial resources; policy, legislation and management

Note: The IPCC risk definition differs from that of the Insurance Industry which defines risk as a function of the probability of the damaging event(s) and the magnitude of damages/losses: low probability events incurring large losses are high risks

Exposure - Coastal flooding projections under CV & C:

SIDSport-ClimateAdapt.unctad.org – 8 Ports and Airports in Jamaica and Saint Lucia





Exposure needs to be understood to adapt effectively

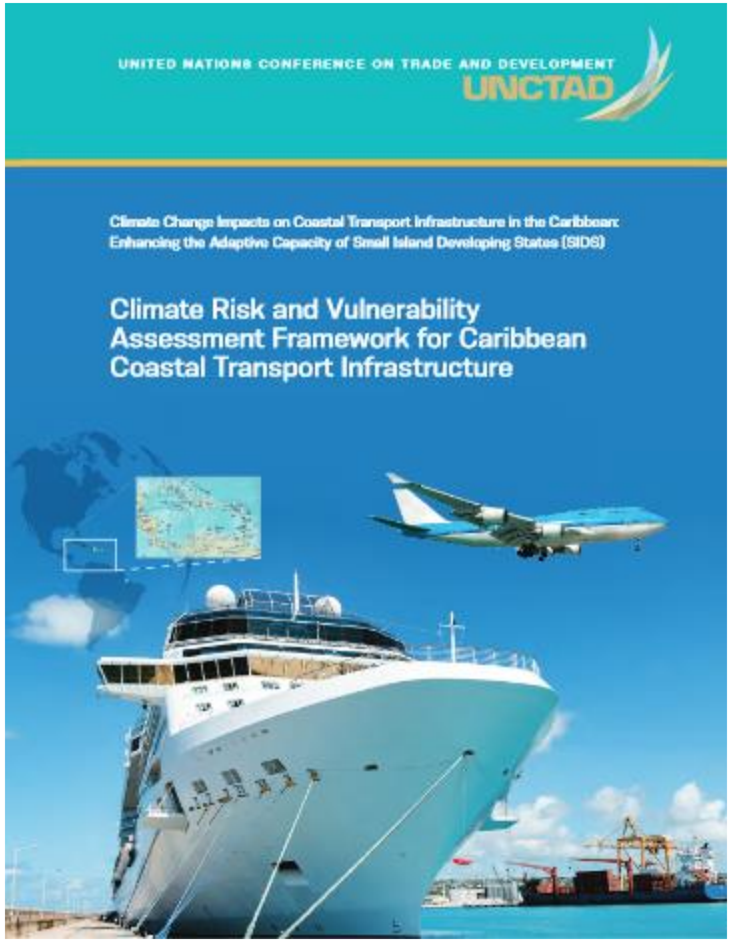
Requires assment at local / facility level

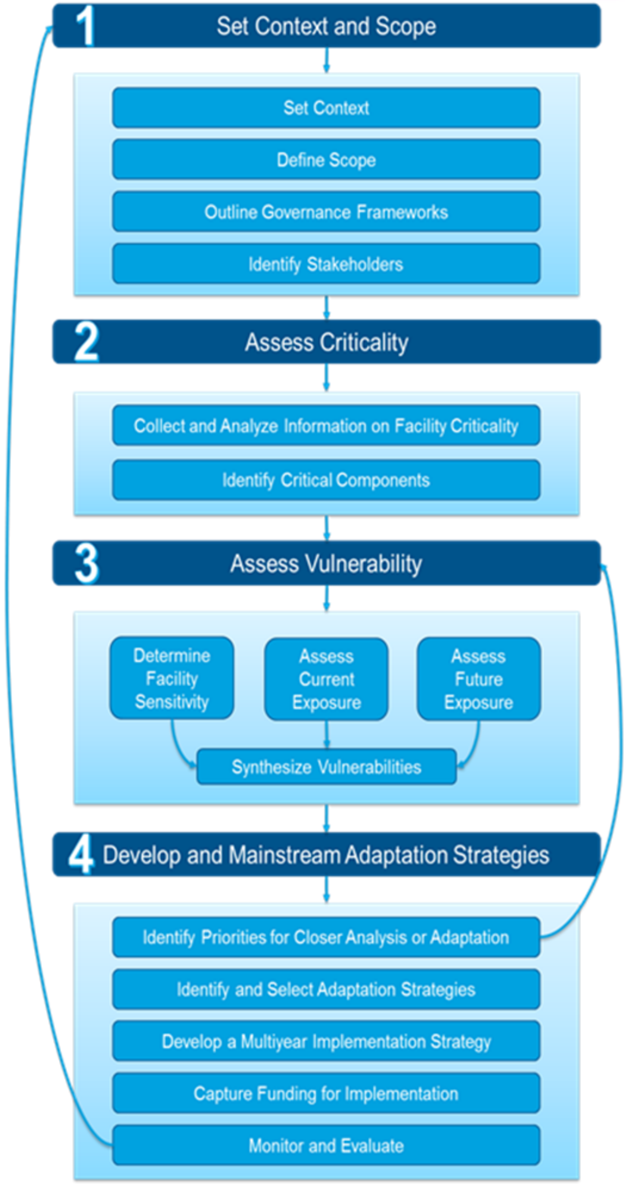
All international transport assets (seaports/airports) of Saint Lucia are **at high risk, under all scenarios, and from as early as 2030s**

Marine flood maps:
(a, c, e) George Charles Int. Airport; Castries seaport; (b, d, f) Hewanorra Int. Airport; Vieux Fort seaport for the: 1-100 year extreme sea level event, ESL100 (1.5C SWL, 2030); 1-50 year extreme sea level event, ESL50 (2050, RCP4.5); ESL100 (2100, RCP8.5). (Monioudi et al, 2018, Reg Env Change; IPCC 2018; IPCC SROCC 2019)

