EXECUTIVE SUMMARY

Port of Manzanillo: Climate Risk Management

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SCT
SECRETARÍA DE COMUNICACIONES Y TRANSPORTES

ESTADOS UNIDOS MEXICANOS

MANZANILLO
COORDINACIÓN GENERAL DE PUERTOS Y MARINA MERCANTE

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Port of Manzanillo: Climate Risk Management

Manzanillo, México

CONSULTORIA TECNICA, S.C.

WorleyParsons

ACCLIMATISE building climate resilience

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Inter-American Development Bank
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DESIGNER

Ana Dorado

Forewords

Message from the Vice President for the Private Sector and Non-Sovereign Guaranteed Operations, a.i., at the Inter-American Development Bank

Hans U. Schulz

Ports are located in coastal areas that are increasingly susceptible to climate change impacts. By 2050, according to IDB estimates, rising sea levels, temperature increases and changes in rainfall patterns will result in an estimated annual cost of 2-4 percent of GDP for Latin America and the Caribbean (LAC)[1]. Climate change has already begun to affect the availability of resources, supply and demand of products and services, and performance of physical assets, making it urgent to strengthen public policy priorities on climate change. Financial returns as well as management of non-financial risks, such as economic development and environmental and social issues, may be affected if climate change is not taken into account in investment strategies. We estimate that the 340 extreme weather phenomena observed in 2007-2012 in LAC left at least 8,000 dead, affected more than 37 million people and led to economic losses of more than US $ 32 billion. Low-income people and women are disproportionately affected by climate change.

More than 80 percent of goods traded worldwide are transported by sea. Ports in developing countries handle more than 40 percent of the total containerized traffic, of which a significant portion relates to export of goods produced in the country[2]. Maritime infrastructure and transport sector is critical to trade growth in most of LAC. The region accounts for 41.8 million twenty-foot equivalent units (TEUs), about 7% of the world's total[3]. Within Latin America, Mexico represents 10.23 percent of total port traffic or third place.

As Mexico is a key operational hub for the logistics supply chain in LAC, it is critical to undertake an ex- ante assessment in collaboration with key logistics providers and or local governments to address vulnerability to climate change. Thus, while ports in Mexico could be impacted by climate change locally, changes to the supply chain and local infrastructure can create additional disruptions that require working collaboratively on a broader climate risk and adaptation strategy.

Specifically, in the case of the Port of Manzanillo, a climate change risk assessment conducted found that aspects of performance are likely to be significantly affected due to climate change, if no action is taken, specifically: (i) increased rainfall intensity causing greater surface water flooding of the internal port access road and rail connections; (ii) increased sedimentation of the port basin, reducing draft clearance for vessels and terminal access, due to increased rainfall intensity; and (iii) increased intensity of rainfall causing increased damage to infrastructure and equipment through surface water flooding.

The aim of this study is to analyze in depth the climate-related risks and opportunities facing the Port of Manzanillo in Mexico. The report also provides an Adaptation Plan for the port. The Port of Manzanillo becomes once again a pioneer, as this is the first climate risk management study performed on a full port in LAC.

1. Climate Change at the IDB: Building Resilience and Reducing Emissions –Inter-American Development Bank (IDB). http://publications.iadb.org/handle/11319/6692?locale-attribute=en#sthash.vTioHDnt.dpuf

2. Climate Risk and Business: Ports, Terminal Marítimo Muelles el Bosque –International Finance Corporation (IFC), World Bank Group. http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/cb_home/publications/climaterisk_ports

3. According to the United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC) statistic on transport: http://www.cepal.org/cgi-bin/getProd.asp?xml=/perfil/noticias/noticias/1/53131/P53131.xml&xsl=/perfil/tpl-i/p1f.xsl&base=/perfil/tpl/top-bottom.xsl

Message from the Director General of the Port Authority of Manzanillo

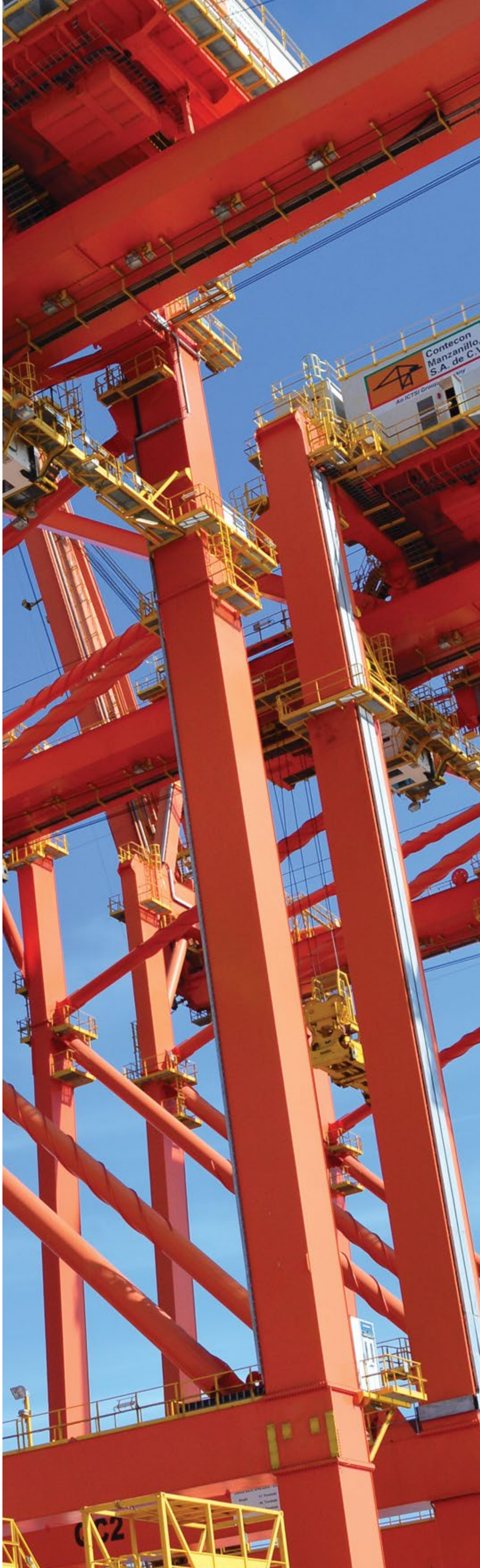
Vice Admiral Ruben Bustos Jorge Espino

I am pleased to announce that the participation of the Port Authority of Manzanillo in the study: Port of Manzanillo: Climate Risk Management, together with the Inter-American Development Bank, strengthens the objectives and actions set out in the Mexican National Development Plan 2013-2018 to address the adverse effects of climate change.

The content of this study will undoubtedly serve as a guide to determine priorities and programs to encourage best practices of climate change adaptation and mitigation to reduce emissions of greenhouse gases, more sustainable and environmentally friendly processes in the Manzanillo port community.

We commit to include this study as part of the strategy, plans and the daily actions of our performance.

We thank all the institutions, federal, state and municipal agencies, terminals and port service providers who made possible this study –first of its kind for a Mexican port, who generously and transparently shared information, experience and practices in the use of systems and technologies oriented to operation with low-carbon emissions.



Content

This publication provides a summary of the findings of the Climate Risk Management Study for the Port of Manzanillo in Mexico. The full results are available in a report which analyzes in depth the climate-related risks and opportunities facing the Port of Manzanillo. Wherever possible, the analyses include estimates of the financial impacts of climate change on the port over the coming decades, if no action is taken to adapt. For some of the more significant risks, the report provides assessments of the cost effectiveness of adaptation investments, and evaluates when measures should be implemented. The report also sets out in full the recommended Adaptation Plan for the port.

The methodologies employed to undertake the assessments are provided in detail in the full report. Supplementary material is also provided in a set of appendices.

Introduction

Climate change is underway. Global average temperatures and sea levels are rising, and droughts, floods, heat waves and storms are becoming more common. Even if emissions of greenhouse gases are reduced dramatically, the world faces inevitable future changes. If the risks are not addressed, the implications of climate variability and change for ports and their stakeholders could be significant.

'Adaptation' is the general term used to describe the range of actions that can be taken to reduce vulnerability to climate change.

In general terms, ports are widely regarded as being highly vulnerable to the impacts of climate change. They are located on the coast and can be affected by rising sea levels, changes in storminess and waves. These climate-related factors, along with others such as increases in temperature and changes in precipitation, can damage port infrastructure and equipment, reduce operational capacity, compromise pollution control equipment and pose challenges for health and safety. Wider impacts of climate change on the global economy will affect overall trade and hence port revenues.

In this context, the development of climate change risk assessments and adaptation plans are a priority for ports themselves, and for the economies of the countries they serve. Ports have a critical role to play in the globalized and highly interconnected economy. They act as centers for national and international commerce, provide suitable environments for trading and support economic development. The Port of Manzanillo in the State of Colima, Mexico, is internationally renowned as one of the main containerized cargo ports globally.

The Inter-American Development Bank ('IDB') has partnered with the Administracion Portuaria Integral de Manzanillo S.A. de C.V. ('API Manzanillo') on a Technical Cooperation to promote sustainability practices at the port. Recognizing the potential significance of climate change to ports, this Technical Cooperation includes the preparation of a study to assess climate-related risks and opportunities for the Port of Manzanillo, and to develop an Adaptation Plan.

The study aims to address the following questions:

- What risks and opportunities does climate change present for the port?

- How could the port manage climate risks and uncertainties in the most financially optimal way, taking account of environmental and social objectives?
- How could climate-related opportunities be developed and exploited?
- What key climate-related factors should API Manzanillo take into account to maintain its competitiveness and develop its medium and long term business strategy?
- How should adaptation actions be prioritized and sequenced in an Adaptation Plan?
- Where could API Manzanillo work in collaboration with other stakeholders to best manage climate risks and take advantage of opportunities?

The Port of Manzanillo, Mexico

The Port of Manzanillo is located in the Pacific coast of Mexico in the State of Colima. It is an important regional traffic hub and is considered Mexico's leading port in the Pacific. It is ranked as one of the ten largest and most important ports in the Americas and the second most important Latin American port in the Pacific. Its area of influence in the country includes 15 of the States of Mexico, accounting for 60% of national GDP and 42% of the total population.

In recent years, the port has positioned itself as the key port for the management of containerized cargo in Mexico, accounting for 60% of containerized cargo on the Pacific coast of Mexico and 46% within the entire country. In addition to containerized cargo, the port provides services and facilities for the handling of other business lines (Table 1).

