# Port of Manzanillo: Climate Risks and Opportunities

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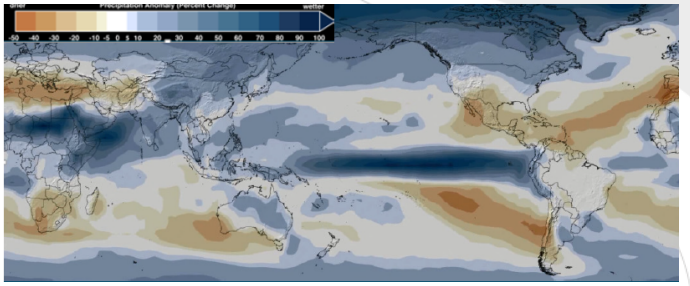
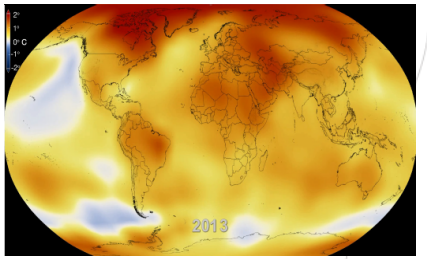
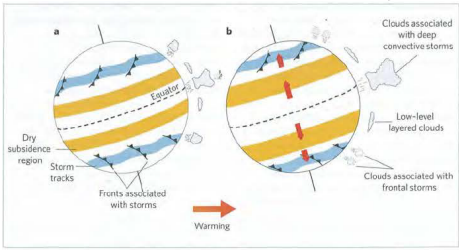
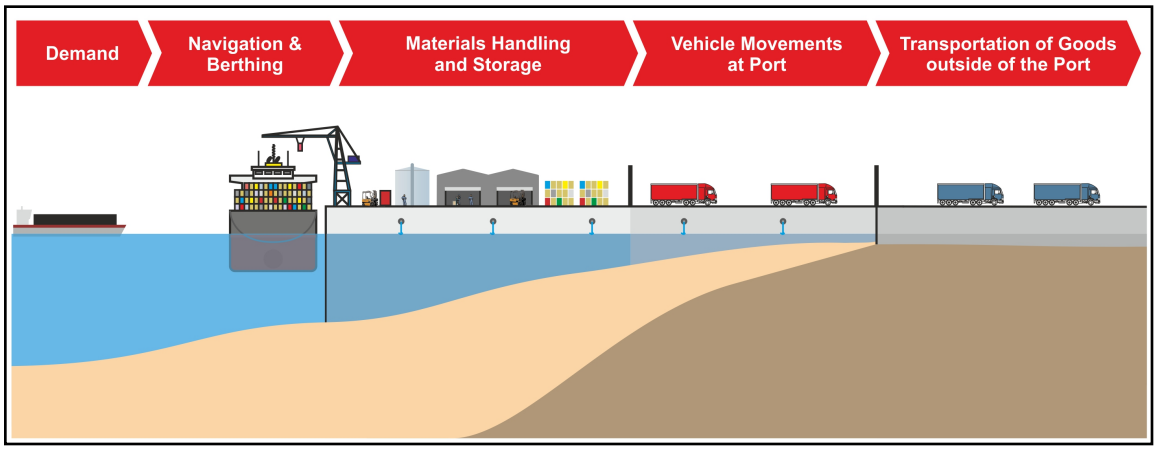
# Ports and climate change

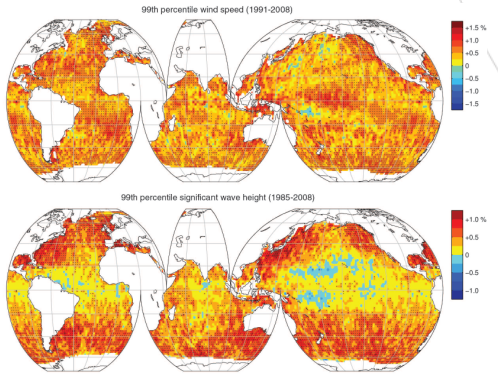
- Globally, about 90% of goods transported by ships
- Ports and related infrastructure are long-lived key assets, sensitive to climate
- Locations, on coasts, rivers or lakes, exposed to impacts
- Dependence on trade, shipping and inland transport which are also climatically-vulnerable
- Reputation and consequent customers' choice heavily influenced by port's reliability