Exposure – Operational Disruptions under CV & C:

SIDSport-ClimateAdapt.unctad.org

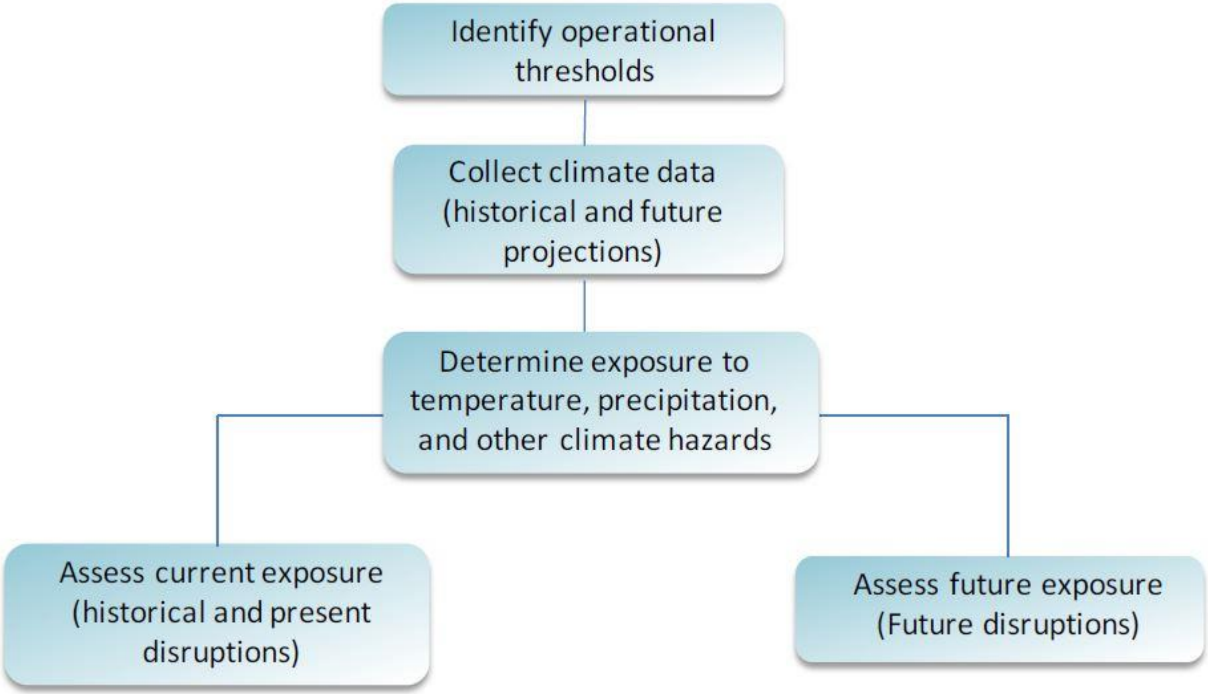




Exposure – Operational Disruptions under CV & C:

SIDSport-ClimateAdapt.unctad.org

The operational thresholds method



Gathering Operational Thresholds

Generic Standards and Thresholds

Example thresholds and their impacts from a variety of vulnerability assessments and literature source.

Component	Hazard	Example Threshold	Impact
Ports			
Operations	Extreme Heat	1°C warming = 5% increase in energy costs (in one illustrative terminal)	Energy costs
Paved surfaces		Depends on asphalt pavement grade	Asphalt pavement softening
Cranes	Heavy Rain	In Manzanillo, intense rainfall > 20 mm within 24 hours reduces visibility enough to impair operations	Low visibility inhibits crane operation
Goods handling		Precipitation > 1 mm within 24 hours	Inability to handle water-sensitive goods
Operations	Flooding	Conditions that cause flooding will vary by facility.	Flooding in some locations of the port could impair operations.
Docks	Tidal Flooding	Dock elevation/quay height	Flooding
Cranes	Wind Speeds	Varies by crane type. For example, 25 m/s (56 mph, 48.6 knots) for a CONTECON SSA	Ability to operate
Navigational channel		Varies by facility. For example, at Kingston Container Terminals (KCT) in Jamaica: • Winds ≥ 18 m/s (40.3 mph, 35 knots) force operational shutdown • With winds of 12.8-18 m/s (28.8-40.3 mph, 25-35 knots), discretion is applied	Ability to berth ships (due to waves)
Airports			
Runways	Extreme Heat	Runway length requirement varies based on plane type, weight, and runway length. Rule of thumb: Runway length requirements increase by 1% for every 1°C by which the mean daily maximum temperature of the hottest month exceeds 15°C (assuming runway is at sea level) (ICAO, 2006)	Ability of aircraft to take off
Flight operations		47.7°C (118°F)	Aircraft maximum take-off operational temperature
Personnel		Heat Index* over 39.4°C (103°F) is "high" risk Heat Index* over 46°C (115°F) is "very high" risk	Reduced employee ability to work safely outdoors (need for more breaks)
Flight operations	Heavy rain	Varies by airport	May decrease runway friction to aircraft cannot take off
Flight operations	Flooding	Any flooding on the runway can impair operations. Conditions that cause flooding will vary by airport.	Inability of aircraft to land or take off
Flight operations	Sea Level Rise	Runway elevation	Flooding on the runway
Flight operations	Wind Speeds	Commercial airports: sustained winds of 20 m/s (45 mph, 39 knots) or frequent gusts of 26 m/s (58 mph, 50.4 knots) General Aviation airports: 11.2 m/s (25 mph, 21.7 knots)	Inability of aircraft to land or take off

*Heat Index is a function of temperature and relative humidity. See http://www.nws.noaa.gov/om/heat/heat_index.shtml. For a relative humidity of 70%, Heat Index would exceed 39.4°C (103°F) at 32.2°C (90°F) and would exceed 46°C (115°F) at 34°C (94°F).