The Port of Manzanillo is administered by the Administracion Portuaria Integral de Manzanillo S.A. de C.V. 'API Manzanillo', a federal agency created in 1994 with a 50 year concession to administer, promote, build and maintain it.

The port has 14 terminals under concession all of which are managed by private capital investors.

FIGURE 1

Location of the Port of Manzanillo

Source: Report authors

Roles and responsibilities are shared between API Manzanillo and the terminals. API Manzanillo is responsible for the overall management of the port facilities, including maintenance of the internal roads, customs, general infrastructure and equipment, quays and laydown areas. API Manzanillo is also primarily responsible for environmental performance at the port.

API Manzanillo's main revenue sources are from:

- Berthing, docking and mooring
- Loading and unloading
- Wharfage
- Storage
- Other port services

The terminals are responsible for maintaining their specific equipment and infrastructure, such as cranes and buildings. The terminals have environmental protocols within the ports overall environmental management plan.

Some of the key facilities and services provided by the terminals are:

- A total static capacity of over 49,000 TEUs and dynamic capacity of over 2 million TEUs.
- Two terminals are specialized in mineral bulk with an overall capacity of 60,000 tons and can load/unload up to 200 tons per hour.
- The freezing compartments provided by the terminal specializing in fishing produce (Marfrigo) offer storage space of up to 3,500 tons.
- The specialized terminal on containerized cargo operated by Contecon can load/unload 3 vessels simultaneously with a maximum performance of 120 containers per hour per vessel.
- The agricultural bulk installations have five storage silos.
- One of the agricultural bulk terminals, la Comercializadora La Junta offers loading services of up to 1,000 tons per hour and storage space of up to 50,000 tons.
- There are two multiple use areas for the management of general and containerized cargo and two freezers for the storage of perishable goods with a total storage space of more than 6,000 tons of fresh produce.
- There is one storage area for cement with a capacity of 25,000 tons, operated by APASCO.
- There are two storage spaces operated by CEMEX, one for the management of 50,000 tons of clinker and one for the management of 16,000 tons of cement bulk and general bulk.

A brief overview of the terminals is provided at the end of this Executive Summary.

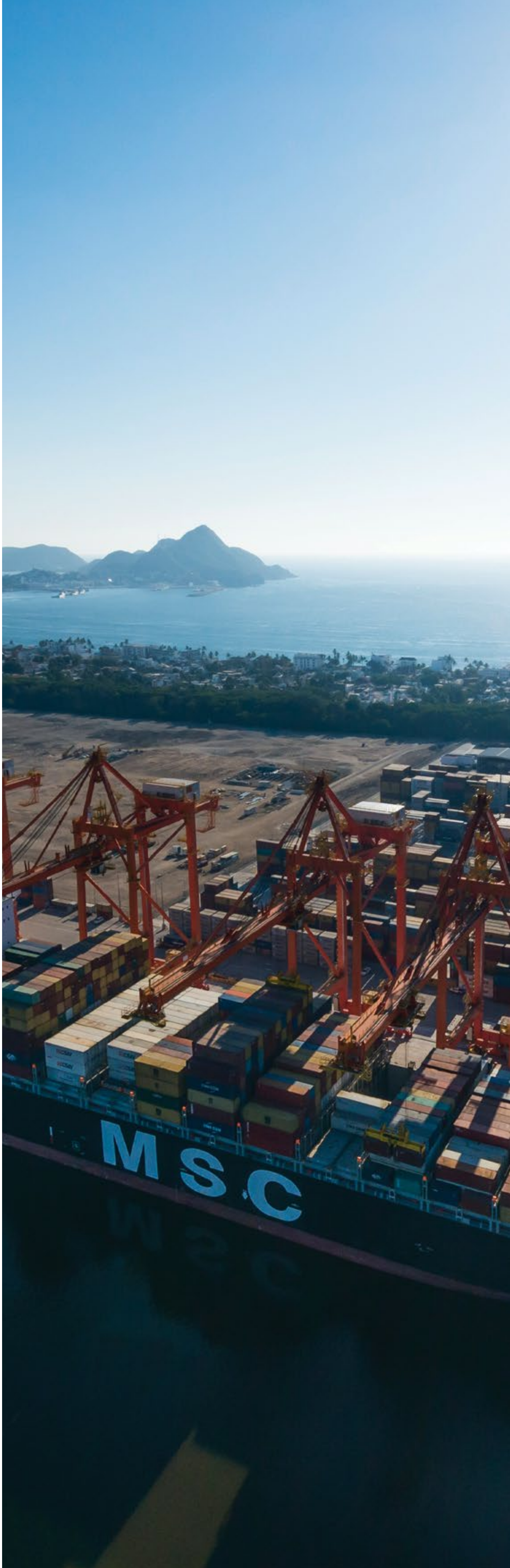
TABLE 1

Cargo by business line (2014)

Cargo	Thousand tonnes in 2014
Containers	19,000
Bulk minerals	5,000
General cargo	1,600
Agricultural bulk	1,100
Petroleum products	2,750

Source: API Manzanillo

Main port of entry for international goods in Mexico –a dynamic capacity of 2.4 million TEUs p.a.



Climate variability and climate change at Manzanillo

Mexico experiences a long dry season from December to May and a wet season from June to November. Most of the wet season rainfall is from tropical thunderstorms.

At Manzanillo temperatures reach about 27°C in June to August and then they cool. Rainfall is highest in September. Winds are generally light, except when a tropical storm or tropical cyclone is nearby.

Tropical cyclones and tropical storms disrupt operations at Manzanillo. Analysis of data on disruptions during 2014 showed that only tropical cyclones and storms passing within a few tens of kilometers of the port led to downtime. Overall, the North East Pacific has the second highest number of tropical cyclones globally (after the West Pacific) (Figure 2). The west coast of Mexico has more hurricanes than the coast of the Gulf of Mexico.

Average rainfall over Mexico is already decreasing, though there is an increasing number of days experiencing heavy rainfall events. Temperatures in the wet season are increasing, as are wind speeds in some months.

These trends are expected to continue with climate change (Table 2). In the future, mean rainfall over Manzanillo is projected to decrease in both the wet and the dry season. Extreme rainfall will increase, as climate change brings more energy in the lower atmosphere. Future temperatures are expected to rise, by around 1°C by the 2020s, rising to 3°C by the 2070s. Projected changes in wind speeds are very small, but are not well predicted by climate models.

Forecast: Below average precipitation; above average temperatures; as well as more frequent extreme weather events

Tropical cyclones are migrating poleward, at a rate of about 50 km per decade. It is likely that this trend will continue, leading potentially to fewer tropical cyclones over Manzanillo, although this statement has low confidence. Tropical cyclones are expected to decrease in frequency of occurrence but the most intense phase of cyclones is expected to last longer. Overall, it can be expected that more intense tropical cyclones in future will lead to increased storm surge heights.

FIGURE 2

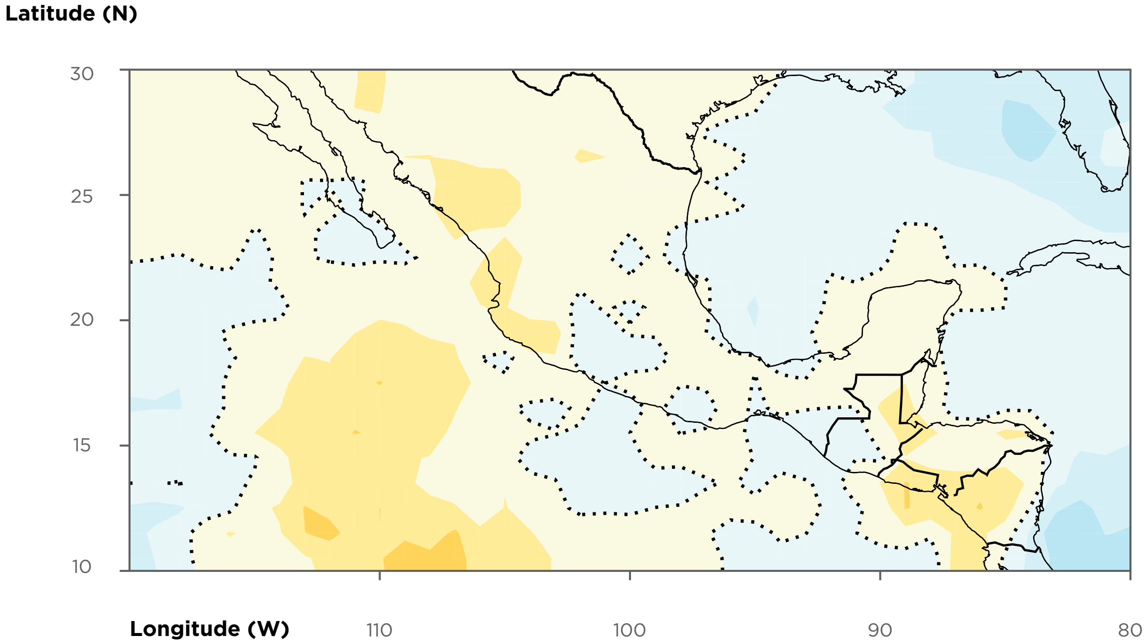
Distribution of tropical cyclones at their maximum intensities

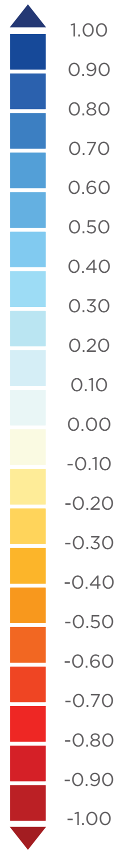
Source: Ramsay, H. (2014). Shifting storms. Nature. 509, 290-291

