Port of Manzanillo: Climate Risks and Opportunities

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Vladimir Stenek, IFC, World Bank Group
• 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
• 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**: 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
- 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

- 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

- SLR projections are changing: models and observations
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)
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*

- 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)

* Maximum potential sea level (mean SLR + tidal\seasonal\ENSO + 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

- 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

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

![Graph showing increased wharfage revenue due to increased intensity of rainfall](image-url)
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

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

Tropical depression 20E is forecast to strike Mexico as a hurricane at about 21:00 GMT on 23 October.

Intense hurricane Patricia struck Mexico at about 21:00 GMT on 23 October.


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

(Source: Report authors)
• 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
- 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)
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).
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:

  - **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

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