Operational thresholds method

SIDSport-ClimateAdapt.unctad.org – 8 Ports and Airports in Jamaica and Saint Lucia

On how many days per year will identified operational thresholds be exceeded under climate change?

Some key findings – at 1.5^{0}C Specific Warming Level, by 2030

- **Staff working outdoors at ports** and airports will be **at 'high' risk** for **5 days/year (Jamaica) and 2 days/year (Saint Lucia)**

N.B. Depending on climate scenario, high risk days **may increase to 30d/y and 55 d/y** (2081-2100)

- In **Jamaica**, Boeing 737-800 **aircraft** will have to **decrease their take-off load** for **65 d/y** at SIA and **24 d/y** at NMIA

- **Baseline energy requirements will increase by 4 % for 214 d/y at Jamaican ports** and **168 d/y** at **Saint Lucian** ports

Energy efficiency, decarbonization and renewables may offer important co-benefits for adaptation, energy security and costs

Action needed to adapt and build resilience

Accelerate action to ensure that by 2030 critical transport infrastructure is climate resilient to 2050 *(cf. MPGCA Milestones for 'Transport' and 'Resiliency')* - will be key in achieving progress on many SDGs (incl. 9, 13, 14 and 1.5)

High-quality risk and vulnerability assessments, based on the best available science/data needed to **improve understanding of impacts on ports,** guide effective **adaptation responses and prioritization of resources**

- **Improve data** collection/availability; **plan early** (asset lifespan); adopt **systems approach**; **avoid maladaptation**/over-engineering;
- **Mainstream** CC considerations in port infrastructure planning/operations;
- **Ensure funding for technical studies to inform priorities, effective policies, plans, action**;
- **Increase capacity building (human resources, at local levels) and better access to affordable climate finance**;
- **Ecosystem approaches to adaptation:** important elements in any future strategy;
- Successful adaptation strategies need to be underpinned by strong **legal, regulatory and policy frameworks**; as well as **standards** (eg ISO 14090), **guidance** (eg PIANC), **methodological tools** (eg UNCTAD)
- Integrate relevant considerations into **National Adaptation Plans** and NDCs

Many thanks!

UNCTAD PLS: climate change implications for maritime transport

2009 Follow-up	**UNCTAD Multiyear Expert Meeting: "*Maritime Transport and the Climate Change Challenge*"** UNCTAD ed. multidisciplinary book: **Maritime Transport and the Climate Change Challenge** UN-Earthscan (2012)
2010 Follow-up	**Joint UNECE-UNCTAD Workshop: "*Climate change impacts and adaptation for international transport networks*"** UNECE *Group of Experts on Climate Change Impacts and Adaptation for International Transport Networks* 2013 EG Report - *Climate Change Impacts and Adaptation for International Transport Networks* 2020 EG Report - *Climate Change Impacts and Adaptation for International Transport Networks*
2011 Follow-up	**UNCTAD Ad Hoc Expert Meeting**: **"*Climate Change Impacts and Adaptation: a Challenge for Global Ports*"** Becker et. al, **A note on climate change adaptation for seaports**, Climatic Change, 2013
2014	**UNCTAD Ad Hoc Expert Meeting: "*Addressing the Transport and Trade Logistics Challenges of SIDS: Samoa Conference and Beyond*"** **UNCTAD Multiyear Expert Meeting: "*Small Island Developing States: Transport and Trade Logistics Challenges***
2017-18	**UNCTAD Port-Industry Survey on Climate Change Impacts and Adaptation**
2015-2017 Follow up	**UNCTAD DA Project - SIDSport-ClimateAdapt.unctad.org *"Climate change impacts on coastal transport infrastructure in the Caribbean: Enhancing the adaptive capacity of Small Island Developing States (SIDS)*** Monioudi et. al, **Climate change impacts on critical international transportation assets of Caribbean SIDS: the case of Jamaica and Saint Lucia**, Reg Environ Change 2018: 2211
2019-2020 **2021**	**UNCTAD Ad Hoc Expert Meeting: *"Climate Change Adaptation for International Transport: Preparing for the Future"*** **UNCTAD – UNEP *"Climate-resilient transport infrastructure for sustainable trade, tourism and development in SIDS"*** *Climate Change Impacts and Adaptation for Coastal Transport Infrastructure: A Compilation of Policies and Practices* **UNCTAD Multiyear Expert Meeting**: *"Climate Change Adaptation for Seaports in Support of the 2030 Agenda"* **Climate change impacts on seaports: a growing threat to sustainable trade and development** (2021)