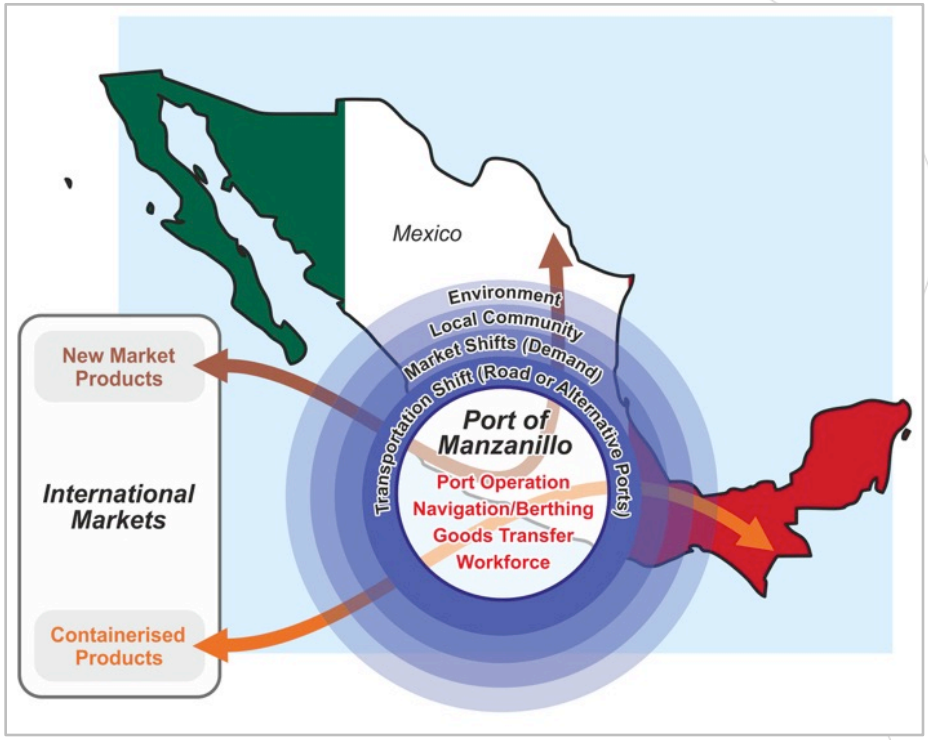
# Port of Manzanillo

- Considered Mexico's leading port on the Pacific coast (47% of Mexico's total TEUs)
- Important regional traffic hub, maintains active trade relationships with over 14 countries worldwide.
- Containerized cargo, bulk minerals, general cargo, agricultural bulk, petroleum
- 14 terminals under concession, managed by private investors
- Total static capacity >49,000 TEUs

- What are the implications of a changing climate to the port (financial, environmental and social performance)?


# Approach

- Risk-based adaptation decision-making
  - Port objectives and success criteria
  - Evaluation of vulnerabilities and risks
  - Identification of adaptation measures
  - Appraisal of measures
- Value-chain approach
- Financial analysis of risks
- Cost-effectiveness of adaptation measures
- Approach aligns well with national guidance




Schematic of Port of Manzanillo value chain and areas evaluated in the study (Source: Report authors)

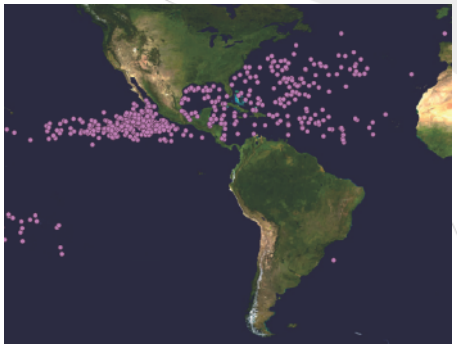
# Temperature, precipitation, wind

- **Temperature:** projected increase relative to 1979-2000, RCP 8.5 is around 1°C in 2020s and 2°C by 2040s

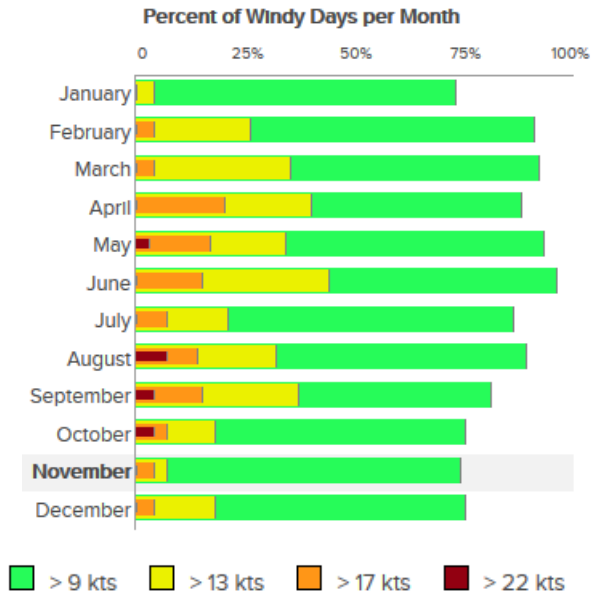
- **Precipitation:** mean dry season rainfall decreasing by 2.7 mm/ year
- High rainfall extremes: significant increasing trend in some months

- **Winds:** predominant winds generally light except when a tropical storm or tropical cyclone is nearby

- **Cyclones:** observed pole-ward migration in tropical cyclones, 50 km per decade (1982 to 2012)
- Science does not yet provide definitive answers about future changes in tropical cyclones (frequency, intensity) but possible increase in Cat. 4 and 5 cyclones