FIGURE 3

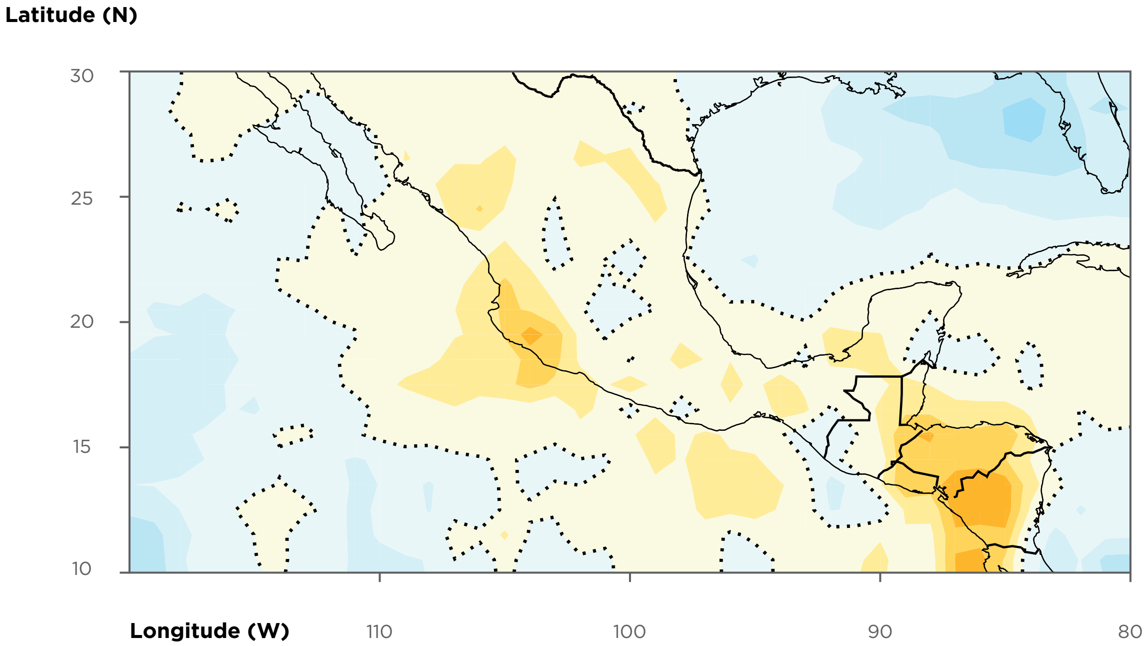
Changes in wet-season rainfall (mm/day) by the 2020s and 2040s relative to 1979-2000 baseline period

2020





2040



Source: Report authors

TABLE 2

Current and future climate conditions for Manzanillo

Variable	Current conditions	Future changes compared with current climate (under RCP8.5 scenario)[4]			
		2020s	2040s	2070s	Comments
Mean dry season rainfall	Less than 1mm decrease between 1979 and 2012 (not statistically significant)	Decrease of approximately 50mm over the dry season (-0.3mm per day)	Decrease of approximately 90mm over the dry season (-0.5 mm per day)	Decrease of approximately 126mm over the dry season (-0.7mm per day)	The very small drying trend evident in the current period strengthens and continues into the future
Mean wet season rainfall	Increase of about 37mm (1.1mm per year) between 1979 and 2012 (not statistically significant)	Decrease of approximately 18mm over the wet season (-0.1mm per day)	Decrease of approximately 54mm over the wet season (-0.3 mm per day)	Decrease of approximately 72mm over the wet season (-0.4 mm per day)	The drying trend replaces the current (statistically insignificant) wetting trend and the decrease strengthens into the future
Mean dry season temperature	No statistically significant trends in mean, maximum or minimum temperature	Increase of 1.0°C	Increase of 1.7°C	Increase of 3.1°C	Warming continues into the future and increases towards the end of the century
Mean wet season temperature	Increase of approximately 0.5oC between 1979 and 2012 for maximum temperature. No significant trends for mean and minimum	Increase of 1.1°C	Increase of 1.8°C	Increase of 3.4°C	Warming continues into the future and increases towards the end of the century. Wet season increases are larger than dry season increases.
Rainfall extremes	Frequency of occurrence of rainfall in excess of 10mm per day and 20mm per day is increasing in June	Not explicitly analyzed but expected to increase and assumed to linearly increase following observed trends	Not explicitly analyzed but expected to increase and assumed to linearly increase following observed trends. Values of extreme 24-hour rainfall with a 20-year return period could increase by 8%.	Not explicitly analyzed but expected to increase. Values of extreme 24-hour rainfall with a 20-year return period could increase by 10%.	

Variable	Current conditions	Future changes compared with current climate (under RCP8.5 scenario)[4]			
		2020s	2040s	2070s	Comments
Wind speed	Increases in frequency of occurrence of winds in excess of 1m/s in August, 2m/s in March and December, and 3m/s in February, October and November. All increases are small.	No change in dry season or wet season mean wind speed	Very small increase (0.1 m/s) for dry season, no change in wet season	Very small increase (0.1 m/s) for dry season, no change in wet season	Mean wind speed changes shown here result from changes in the large-scale circulation and not individual weather systems
Tropical cyclones	Current observed poleward migration of tracks	Likely that observed poleward shift will continue, leading potentially to fewer tropical cyclones over Manzanillo (low confidence)			Expected decrease in frequency, but increase in duration of maximum intensity. It is not possible to comment on tracks

Source: Report authors

4. 'Representative concentration pathways' or RCPs are scenarios of future concentrations of greenhouse gases, aerosols and chemically active gases in the atmosphere which are used to develop scenarios of future climate change. RCP8.5 is a high concentration pathway where radiative forcing reaches more than 8.5 W m^{-2} by the year 2100 relative to pre-industrial values.

Hydrological and oceanographic conditions

Hydrology

The Port of Manzanillo is a focal point for rainfall drainage from the surrounding area. Urbanization has already modified the drainage basin, increasing the amount of water entering the port during intense rainfall events.

Due to debris accumulation in the drain from within the city of Manzanillo, insufficient drainage capacity and the impermeable nature of port infrastructure, the main port entrance and internal access road and rail connections are subject to almost annual surface water flooding events.

Due to climate change, there is expected to be a significant increase in the flow of drainage water entering the port by 2050. The likelihood of a flood event is estimated to almost double by 2050. Infrastructure built for a 1 in 100 year event today will only protect from a 1 in 60 year event by 2050 (Figure 4).

Oceanography

Sea level data recorded at Manzanillo showed an observed rate of sea level rise of 3.3 mm per annum. If this observed rate continues, it will lead to 0.12 m of further sea level rise by 2050 (Figure 5).

To capture a range of possible future sea level rise scenarios, moderate and worst case 'accelerated' sea level rise scenarios were also developed, based on Intergovernmental Panel on Climate Change (IPCC) low and high greenhouse gas concentration scenarios. These indicate 0.13 m and 0.16 m of sea level rise by 2050 (0.36 m and 0.66 m by 2100).

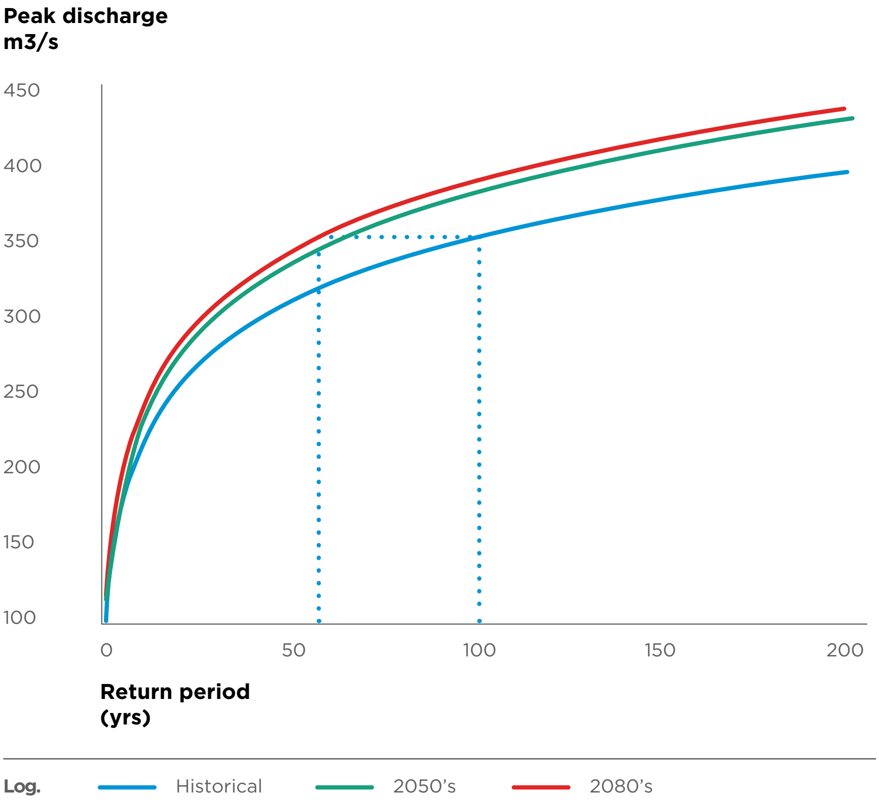
Sea level is projected to rise substantially

Extreme storm surge heights can be significant at Manzanillo, with the height of the current 1 in 250 year event estimated at 2.52 m, and the 1 in 500 year event at 2.85 m. The likelihood of a larger storm surge is considered to increase in the future, reflecting the increasing intensity of tropical cyclones over time. However data are not available to estimate accurately changing storm tracks and their proximity to Manzanillo.

Maximum and average wave height is likely to moderately increase in the future in the Eastern Tropical Pacific. An increase in maximum wave height of approximately 0.12 m is expected by 2100 under a high scenario, and average wave height could increase by 0.08 m.