Climate Change Adaptation Planning for Ports

Jan Brooke

PIANC – The World Association for Waterborne Transport

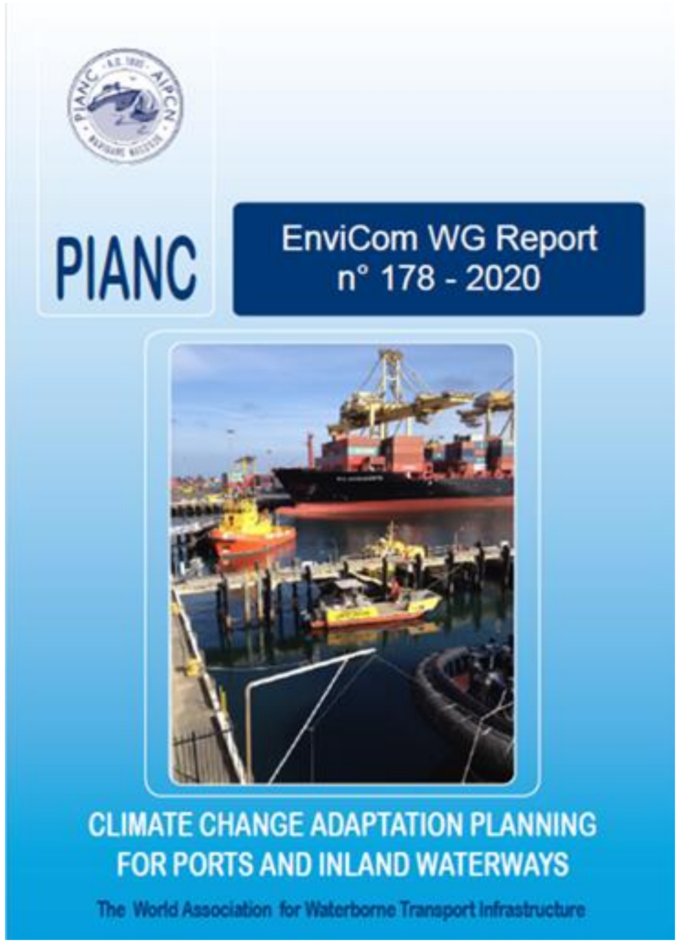
Chair, Permanent Task Group on Climate Change

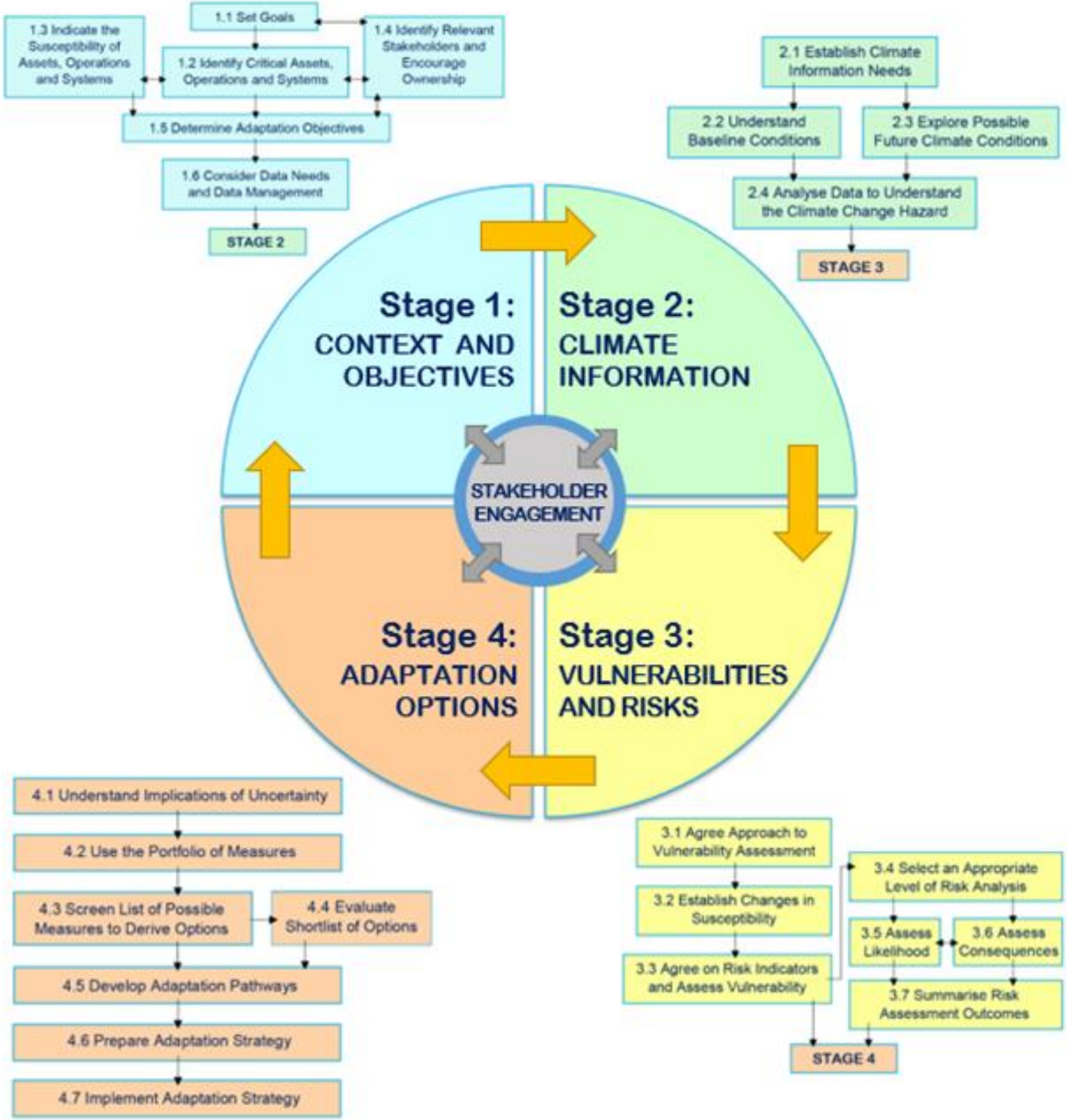
Presentation at Practical Climate Change Adaptation Solutions for Ports conference