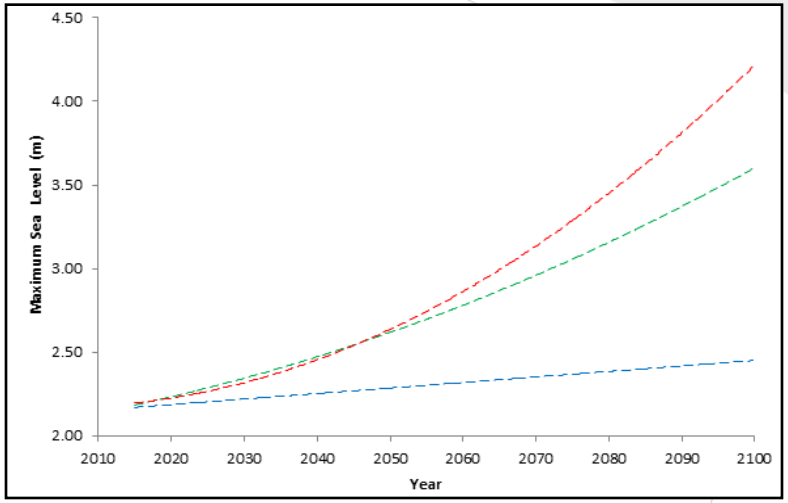
Distribution of tropical cyclones at their maximum intensities.
(Source: Ramsay, 2014)




(Source: Sailflow, 2015)

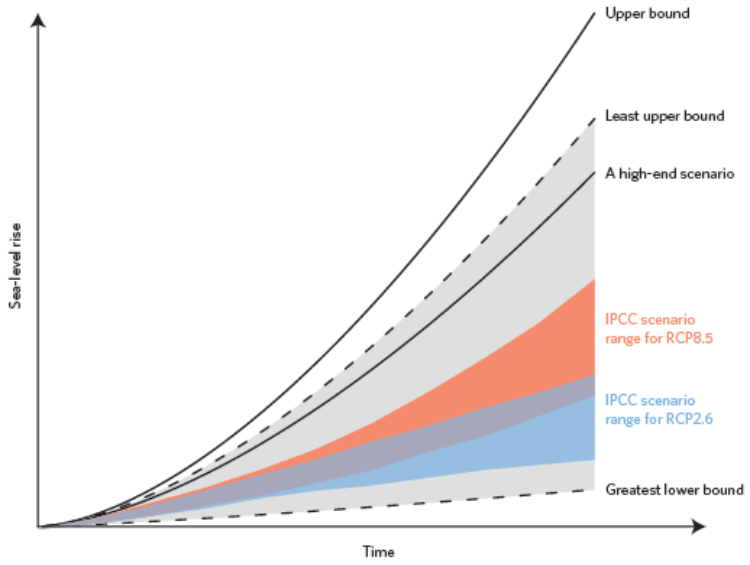
# Sea levels

- Sea level rise of 3.3 mm/year recorded (1952-82; gauge moved in 1992)
- Tidal + Seasonal + El Niño maximum contributions to sea level are +0.7 m
- Storm surge heights:
  - 1 in 250 year event: +2.53 m above mean sea level
  - 1 in 500 year event: +2.85 m above mean sea level




Low, moderate and worst case sea level scenarios (mean SLR plus tidal, seasonal and ENSO fluctuations). (Source: Report authors).

- 3 scenarios of mean sea level rise (SLR) + maximum tidal components + increasing storm surge:
  - Observed scenario: 3.3 mm/year constant until 2100 + 1:100 year storm surge
  - Moderate 'accelerated' scenario: IPCC low range + 1:250 year storm surge
  - High 'accelerated' scenario: IPCC high range + 1:500 year storm surge