FIGURE 4

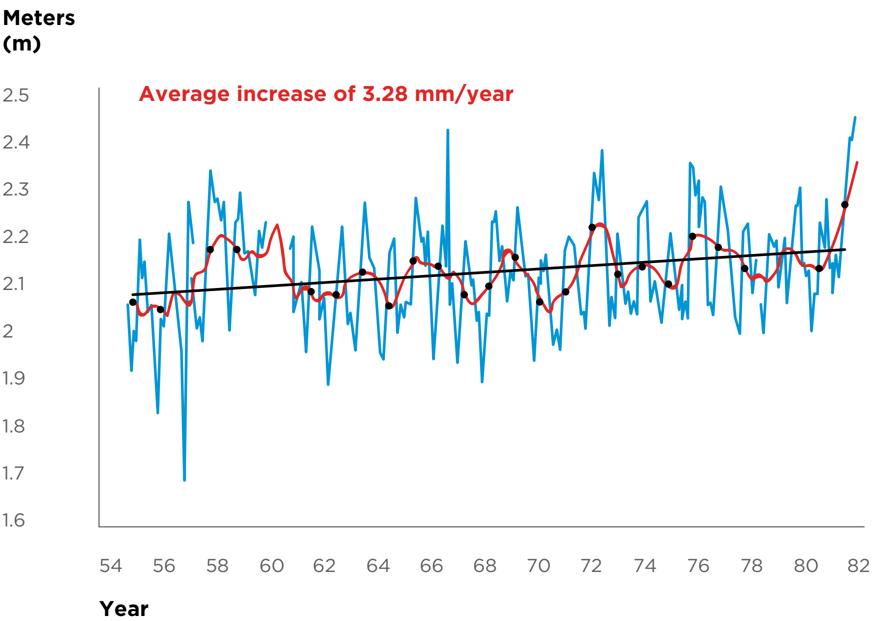
Changes in peak discharge flows



Source: Report authors

FIGURE 5

Observed sea level rise at Manzanillo (1954 to 1982)



Source: INECC/PEACC Colima


HMK 6507

TABLE 3

Current and future hydrological and oceanographic conditions for Manzanillo

Variable	Current conditions	Future changes compared with current conditions	Comments
Peak hydrological flows	Current 1 in 100 year return period for peak flow into the port drainage system estimated at 350 m^3/s.	Values of extreme 24-hour rainfall with a 20-year return period could increase by 8% by 2050. Current 1 in 100 year peak flow event becomes 1 in 50 year event by 2050.	Changes in peak hydrological flow and return periods are assumed to increase proportionally to 8% increase 24-hour rainfall with 20-year return period. More frequent and higher-intensity rainfall events could increase sedimentation non-linearly.
Mean sea level rise	Rising at 3.3 mm per year	By 2050, increase of 0.13 m (moderate, RCP 2.6 scenario) and 0.16 m (worst case, RCP 8.5 scenario). By 2100, increase of 0.36 m (moderate scenario) and 0.66 m (worst case scenario).	Some studies point to more extreme sea level rise scenarios + of 1.79 m and +2.4 m by 2100.
Average and maximum wave height	Average significant wave height at Manzanillo of 0.96m (from 2008-2015). Maximum recorded significant wave height of 4.85 m.	Increase in average wave height of 0.08m by 2100 (RCP 8.5 scenario). Increase in maximum wave height of 0.12m by 2100 (RCP 8.5 scenario).	Increase in wave height is expected to be moderate at Manzanillo. Maximum wave heights are related to tropical cyclone activity.
Storm surge height	1.47 m for 1-in-100 year event 2.85 m for 1-in-500 year event.	Based on expected increases in intensity of tropical cyclones, the likelihood of higher storm surge increases.	Current 1-in-100, 1-in-250 and 1-in-500 year events become more frequent in future.

Source: Report authors

Port success criteria at risk from climate change

Various success criteria for ports can potentially be affected by climate change, as presented in Figure 6.

These relate to the chain of external systems and internal assets and activities on which a port's commercial success relies including:

- **Trade levels and patterns and the consequent demand for port's services.**
- **Navigation in and out of ports and ship berthing.**
- **Goods handling and storage inside ports.**
- **Movements of goods, vehicles and people inside ports.**
- **Inland transportation beyond ports' fence lines.**

In the case of the Port of Manzanillo, the climate change risk assessment found that some aspects of performance are likely to be significantly affected by climate change. These include:

- Disruptions to port operations, due to increased rainfall intensity causing greater surface water flooding of the internal port access road and rail connections.
- Increased sedimentation of the port basin, reducing draft clearance for vessels and terminal access, due to increased rainfall intensity.
- Increased intensity of rainfall causing increased damage to infrastructure and equipment through surface water flooding.

The absence of port-wide risks to berthing at Manzanillo is due to the highly sheltered nature of the inner harbor. Wind and wave related berthing issues are only an issue for the PEMEX terminal outside the harbor entrance.

No significant issues on navigation and approach to the port were identified.

For goods storage, most terminals using reefers will experience minor increases in energy costs due to higher temperatures, though this is not a significant risk across the port as a whole. However for specialist refrigeration and freezing terminals the financial impact of rising energy costs due to higher temperatures is greater.

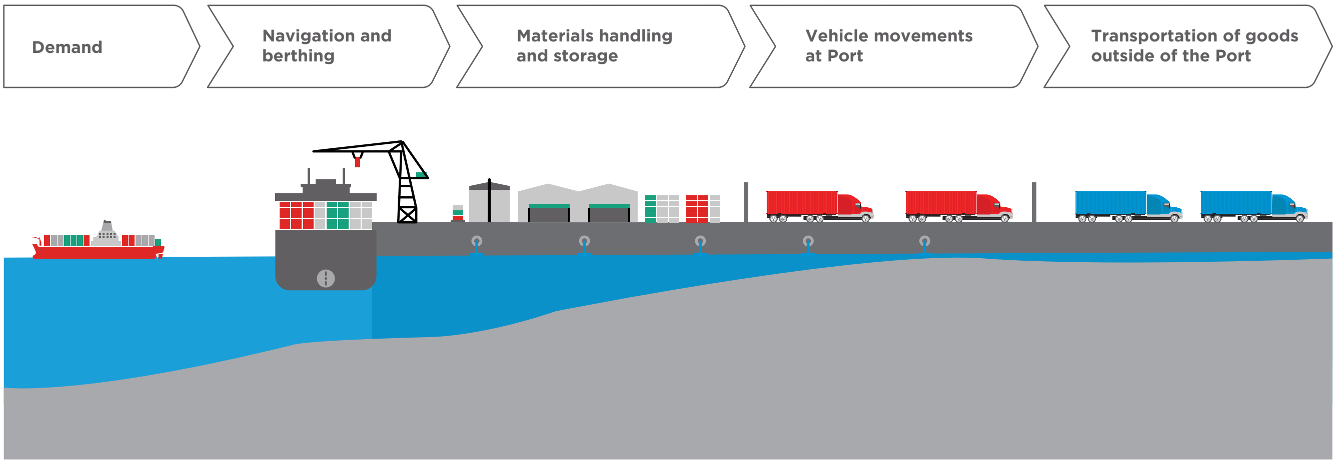
Coastal flooding to goods handling and storage facilities is only a risk under extreme storm surge events. This may affect the MARFRIGO terminal by 2040 under the 1 in 250 year event estimated for 2040 taking account of climate change, as it has the lowest quay heights. Other terminals are not considered at risk from storm surge flooding until the 2070s. Flooding caused by extreme storm surges will be covered by insurance.

Extreme wind speeds are not a risk to goods handling as the port is closed before handling thresholds are reached. Category 4 or 5 tropical cyclones may present a risk of damage to cranes, but quantifying future changes in storm activity is currently not possible.

Risks to environmental performance due to climate change are not considered significant, due to API Manzanillo's existing management procedures and insurances, paid in consultation with SEMARNAT.

FIGURE 6

Conceptual model of a cargo handling port and the main aspects of its value chain that can be affected by climate change



Source: Report authors, adaptada de Stenek, V. et al. (2011). Climate risk and business: Ports. Terminal Marítimo Muelles el Bosque, Cartagena Colombia. Executive Summary.

In general for ports, changes in rainfall intensity and frequency can result in increased flood risk to storage areas.

Higher temperatures can increase energy costs for cooling stored goods. Combined with changing rainfall it can also affect the incidence of pests, rust, mold and diseases.

Areas already affected by dust may see problems exacerbated under drier, hotter and windier conditions.

Access to water and energy services may also be at risk, especially in climatically vulnerable countries also reliant on highly sensitive generation such as hydropower. Thermal power generation reliant on freshwater cooling can also be affected during higher temperatures and periods of low river flows.

Utility contracts should be reviewed to determine priority rights over others in terms of supply continuity. Energy audits, taking account of rising temperatures, can help identify opportunities for savings.

Dust impacts should be monitored and reviewed and mitigation measures put in place taking into account of changing conditions.

Energy costs for cooling

At the Port of Manzanillo, specialist refrigeration and freezing warehouses and terminals with reefers (cooled containers) are at risk of increased energy costs due to higher temperatures.

Data provided by MARFRIGO, who run a specialist frozen warehouse for fish products, showed a statistically significant positive relationship between mean temperature and mean monthly energy costs Figure 7. A 1oC increase in temperature was associated with a 5% increase in cooling energy costs.

Based on the future temperature projections for Manzanillo, increased cooling energy costs for MARFRIGO are estimated to be 9% per year by the 2040s for a mid-range temperature rise, and 14% for a higher-end temperature rise.

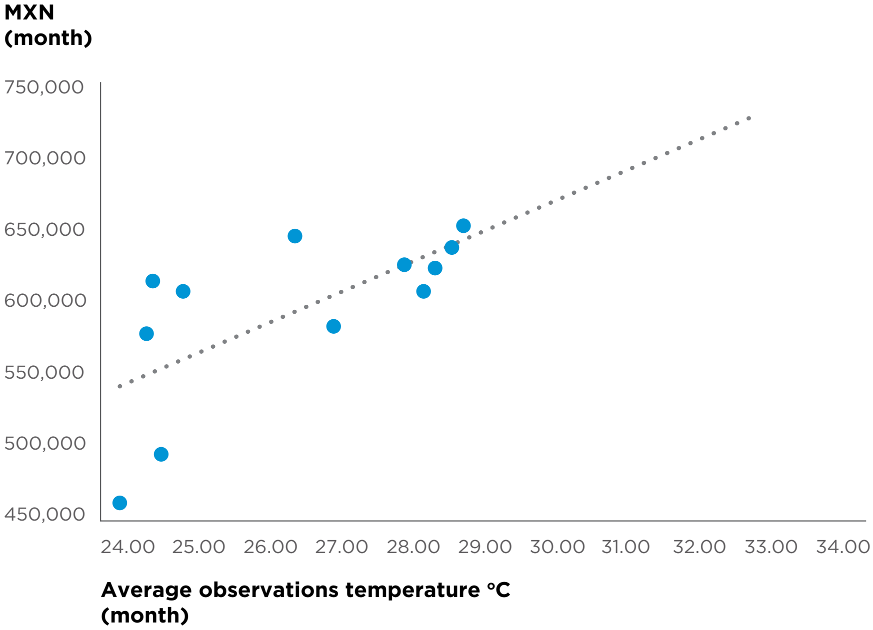
For all the specialist refrigeration and freezing terminals at the port (MARFRIGO, FRIMAN and TIMSA) the financial impact of rising temperatures on cooling energy needs are significant and would warrant investment to mitigate the effects.

For other terminals with reefers, cooling energy costs are smaller, so impacts of increased temperatures are not a significant risk for the port as a whole.

The most important adaptation measure to address this risk is to implement technological improvements over time. For example modern reefers can reduce energy costs by up to 65%. Other measures include evaluating whether some energy costs can be passed on to the customer, and isolating electrical connections to prevent loss of power to reefers and consequent extra energy for re-cooling/refreezing. The 2015 Carbon Footprint Study at the port included energy audits. Additional reviews of energy use at the port can be undertaken taking account of increasing temperatures. Climate change impacts should also be considered when evaluating on renewable energy sources for the port.