COP26 International Maritime Hub, 2nd – 3rd November 2021

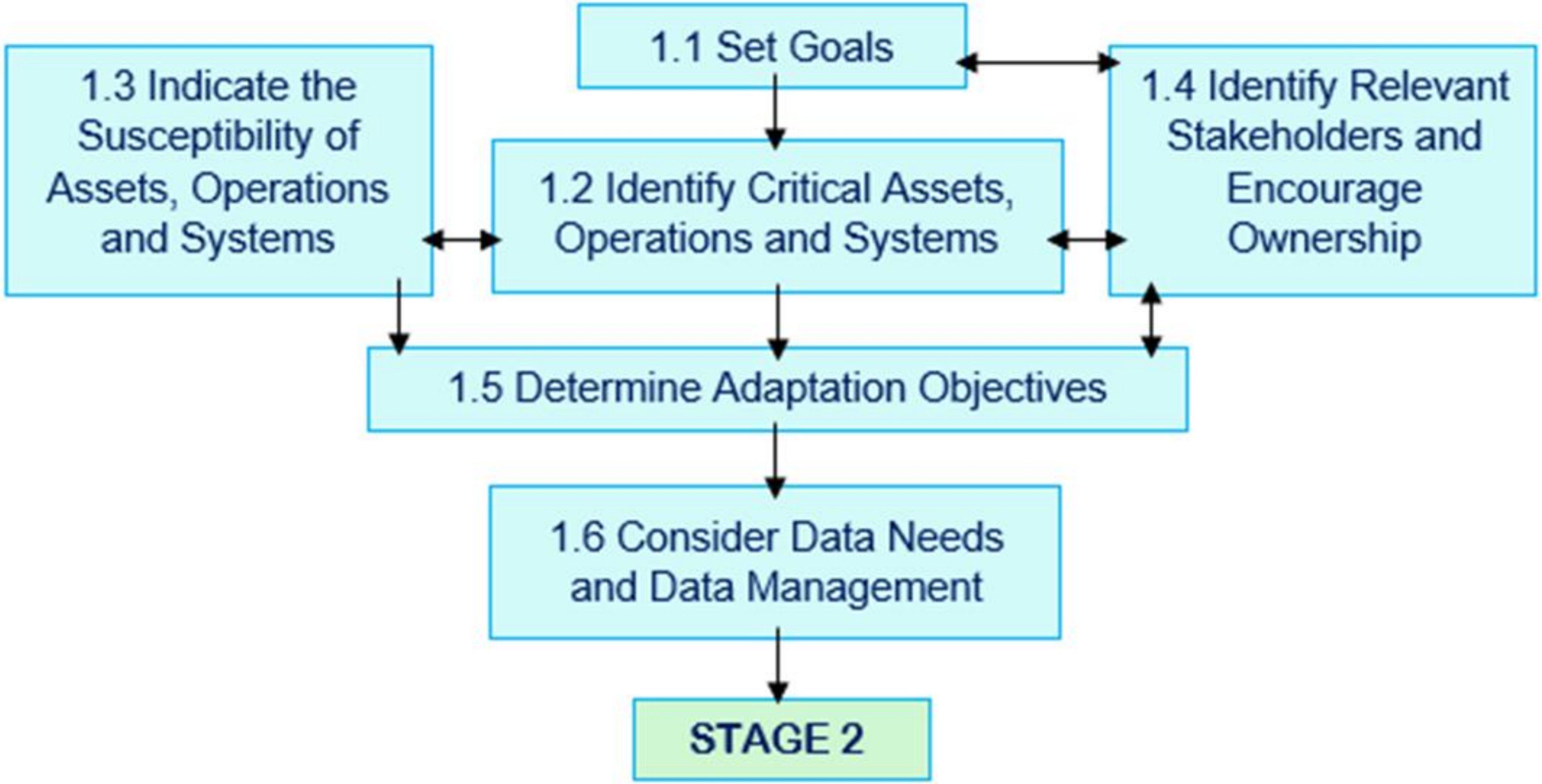
Introduction to PIANC

- **PIANC** – the World Association for Waterborne Transport Infrastructure, established 1885 https://www.pianc.org/
- Provides the global waterborne transport community with expert guidance and technical advice
- Technical Commissions include MarCom, InCom, RecCom, EnviCom
- Permanent Task Group on Climate Change **PTGCC**: a cross-Commission group dealing with climate issues and related guidance
- Three recent climate-related guidance documents: carbon management (WG 188), resilience of maritime and inland waterborne transport systems (WG 193) and adaptation planning (WG 178)




1.1 Set Goals
1.2 Identify Critical Assets, Operations and Systems
1.3 Indicate the Susceptibility of Assets, Operations and Systems
1.4 Identify Relevant Stakeholders and Encourage Ownership
1.5 Determine Adaptation Objectives
1.6 Consider Data Needs and Data Management
STAGE 2
2.1 Establish Climate Information Needs
2.2 Understand Baseline Conditions
2.3 Explore Possible Future Climate Conditions
2.4 Analyse Data to Understand the Climate Change Hazard
STAGE 3
Stage 1: CONTEXT AND OBJECTIVES
Stage 2: CLIMATE INFORMATION
STAKEHOLDER ENGAGEMENT
Stage 4: ADAPTATION OPTIONS
Stage 3: VULNERABILITIES AND RISKS
4.1 Understand Implications of Uncertainty
4.2 Use the Portfolio of Measures
4.3 Screen List of Possible Measures to Derive Options
4.4 Evaluate Shortlist of Options
4.5 Develop Adaptation Pathways
4.6 Prepare Adaptation Strategy
4.7 Implement Adaptation Strategy
3.1 Agree Approach to Vulnerability Assessment
3.2 Establish Changes in Susceptibility
3.3 Agree on Risk Indicators and Assess Vulnerability
3.4 Select an Appropriate Level of Risk Analysis
3.5 Assess Likelihood
3.6 Assess Consequences
3.7 Summarise Risk Assessment Outcomes
STAGE 4