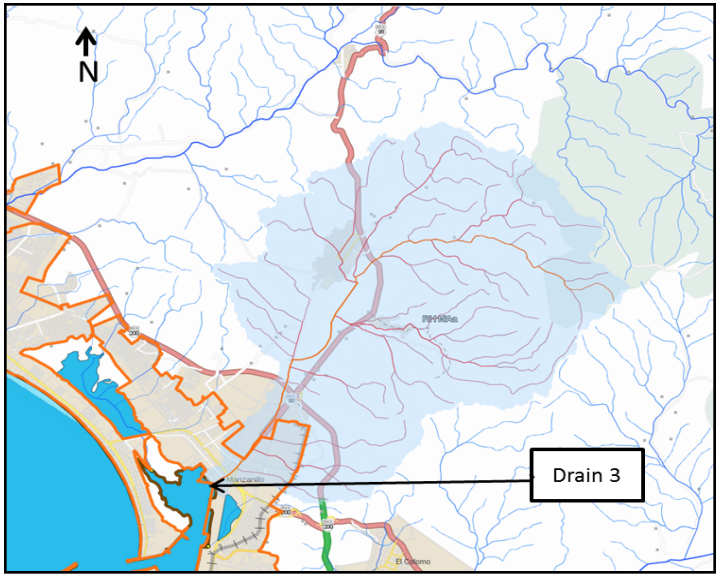



- <u>SLR projections are changing: models and observations</u>

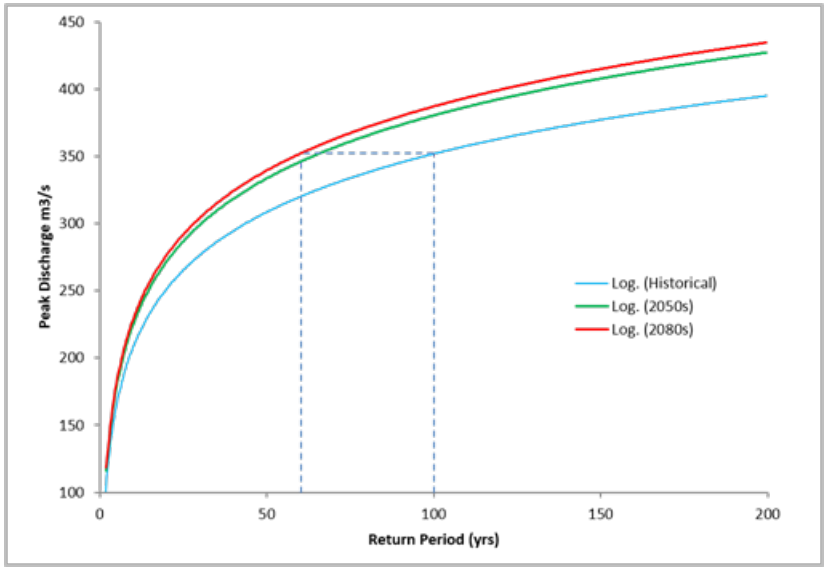
# Hydrology

- Rainfall drainage concentrating in the port
- High rainfall events and debris accumulation => insufficient drainage capacity and flooding
- Main port entrance, internal access road, rail connections: almost annual surface water flooding

- Expected future increase in flow of drainage water entering the port
- Likelihood of a flooding event is estimated to almost double by 2050




Port catchment area and Drain 3 that commonly overflows. (Source: CNA, 2014)




Changes in peak discharge flows. (Source: Report authors)

# Prioritization of risks

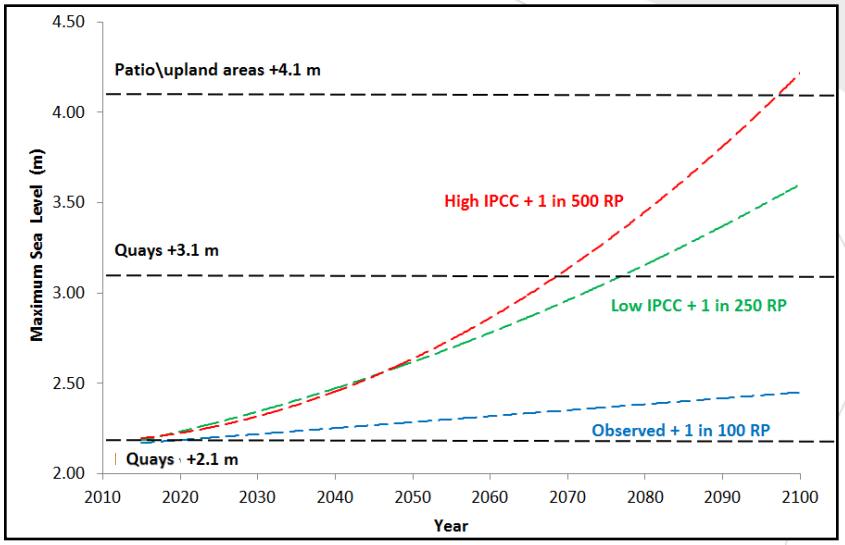
Each identified risk evaluated against four key criteria:

1. Current vulnerability is high
2. Projected impacts of climate change are large
3. Adaptation decisions have long lead times or long-term effects
4. Large uncertainties - scale of future risk is uncertain but could be large

- Risk rated ‘high’ against two or more criteria → high priority risk
- Risks where current vulnerability rated ‘high’ → high priority risk

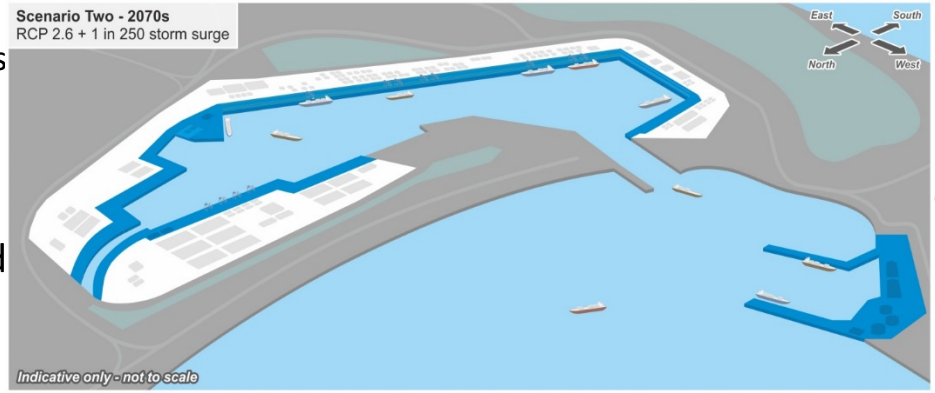
# Seawater flooding stopping goods handling

- Flood risk (depth >30cm) to affect some infrastructure by 2040 with 1:250 year storm surge
- Flood risk to most terminal quays an issue by 2070s, moderate sea level rise + 1:250 year storm surge
- General inundation of port patio and upland areas only for the 'worst case' SLR scenario combined with 1:500 year storm surge event*




Maximum potential sea level (mean SLR + tidal\seasonal\ENSO + storm surge) (Source: Report authors)