FIGURE 7

Relationship between temperature and energy costs for MARFRIGO



Y 21305X + 25713 **R^2** 0.4601

Goods handling

High winds, extreme rainfall and lightning can affect crane operations. Handling highly water-sensitive goods such as agricultural and mineral bulk may be impacted by changes in rainfall intensity and frequency.

High temperatures may have positive or negative effects. Port operations in cold regions may improve; in tropical regions the work force may be negatively impacted by heat stress.

Adaptation options include users of handling equipment monitoring how operations are impacted by climatic events. Existing handling procedures and equipment should be reviewed and updates implemented, taking account of climate change.

Rain stopping handling operations

Rain causes stoppage of handling operations at the Port of Manzanillo in two ways:

- For terminals handling bulk mineral and agricultural products, even light rain can suspend handling operations as the product quality can be affected, so, for instance, vessel hatches are closed.
- Container crane operations are halted during heavy rain due to a reduction in visibility for the crane and forklift operators.

Conditions at the port are becoming drier overall, but heavy rainfall events are becoming more common. If observed trends continue, the port will see a 23% decrease in the number of rainy days by the 2040s and a 90% increase in the frequency of days with heavy rain.

Financial analysis showed that the effect of both of these issues on the port is 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 can be considered for protection against heavy rain events, along with a review of goods handling procedures under adverse climatic conditions.

The overall drier conditions are a beneficial climate change impact for terminals handling bulk mineral and agricultural products, and may result in less disruption.

Adaptation options to address increased intensity of rainfall include providing additional covered handling areas, and reviewing handling operations in adverse conditions e.g. consolidation operations and loading onto trucks and railcars.

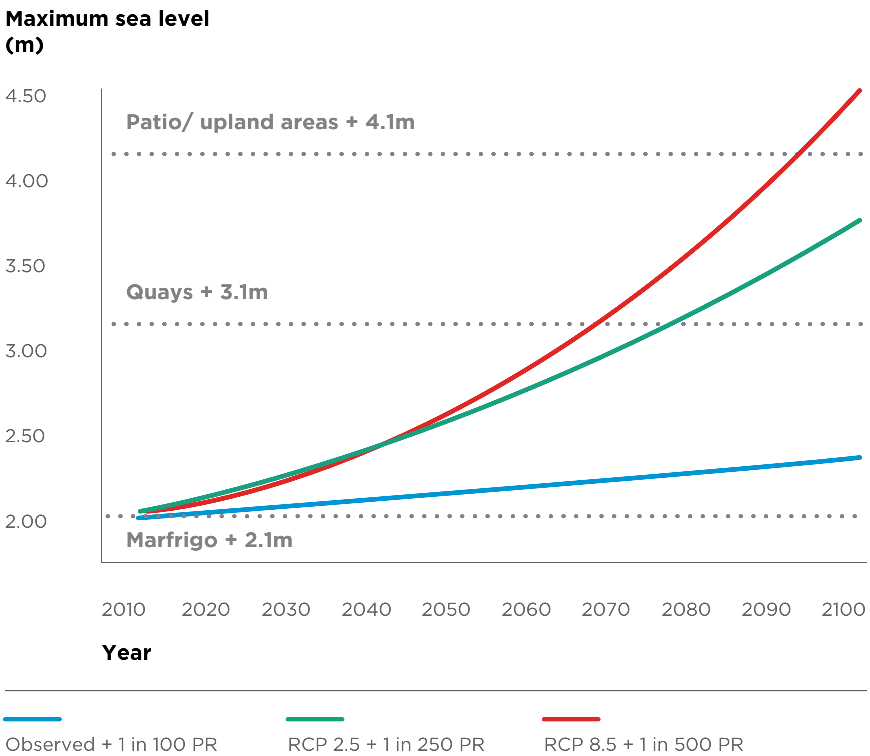
Seawater flooding

Significant flooding risks (flood depths in excess of 0.3 m) could be experienced by MARFRIGO, whose quay is 2.1 m above mean sea level (AMSL) by 2040 under a moderate sea level rise scenario when combined with a 1 in 250 year surge event (Figure 8).

Seawater flooding of the other terminal quays (+3.1 m AMSL) is only an issue by the 2070s when the moderate sea level rise scenario is combined with a 1 in 250 year storm surge (Figure 9). General, inundation of all terminal patios and upland areas would occur only for the ‘worst case’ sea level rise scenario combined with a 1 in 500 year storm surge event, with an average inundation depth of 0.11 m by 2100.

FIGURE 8

Sea level to 2100 for observed, moderate and worst-case sea level rise scenarios combined with various storm surge return periods. The figure indicates the heights of the terminal quays at Manzanillo



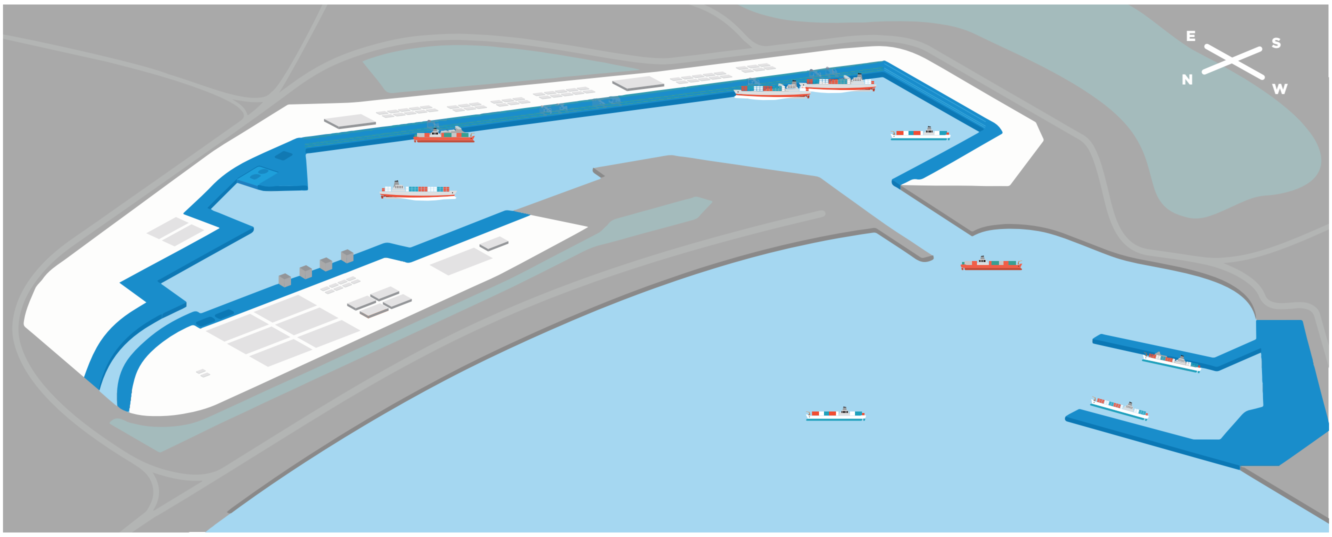
Source: Report authors

FIGURE 9

Storm surge flooding at the Port of Manzanillo under the moderate sea level rise scenario plus 1 in 250 year storm surge event, 2070s. Flooded areas are shown in blue

Scenario Two - 2070s
RCP 2.6+ 1 in 250 storm surge

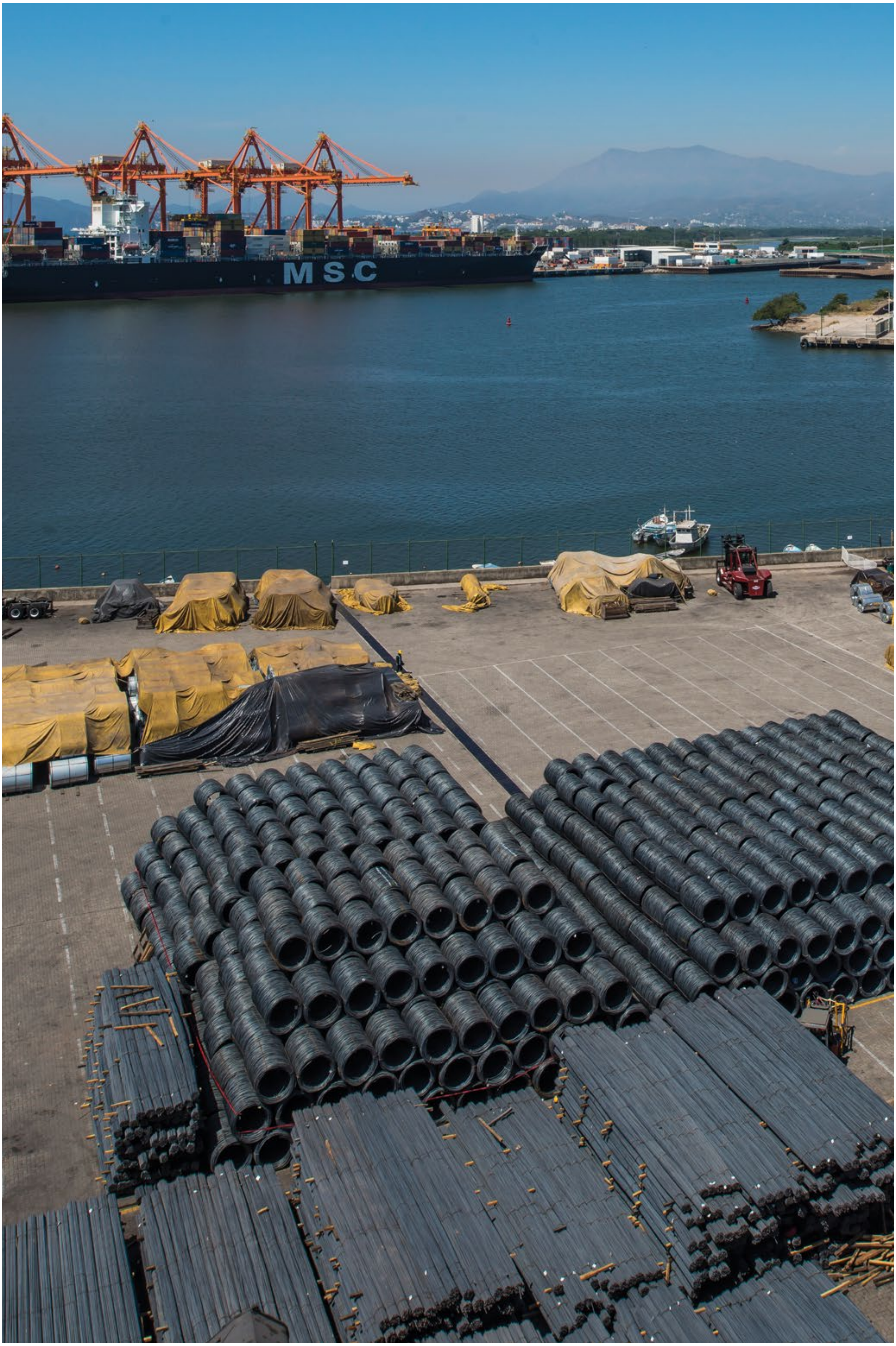
Indicative only - not to scale



Source: Report authors

Losses and damages from extreme storm surge flood events would typically be covered by insurance. However, physical and operational adaptation options can also be considered, such as raising quay heights (in the long term), maintaining natural coastal defenses provided by mangroves and retrofitting flood-sensitive equipment and infrastructure.