Stage 1: Understand context and set objectives

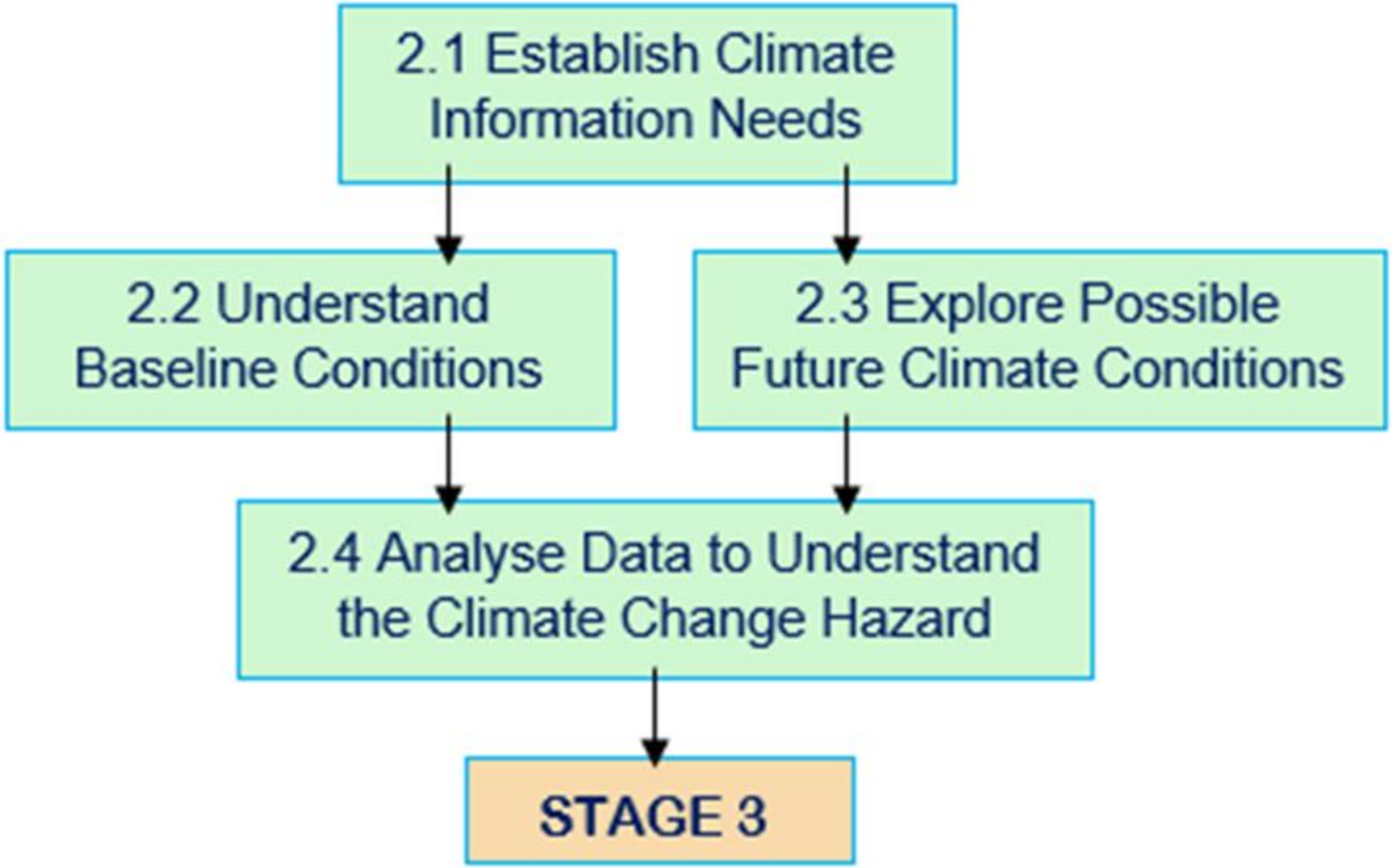


Stage 1: Key considerations

Stage 1: engage with stakeholders, develop goals, prepare inventory of critical infrastructure, establish roles and responsibilities, set objectives

- **Interdependencies**: onward transport, utilities, services, other sectors, local communities, etc. – internal and external collaboration can help to identify mutually beneficial solutions and thus reduce adaptation costs
- **Criticality**: can relate to business continuity needs; network connectivity issues; threshold exceedances; health and safety requirements; etc.
- **Adaptive capacity**: to what extent can an asset or system cope with change? Monitoring and awareness are vital for informed decision making
- **Acceptable level of risk**: the basis for setting adaptation objectives