- Physical and operational adaptation options can be considered for extreme mean SLR*:
  - Raise quay heights (in the long term)
  - Maintain natural coastal defenses provided by mangroves
  - Retrofit critical equipment and infrastructure that is vulnerable to flooding
- At the moment, financial losses and damages would typically be covered by insurance




Areas of port at risk of flooding by 2070s, from mean SLR + 1 in 250 year storm surge (Source: Report authors)

# Rain causing disruption to goods handling

## Light rain

**Bulk mineral/agricultural terminals**

Product quality can be affected so stops (un)loading e.g. vessel hatches closed

**Future: Fewer days with rain are expected**

23% decrease in number of rainy days by 2040s

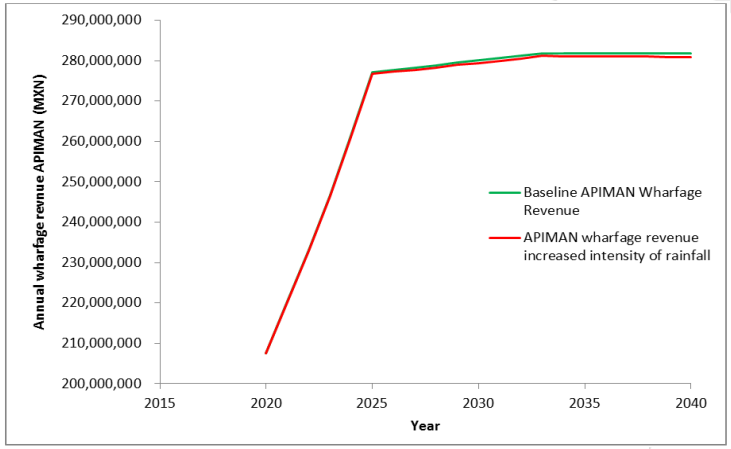
## Heavy rain

**Container terminals**

Handling stopped due to reduction in visibility for crane and forklift operators

**Future: More intense rain is expected**

90% increase in number of heavy rain days (>20mm/day) by 2040s




API Manzanillo lost wharfage revenue due to increased intense rainfall events (undiscounted). (Source: Report authors).

- Financial impact on terminals and API Manzanillo is relatively minor
- Operational downtime for containerized cargo handling due to intense rainfall is estimated to increase from 0.1% at present to 0.2% by the 2040s

- Increased covered handling areas, review of handling procedures can be considered
- Overall drier conditions may result in less disruption for bulk mineral and agricultural terminals

# Damage to port equipment and infrastructure

## Surface water flooding

- Flooding damage already costly
- Future increase in maximum tropical storm intensity and greater flooding events
- Increased costs for
  - maintenance of internal roads/customs area
  - maintenance dredging
  - drain maintenance

Manzanillo post Hurricane Jova 2011. (Source: API Manzanillo).

## Extreme wind speeds

- Likelihood of category 4/5 hurricanes expected to increase
- Potential exceedance of design thresholds for equipment (e.g. cranes)

Clearing mangrove channel post Hurricane Bud 2012. (Source: API Manzanillo).

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**Tropical depression 20E is forecast to strike Mexico as a hurricane at about 21:00 GMT on 23 October.**
Reuters, Tue, 20 Oct 2015 03:55 GMT

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**Intense hurricane Patricia struck Mexico at about 21:00 GMT on 23 October.**
Reuters, Fri, 23 Oct 2015 10:00 GMT

# Port services

## Navigation and berthing

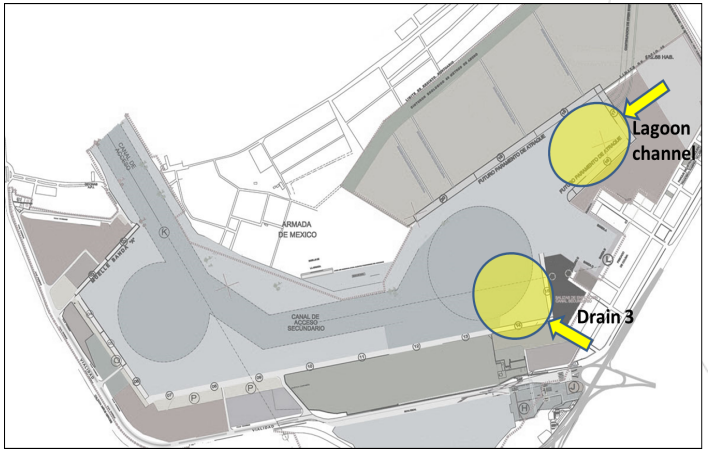
- Inner harbor is highly sheltered and inner terminals not affected by normal wind and wave activity
- One terminal is outside the harbor, less protected
- 5% downtime in 2014 due to adverse weather; downtime determined by proximity of storms

- Physical improvements: rock fill embankment, concrete drawers, operability assessment in case of changes in tropical storms

## Sedimentation and terminal access

- Sedimentation reduces draft clearance close to the quays
- Presence of dredging vessel disrupts terminal operations, e.g. 50 % more time to unload
- High costs per hour for delays; increase by 8%* by 2050

- Upgrade of drainage system traps to prevent sedimentation
- Enhance monitoring of sedimentation in the port
- More frequent drains maintenance; optimization of timing of dredging