Extreme wind speeds were found to not be an issue for goods handling as the Port Harbor Master will close the port before maximum operating thresholds for handling equipment are reached.


MSC

Damage to port equipment

Damage to infrastructure, buildings and equipment can materialize both in the short term (e.g. due to the destructive power of storms) or in the long term due to slow onset events such as sea level rise.

Infrastructure, buildings and equipment may also be affected by extreme winds. Winds can damage cranes and detach lightweight structures with potential to damage other infrastructure.

Storm surges and sea level rise can damage quay and pier infrastructure and undermine infrastructural foundations. Strong wave action and fast moving waters can also dislodge containers and cargo.

Salt water intrusion from sea level rise can corrode construction materials and equipment. Additionally, flooding of electricity sub-stations can result in black-outs, short-circuits and risk of fire.

Adaptation options include early warning systems and contingency plans. Permanent or temporary walls can help protect against impacts of winds on sensitive equipment. Design standards for cranes and other infrastructure should be reviewed and port infrastructure in general may require reinforcement against extreme events.

Vulnerable electrical systems, especially below ground, should be insulated against water ingress.

Flood and erosion defenses should be reviewed and flood risk management plans put in place, considering hard engineered defenses and ecosystem-based measures.

Surface water flooding

Due to present-day surface water flooding, the maintenance and repair of damage to internal roads and the customs area is the most significant component of API Manzanillo's annual maintenance costs, with the exception of dredging. In addition to the operational downtime for the terminals, the cleanup of sediment and repair of damaged equipment is costly to API Manzanillo. The Port Master Plan estimated 6 million MXN in costs for 2015.

Since Manzanillo is expected to experience more intense rainfall over time, the required maintenance of these areas could increase. The magnitude of the 1 in 20 year 24 hour precipitation is estimated to increase 8% by 2050 and return periods for current peak flows into the port drainage system will approximately halve by 2050. This will lead to greater frequency and magnitude of flooding events, resulting in greater water and sediment damage.

The Port Master Plan includes a forecast increase in road and customs maintenance costs of 5% per year, without taking account of the effects of climate change. The study assumes that the 8% increase in intense rainfall will result in an 8% increase in surface water flooding/sedimentation, requiring a proportional 8% increase in road/customs maintenance costs. When this 8% increase in maintenance costs is applied on top of the 5% forecast, then additional costs of 3 million MXN per year by 2050 are estimated. These costs are covered by API Manzanillo.

Available adaptation options to prevent and mitigate flood damage include physical upgrade of the drainage system inside the port to increase maximum capacity, and retrofitting flood-sensitive infrastructure e.g. electrical equipment. Options for using sustainable drainage systems (SuDS) can be reviewed, along with catchment level landscape planning. The capacity of the drainage system can be maintained by upgrading sediment traps and more frequent clearing. Early flood warning systems can also be reviewed and improved.

The risk of equipment damage caused by sea water flooding is low and not considered a priority.

Extreme wind speeds

Due to their height (approximately 50 m), container handling cranes have the potential to be subject to damage from extreme wind speeds. Contecon cranes have design thresholds of 56 m/s which will be exceeded by Category 4 and 5 hurricanes. Although data were not available for the other (older) cranes at the port, these will potentially have lower design thresholds and perform

less well during extreme wind conditions. In general, more attention is paid nowadays to the design of cranes and tie-downs for extreme winds than in the past.

Accurately quantifying future changes in storms is currently beyond scientific method. However the likelihood of experiencing a Category 4 or 5 hurricane event is likely to increase.

Adaptation options include improvements to the cranes' tie-down systems, estimated at 750,000 MXN to 2,250,000 MXN. Improvements to the cranes' braking systems and wind speed prediction systems can also be considered.

Maintenance requirements

Sea level rise is likely to result in increasing water depths, which may benefit ports due to increased available draft and lower dredging and maintenance requirements.

Coastal and riverine erosion driven by high rainfall events and extreme wind speed may result in greater accumulation of sediments, potentially increase costs of dredging maintenance.

Salt water intrusion into groundwater from sea level rise can increase the need for infrastructure repairs and maintenance.

Increases in temperature can result in higher cooling demand and increased loads on equipment, with associated increase in maintenance requirements.

Adaptation options include sedimentation and sea level monitoring at key locations. Dredging programs should be reviewed and updated in light of changes to sediment accumulation.

Increased maintenance dredging

The requirement for maintenance dredging at the Port of Manzanillo is a factor of the intensity and frequency of rainfall. Peak flows into the drainage system will increase over time, reflecting the 1 in 20 year 24-hour precipitation increase of 8% by 2050. This will lead to higher transport and deposition of sediment into the port basin.

Maintenance dredging costs in 2014 were 54 million MXN at 108 MXN per m3 of dredged material. An increase in 8% of sediment load would require an additional 8,000m3 of material to be removed per year by the 2050s, at an additional cost of 864,000 MXN per year. Mean sea level rise would increase draft clearance somewhat, reducing these additional costs by between 86,400 and 108,000 MXN per year.

Increased drain maintenance

Sedimentation and collection of material within the port drainage system currently occurs, requiring an annual drain maintenance and clearing program. Costs in 2014 for drainage maintenance were 19.5 million MXN (4.5% of API Manzanillo's total operating expenditure).

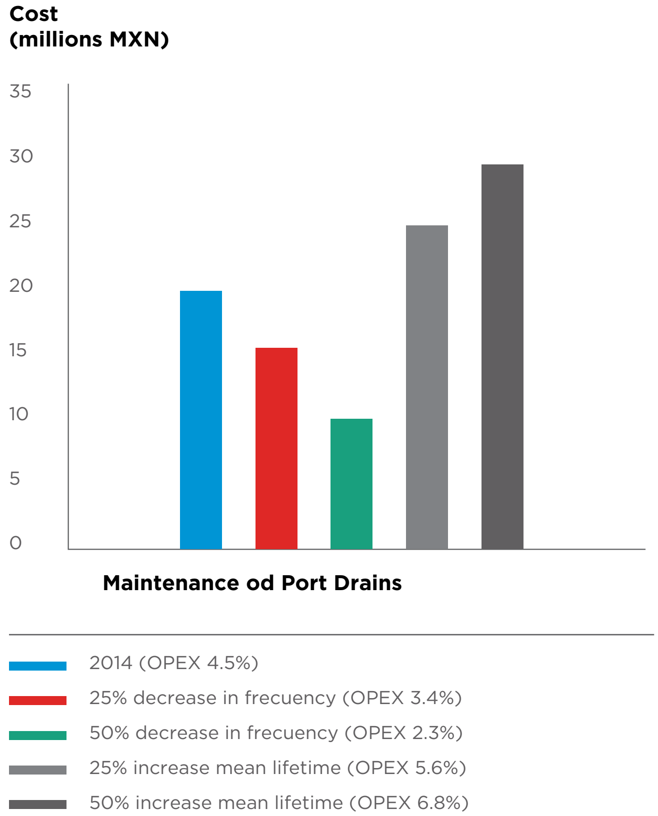
A proportional 8% increase in intense rainfall and sediment deposition would result in additional costs of around 1.6 million MXN per year by the 2050s. Sedimentation of the drains is also related to storm frequency and intensity. As future projections of changes in storminess are uncertain, sensitivity tests have been used to evaluate potential impacts. Figure 10 shows potential increases in maintenance costs under reasonable changing storm scenarios.

Increased maintenance of roads and customs area

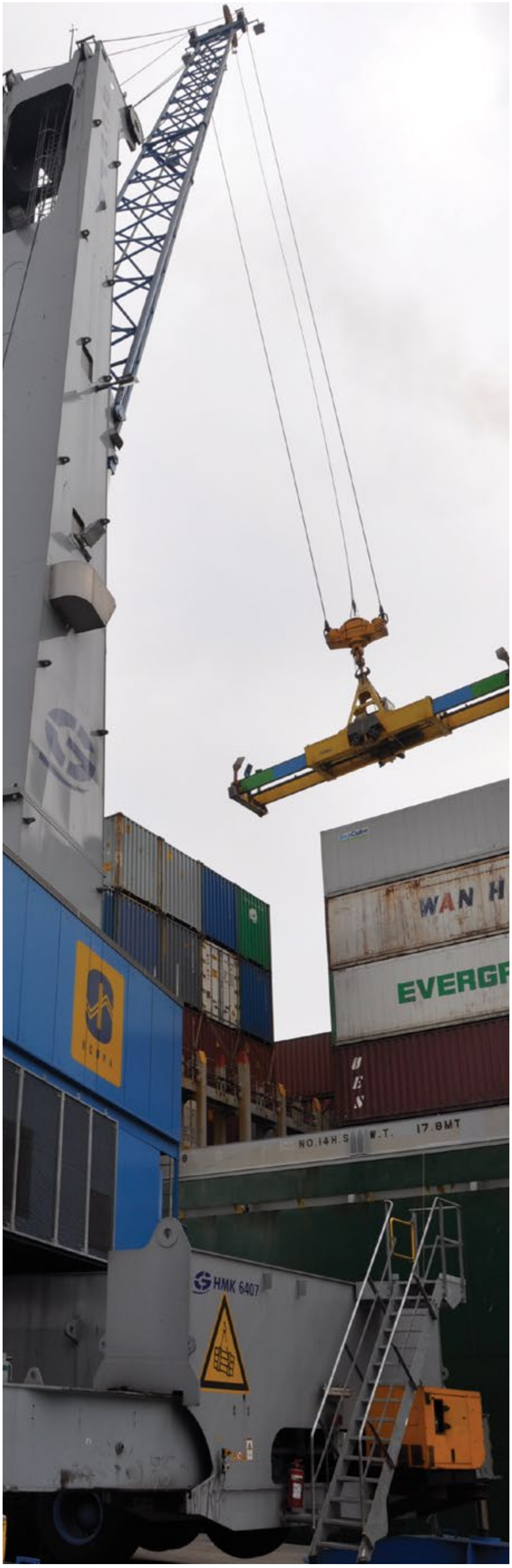
As noted above ('Damage to port equipment'), additional costs of 3 million MXN per year by 2050 could be incurred by API Manzanillo due to increase rainfall intensity.