Stage 2: Collate climate data

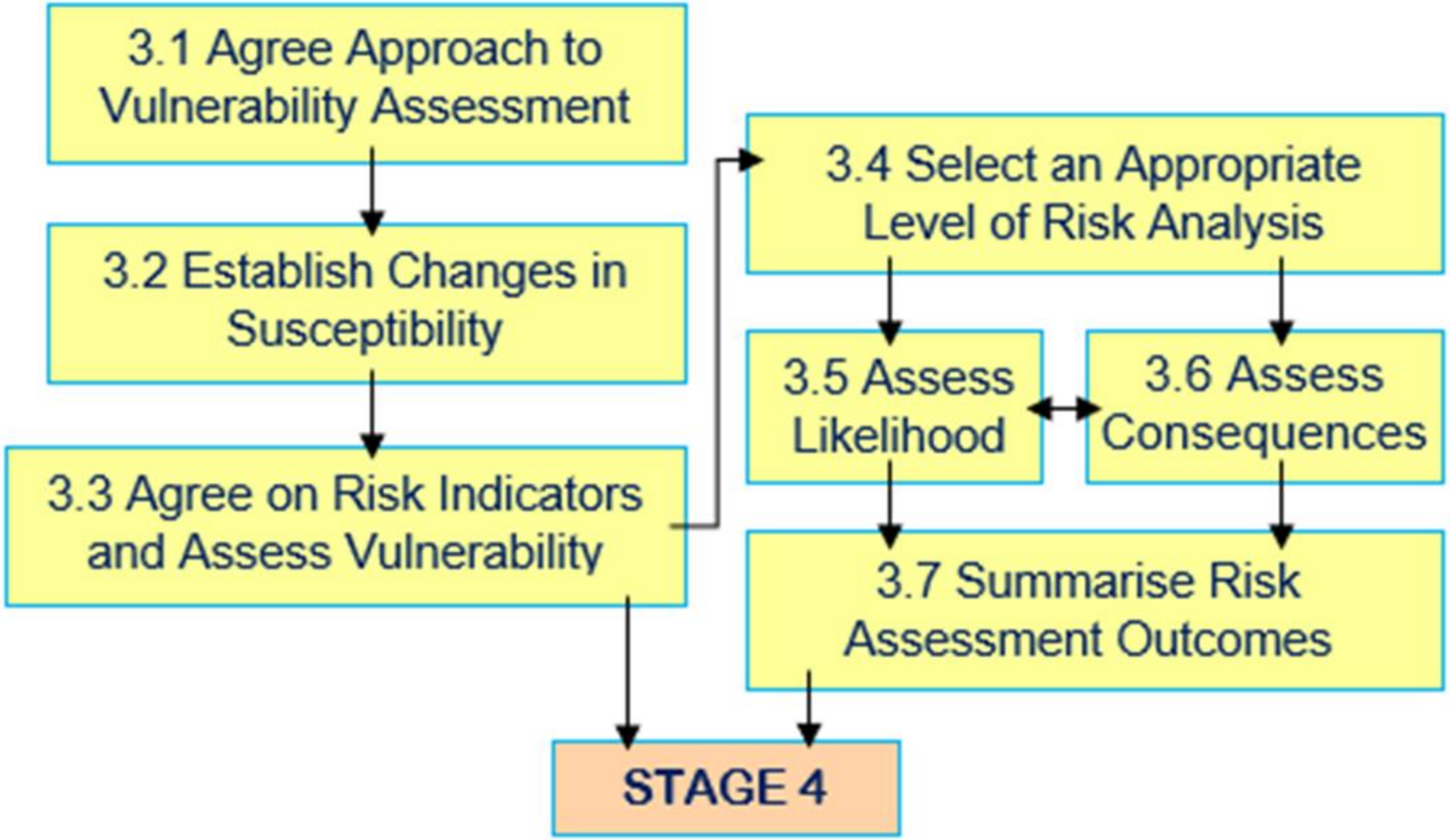


Stage 2: Key considerations

Stage 2: understand baseline conditions and future climates (projected changes)

- In addition to projected **trends** in weather-related, hydro-meteorological or oceanographic parameters, take account of increases in the frequency or severity of **extreme events**, and possible **joint occurrences**
- To reduce the risk of **maladaptation** (implementing a measure that proves inadequate or excessive) develop and use a range of plausible climate change **scenarios**; can include ‘most likely’ and ‘worst case’ scenarios
- The **planning horizon** is important!