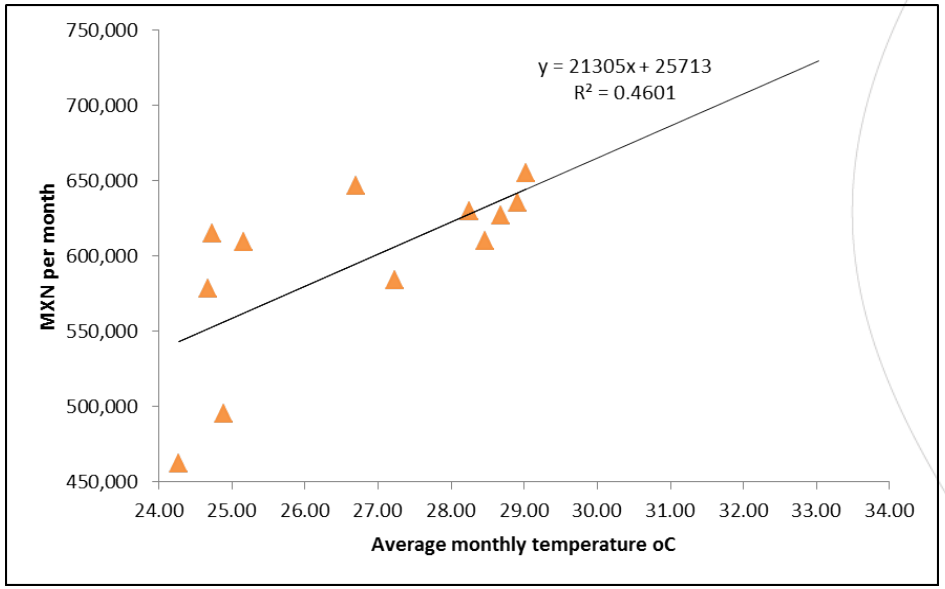



Areas of higher sedimentation at the port (Source: Report authors)

# Goods storage

- Temperature estimated to rise 1.2 - 2°C in dry season by the 2040s and 1.8 - 3°C by the 2070s
- Terminals with reefers and cold storage warehouses face increased cooling energy costs
- Significant positive relationship between mean temperature and mean monthly energy costs
- 1°C increase in temperature was associated with 5% increase in energy costs
- Increased cooling energy costs for terminal are 9% to 14% by the 2040s

- Implement technological improvements to improve efficiency (modern reefers can reduce energy costs by up to 65%)
- Isolate electrical connections to prevent loss of power and consequent extra energy for re-cooling/refreezing




Relationship between temperature and energy costs for frozen warehouse terminal. (Source: Report authors).

# Inland transport

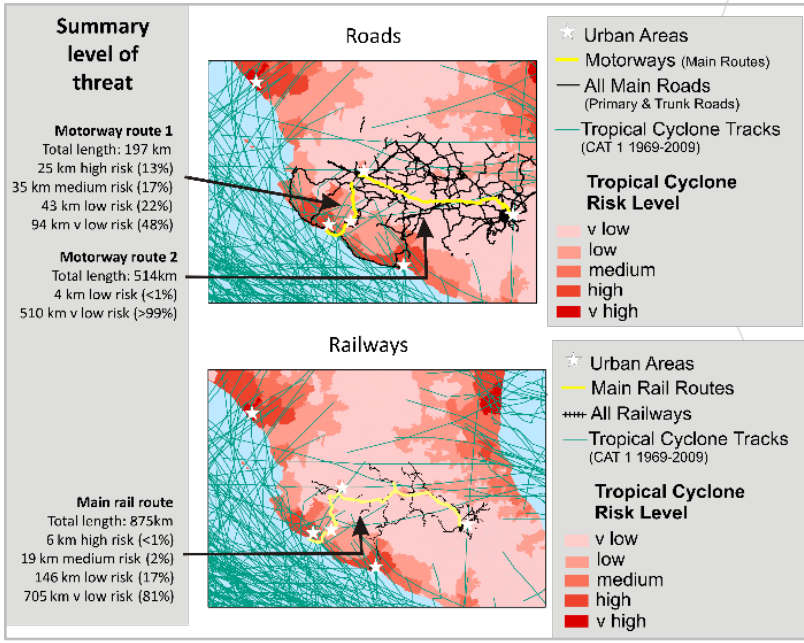
## In Manzanillo and the port

- Surface water flooding of internal access road and rail connections occurs every other year when heavy rainfall (tropical storms) causes overflow of drainage system
- Can stop movement of trucks and trains for up to 3 days (depth of water and residual sediment)
- Effect of 8% increase in peak flows by 2050: additional losses

## Beyond the port and the city

- 13% of main roads from Manzanillo and Guadalajara at high risk from tropical cyclones; 17% at medium risk
- >1% of rail network from Manzanillo to Mexico D.F. and Guadalajara at high risk

- Undertake closer monitoring of effect of transport network disruptions on terminals' revenues and impacts on customer satisfaction levels
- Collaborate with Municipality and State of Colima to promote development of intermodal networks