FIGURE 10

API Manzanillo drain maintenance costs under changing storm scenarios by 2050s



Source: Report authors



Sea level rise may exceed operability thresholds for some infrastructure. For example, bridge clearance and water level to dock height may be impacted, affecting vertical operability range of quays, piers and material handling, resulting in increased capital expenditure.

Sea level rise, storms and high wave intensity may result in increased coastal erosion. Coastal and riverine erosion may also be driven by high rainfall events and extreme wind speeds, leading to greater accumulation of sediments.

Reduced precipitation may result in lower water flows, hindering navigability in rivers, lakes and channels, in turn affecting port access. Extreme wind conditions may also affect navigability and maneuvering of large vessels at ports.

Assessments should be undertaken on impacts of these changing factors on exceedance of critical climate-related thresholds for port services (e.g. berthing and maneuvering operational thresholds). These can help to identify operational changes and upgrade requirements.

Downtime due to high winds and waves

The inner harbor of the Port of Manzanillo is highly sheltered. No existing navigation and berthing issues were reported by the terminals inside the harbor. The PEMEX terminal outside the main harbor entrance is subject to operational downtime due to high winds and waves affecting berthing availability. Downtime in 2014 was 5%. The main issue that determines downtime at PEMEX is the proximity of the storm to the terminal. Only those storms passing within a few tens of kilometers appear to lead to downtime. Estimating future changes in storm tracks is currently beyond scientific method, but an increase in proximity is considered possible.

Downtime due to sedimentation and dredging

Sedimentation occurs during heavy rain events, which are reported to reduce draft clearance close to the quays and result in delays in vessel access. Terminals closest to the Drain 3 discharge and the channel to Laguna de las Garzas are at greatest risk (Figure 11).

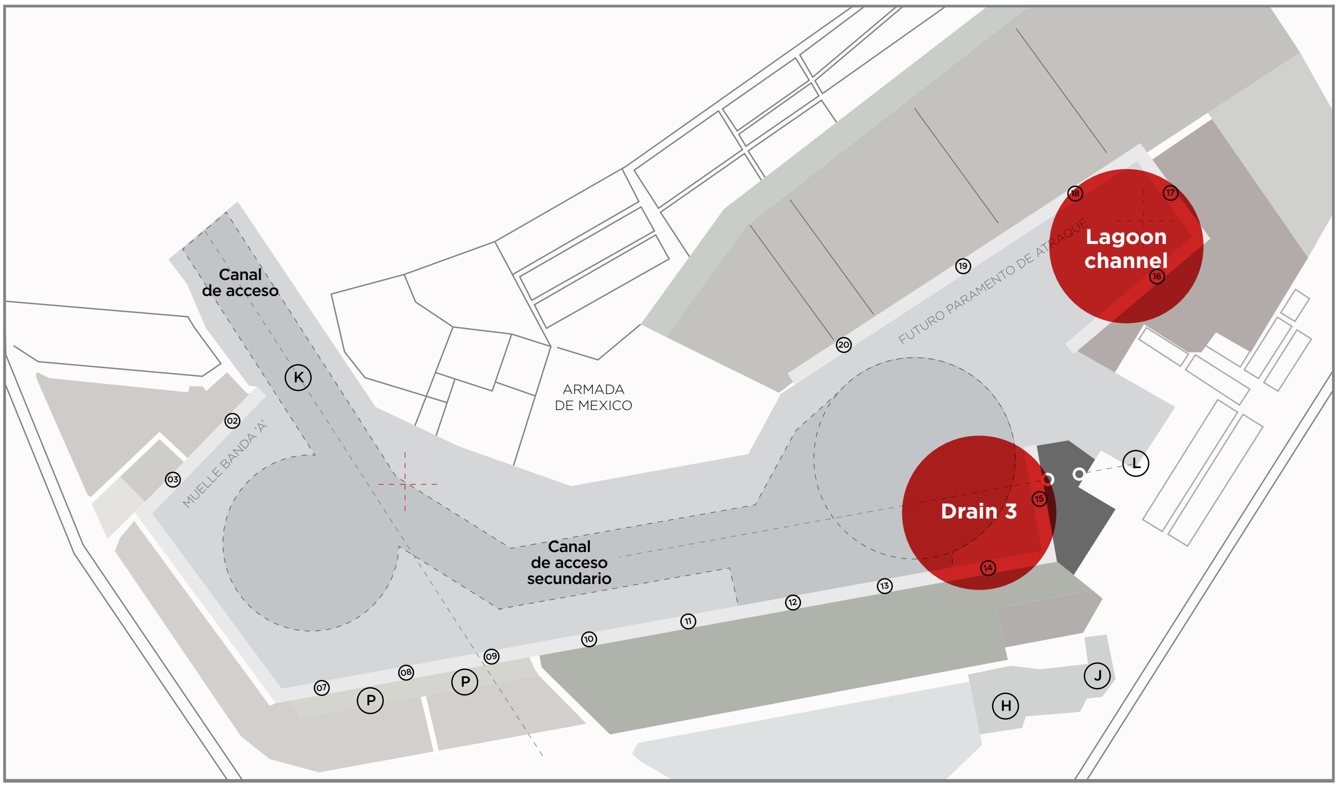
The presence of the dredging vessel also disrupts vessel access to the terminals. For example TIMSA reported an increase of 50% (10 hours to 15 hours) to unload a vessel cargo when the dredging vessel is operating.

Delay costs per hour in total for all terminals due to the dredging vessel were estimated at 233,884 MXN. Data on the hours of delays currently experienced were not available from all terminals, so this hourly cost was calculated by taking the figure provided by one terminal as a representative average for all terminals. An 8% increase in delays and associated costs is estimated by the 2050s.

For adaptation, a program can be initiated to monitor sedimentation levels in the port more closely throughout the year. The results can be reviewed to assess the frequency of the current maintenance dredging program. If vessel access issues occur at regular times through the year, then the dredging program can be adjusted accordingly. In addition, the traps that prevent sediment entering the harbor can be upgraded, and cleared more often to ensure maximum efficiency of operation.

FIGURE 11

Areas of higher sedimentation at the port



Source: Adapted from API Manzanillo

Land transport routes can be disrupted by extreme events affecting road and rail infrastructure.

Maritime shipping can be disrupted by major storm events.

Shipping routes may be transformed by the opening of new routes across the Arctic and the expansion of annual availability due to receding sea ice as Arctic temperatures rise. A new trading route between Europe and Asia could reduce shipping journeys by about 4,000 miles (30%) compared to the current Panama Canal route.

Adaptation options include port operators and users engaging with owners of transport networks on actions they are taking on climate resilience.

Research on climate change impacts on shipping routes should be regularly reviewed and feed into port business strategies.

Ports should also monitor changes in international supply and demand markets to determine how new shipping routes could create new risks and opportunities.

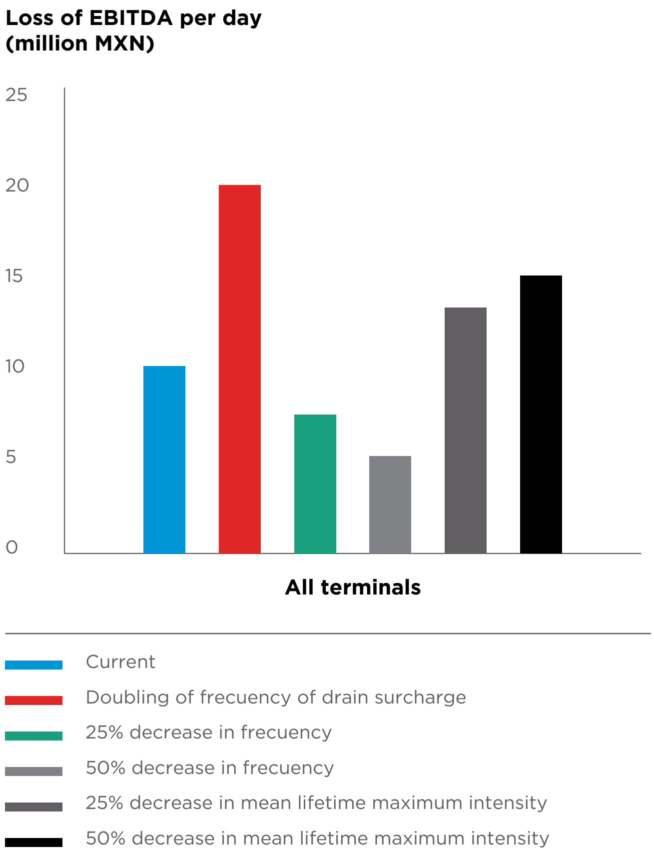
Loss of connectivity of the Port of Manzanillo with land transport routes

Surface water flooding of the port's internal access road and rail connections occurs every other year on average, mainly due to heavy rainfall during tropical storms causing overflow of the drainage system. This can stop movement of trucks and trains for up to 3 days, due to more than 30 cm depth of water and residual sediment.

Average current downtime for terminals due to surface water flooding of transport infrastructure is 1 to 2 days per year, every other year. This equates to an average

FIGURE 12

Average annual total loss of EBITDA across all terminals due to surface flooding of the port access road and railway, under various flooding scenarios



Source: Report authors

annual loss of EBITDA across all terminals of around 9.9 million MXN. Sensitivity analysis shows the effect of an 8% increase in peak flows by 2050 under four changing storm scenarios (Figure 12).

Financial and reputational impacts are borne by API Manzanillo due to surface water flooding; as the port effectively closes. Certain variable fees paid to API Manzanillo are dependent on the port being operational, such as those based on cargo throughput. Due to the loss of these variable fees, a 24-hour port closure results in a loss of 0.12% of total annual revenue for API Manzanillo Other income to API Manzanillo is independent of port closure, such as annual terminal contract fees.