Stage 3: Assess vulnerabilities & risks

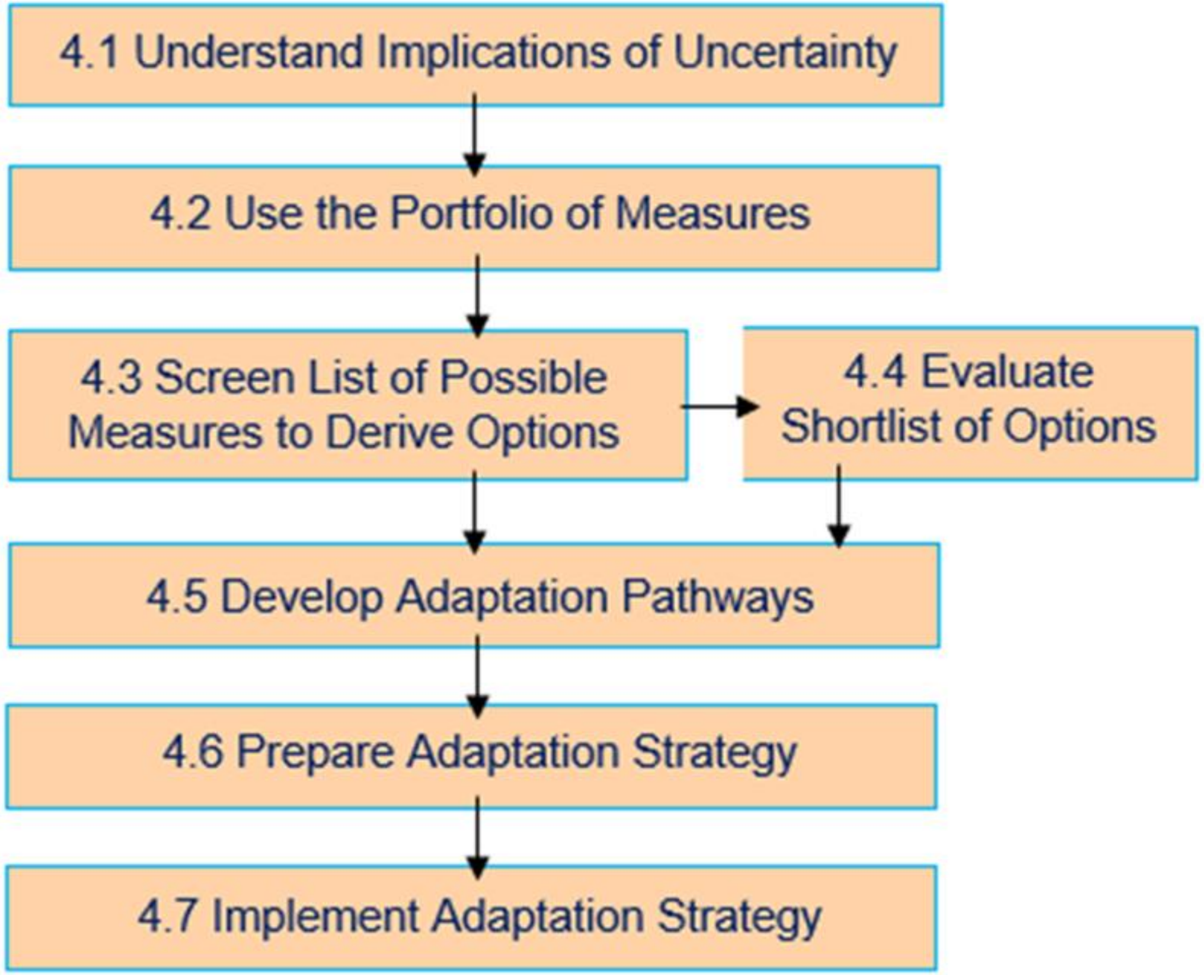


Stage 3: Key considerations

Stage 3: identify and assess risks, exposure, vulnerability, adaptive capacity, costs and consequences of inaction, timing of impacts, overview of risks

- **Risk assessment** can be simple or complex, but vulnerability assessment may suffice
- Change in climate parameters can have a **range of consequences**, positive as well as negative; direct and indirect
- Preparing a simple **colour-coded matrix**, highlighting the main risks, can be a useful aid to decision making

Stage 4: Assess adaptation options



Physical measures Structures; systems; technologies; services	Social measures People; behaviour; operations; information	Institutional measures Governance; economics; regulation; policy
Prioritise **maintenance** to maximise resilience and improve adaptive capacity Install **real time monitoring** infrastructure **Relocate vulnerable assets** out of high risk areas Invest in **redundancy**, temporary infrastructure or other back-up provision for critical assets (including power and water supply) **Reinforce, raise, strengthen** or otherwise protect or modify critical assets Install or develop new, **responsive** or **demountable infrastructure** or equipment Install **warning equipment** Nominate or provide physical **sanctuaries** Increase **storage capacity** Install **multi-modal equipment** Apply **Nature-Based Solutions**; Working with Nature; soft engineering Install **treatment** or **reception facilities** Incorporate **flexibility** in new or replacement infrastructure design to allow for modification as conditions change Modify **material or equipment selection** to accommodate changing conditions	Undertake climate change **risk assessment**; prepare **risk maps** **Prepare** and **raise awareness** of contingency, emergency or disaster response **plans** Introduce and regularly review **warning systems** Prioritise **asset inspection** **Educate** workforce, stakeholders, local communities Liaise and **coordinate with utilities** and other service providers; develop **information-sharing** protocols Improve (or instigate) **monitoring, record keeping** and **data management**; consider cyber-security issues Undertake trend analysis or **forecasting** Develop **revised operational protocols**; modify **working practices** as conditions change Introduce and implement **adaptive management** procedures; base operations or working arrangements on monitoring outputs Allow for **flexibility** and responsiveness in programming (staffing **rotas**, vessel **scheduling**, lock operation, etc.) Revert to **traditional, low tech,** ways of operating Ensure availability of **transport** and **accommodation** for personnel during an incident **Temporarily** or **permanently restrict** activities in high risk areas Nominate **safe routes** and **areas**; identify **diversions** Identify and exploit **interconnectivity** and **intermodal options** to maintain business continuity during events Provide **training** on new tools, codes of practice, procedures or **protocols**; ensure importance of **redundancy** is understood Facilitate **technology transfer**	Prepare strategic level climate change **adaptation strategies** Review and revise relevant **codes of practice, standards, specifications or guidelines** to accomodate changing conditions Review **health and safety** requirements and revise if needed Introduce **penalties** for non-compliance with standards Require **zoning** of assets, operations or activities based on risk Use local regulations (e.g. **byelaws**) to reduce risks, especially in multi-use locations Encourage **relocation** out of high risk areas Collaborate with **land-use planning** systems e.g. to introduce **set back** or **buffer areas** **Limit new infrastructure development** in high risk areas Identify, secure and coordinate **alternative transport routes or modes** Promote **reduced insurance premiums** if improved resilience is demonstrated Set up **contingency** or disaster response **fund** Introduce and enforce **build-back-better** policy Facilitate **diversification** in facilities; employment as conditions change Improve **legal protection** for vulnerable habitats with risk reduction role (e.g. absorbing wave energy, providing erosion protection) Provide **grants or incentives** e.g. for development or maintenance of resilient infrastructure **Research** and develop novel tools and methods

Stage 4: Key considerations

Stage 4: identify, screen, evaluate, implement and monitor measures, prepare an adaptation strategy, manage data effectively

- Consider **consequences of inaction**/incremental cost of climate-resilience
- Climate change will often need **innovative, flexible solutions**
- Prepare **adaptation pathways**; consider temporary or **low-regret** measures
- Retrofitting can be costly and complex; understand **adaptive capacity**
- Option **evaluation** can be simple but note that conventional evaluation methods may not be the most appropriate for use in climate change decision making

Role of monitoring

Develop **monitoring** and **data management** programmes to inform decisions on *when* action is needed

- Monitor **asset condition**, operational characteristics, performance at system level
- Collect data; where relevant develop **real-time** monitoring and **early warning** systems
- Record costs/consequences of extreme events/disruption to **support business case**
- **Monitoring** does not need to be sophisticated; must be **fit-for-purpose**
- Effective data management is critical to **just-in-time** decision making
- Prioritise **maintenance** to maximise resilience, improve adaptive capacity
- **Adaptive management** can help deal with uncertainties but needs data

Thanks for listening!

https://www.pianc.org/publications/envicom/wg178

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PANEL
DISCUSSION

THANK YOU