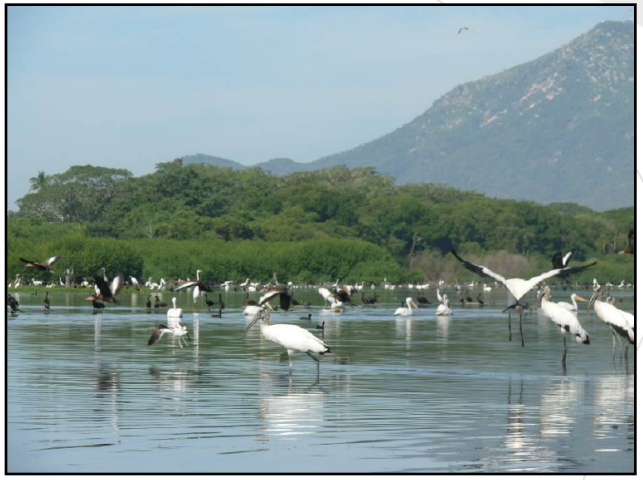



Present-day level of risk from tropical cyclones for roads (top) and rail lines (bottom) used by port clients. (Source: Report authors)

# Environmental and social performance

Effects of projected impacts:

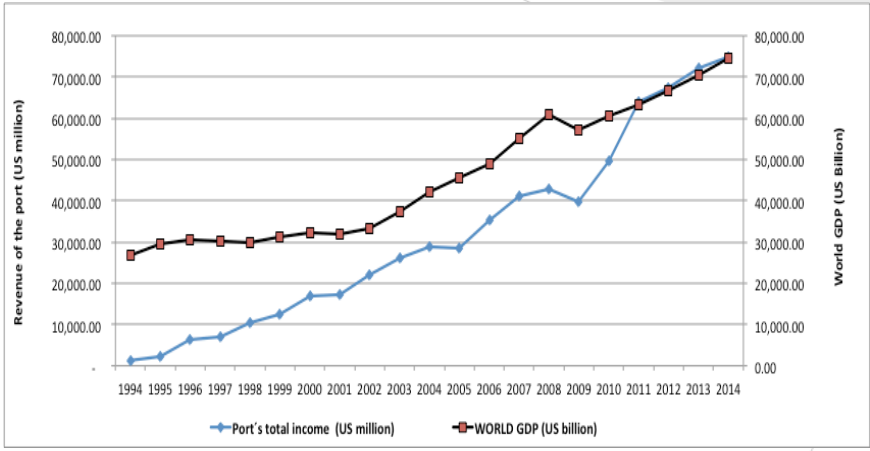
- **Mangroves:** SLR, drier and hotter conditions increase pressure
- **Dust:** increase in levels inside and outside the port
- **Dredging:** increase in disposal of material that may affect water quality and benthic habitat
- **Energy:** increase in use and GHG emissions
- **Health risks to employees:** increase in heat, high winds and rain
- **Health risks**: dengue fever becoming more prevalent in Mexico.



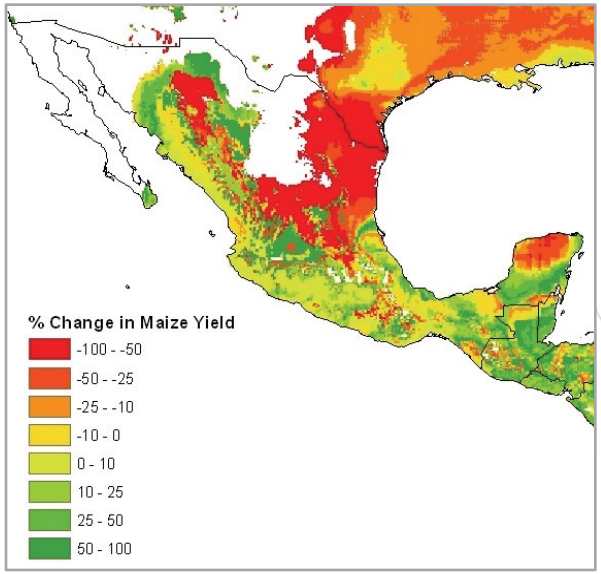
- Manage mangroves within the port to adapt to SLR and reduce other negative stressors
- Enhance current protocols for dust management
- Reduce GHG emissions related to energy use for reefers
- Monitor dengue cases
- Provide heat health warnings to workers, maintain contact with health authorities
- Review dust suppression and traffic amelioration measures
- Collaboration between port and city authorities, and integrated adaptation initiatives

# Demand and trade

- Global GDP and revenue flows at Port of Manzanillo strongly correlated: for every 1% fall in global GDP, revenue at the port falls by 1.5%
- Port's economic output could be negatively affected by impacts of climate change on global economy
- Climate change scenarios suggest reductions of up to 4% by 2020 in the arable land suitable for seasonal corn crops in Mexico
- Monitoring; diversification of trading partner regions, diversification of business lines




Comparison between world GDP and Port of Manzanillo revenue from 1994 to 2014. (Source: Report authors)

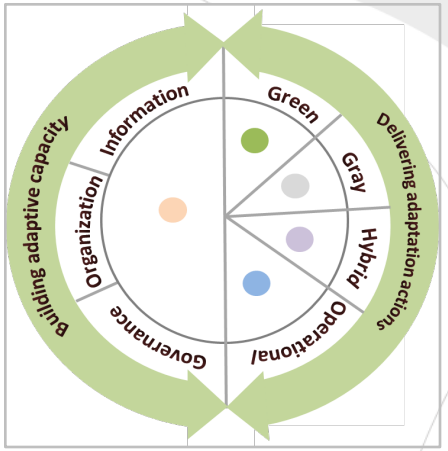



Crop suitability index for corn: yield by 2055 compared to 1961–90 baseline. (Source: World Bank)

# Port of Manzanillo Adaptation Plan

## Key principles

- Address priority risks first (e.g. with high current vulnerability)
- Avoid maladaptation
- Account for environmental services
- Emphasize measures that perform well under uncertainty:
  - No regret
  - Low regret
  - 'Win-win'
  - Flexible or adaptive management options
- Align with federal, state and municipal climate change policy frameworks
- Work in partnership with other stakeholders to develop and implement adaptation measures

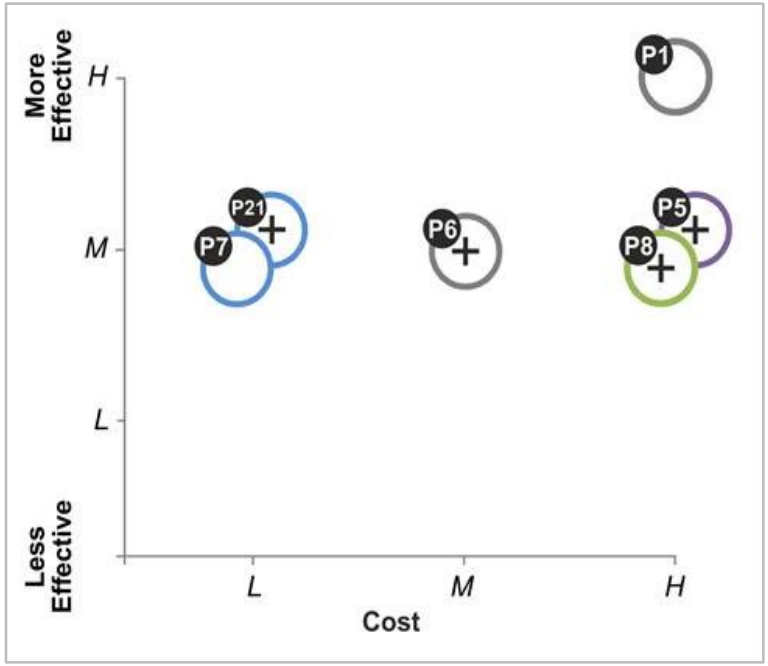



Types of climate change adaptation measures recommended for the Port of Manzanillo. (Source: Report authors).

| Risk area for port | Adaptation objective | Adaptation measure | Type | Cost | Effectiveness | Lead entity |
|---|---|---|---|---|---|---|
| DAMAGE TO INFRASTRUCTURE, BUILDING AND EQUIPMENT | Increase resilience to floods and intense rainfall events | P1 Upgrade drainage system inside the port to increase maximum capacity and handle increased flow. | | H | H | API Engineering |
| | | P2 Retrofit infrastructure or assets that are vulnerable to flooding, in particular critical infrastructure (e.g. insulate electrical equipment, use water resistant materials) | | L | M | API Engineering |
| | | P3 Engage with stakeholders to plan landscape level flood management options | | No regret | | API Engineering, API Ecology |
| | | P4 Review early flood warning systems and identify areas for improvement in light of increased risk due to climate change | | No regret | | API Engineering, API Ecology |
| | | P5 Review options for using sustainable drainage systems (SUDS ) taking into account potential for changes in precipitation | | H | M | API Engineering, API Ecology |
| | | P6 Upgrade and improve sediment traps | | M | M | API Engineering |
| | | P7 Undertake review and adjust maintenance program to ensure that maximum capacity of existing drainage system is being achieved e.g. frequency of drain clearance | | L | M | API Engineering |
| | | P8 Consider catchment level landscape planning and ecosystem based adaptation options for reducing risk of drainage overflow | | H | M | API Ecologia |

# Cost effectiveness of adaptation measures

- High level analysis of cost effectiveness of operational and physical adaptation measures conducted
- For example surface water flooding adaptation measures:




Cost effectiveness of adaptation measures for surface water flooding. (Source: Report authors)

**P1** Upgrade drainage system inside port

**P5** Install sustainable drainage systems (SuDS)

**P6** Upgrade and improve sediment traps

**P7** Review and adjust maintenance program for drainage system to ensure maximum capacity is achieved e.g. frequency of drain clearance

**P8** Catchment level landscape planning

**P21** Implement traffic management measures to minimize bottlenecks during flood events

| *Option Category* | | *Consequences* | |
|---|---|---|---|
| Ecosystem Based | Hybrid | + Overall positive | Approximately neutral |
| Engineering | Operational | − Overall negative | |

# Summary of financial impacts

**Risks with significant financial impacts**

- Increased surface water flooding of the port entrance/access road
- Increased sedimentation of the port basin
- Impacts of climate change on the global economy, which could affect trade through the port

- If no action is taken, potentially significant financial impacts, but
- Little risk to long term continuity of business (2050s and 2080s), assuming no disruptive events*
- Monitoring and ongoing update of analyses with latest information

# Thank you for your attention

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