Adaptation options include upgrading the drainage system inside the port to increase its maximum capacity and the use of sustainable drainage systems. Maintenance of the drainage system can be adjusted to ensure maximum capacity is maintained.

Early flood warning systems can be reviewed and improved, and plans for business continuity during flooding can be enhanced.

Catchment level landscape planning can also reduce the risk of drainage overflow. Finally, traffic management measures can minimize bottlenecks during extreme events and maintain operations longer.

Land transport on wider network

Key routes connecting the port to Colima City, the capital of Colima State, are the Carretera Federal 98 and the Carretera Federal 100. From Colima City, goods are transported onwards to Guadalajara, the capital of Jalisco, and this route represents the key entry/exit node connecting Manzanillo to its wider market. Ferromex provides the rail services to and from the port, with one rail route connecting Manzanillo to Guadalajara, via Colima. Good rail conditions and lack of interruptions in this section of the track is therefore key for the reliable transport of port shipments by rail.

Based on historic data, 48% of main roads between Manzanillo and Guadalajara are at high risk (13%) or medium risk (35%) from tropical cyclones. Less than 1% of the rail network connecting Manzanillo to Mexico D.F. and Guadalajara is currently at high risk from tropical cyclones. Most of the area at risk is in the vicinity of the port.

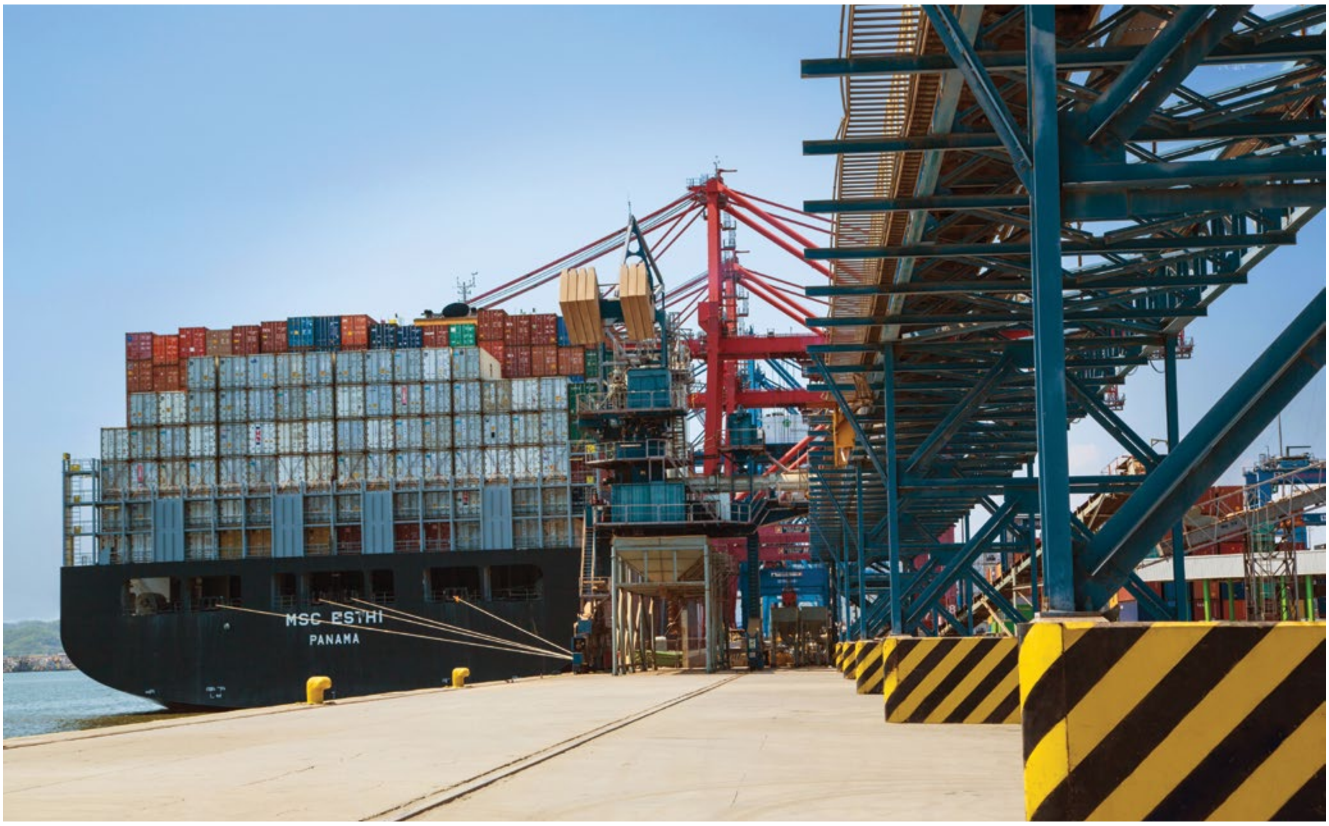
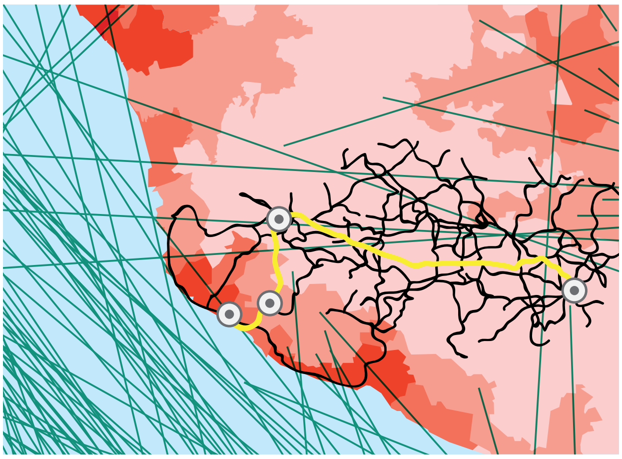


FIGURE 13

Present-day level of risk from tropical cyclones for roads and rail lines used by port clients

ROADS	Summary level of threat	Routes	Tropical Cyclone Risk Level



Motorway route 1

Total length:
197 km
25 km high risk
(13%)
35 km medium risk
(17%)
43 km low risk
(22%)
94 km very low risk
(48%)

Motorway route 2

Total length:
514 km
04 km low risk
(<1%)
510 km very low risk
(>99%)

Urban Areas

Motorways (Main Routes)

All main roads (Primary and Trunk Roads)

Tropical Cyclones Tracks (**CAT 1** 1969-2009)

Very low

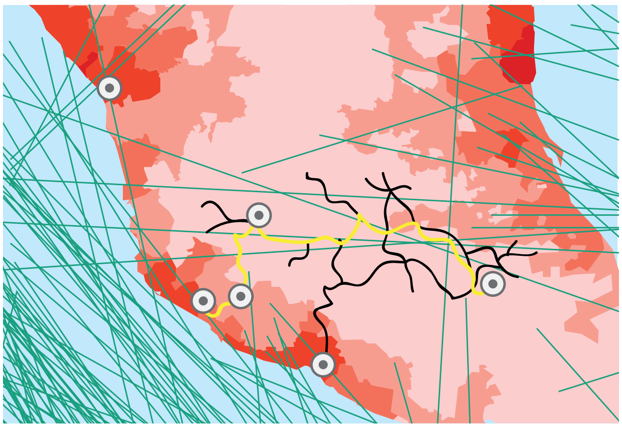
Low

Medium

High

Very High

RAILWAYS



Main rail route

Total length
875 km
06 km high risk
(<1%)
19 km medium risk
(2%)
146 km low risk
(17%)
705 km very low risk
(81%)

Urban Areas

Main Rail Routes

All railways

Tropical Cyclones Tracks (**CAT 1** 1969-2009)

Very low

Low

Medium

High

Very High

Source: Report authors

Due to uncertainties about future changes in cyclonic activity it is not possible to estimate future changes across the transport networks.

Adaptation planning should begin with closer monitoring of the effect of transport network disruptions on terminals' revenues and impacts on customer satisfaction levels. API Manzanillo should work in closer collaboration with the Municipality and the State of Colima to promote the development of intermodal networks that increase the resilience of land transport systems.

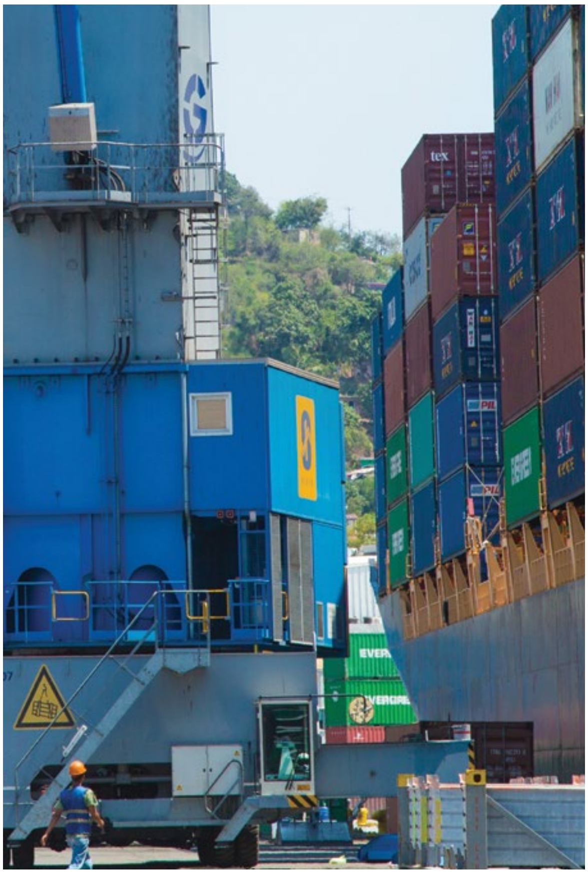
Maritime transport

Asian typhoons can cause delays in vessels reaching the Port of Manzanillo. In 2014, some 25% of vessels originated from SE Asia. Changes in East Pacific tropical storms can also affect regional export and import of goods from Manzanillo. The port receives 68% of its cargo from the Mexican Pacific.

A future increase in maximum intensity and duration of typhoons and tropical storms will potentially affect regional Pacific trade using smaller vessels (<500 UAB) more than it will affect international trade using larger vessels (>500 UAB).

Adaptation options include broadening the port's client base to be less dependent on maritime traffic to/from South East Asia, by increasing the diversity of clients from international regions less subject to storms. For example new shipping routes such as the Northern Passage could be exploited.

The attractiveness of the port to Mexican Pacific cargo can be maintained through well-developed regional contingency plans, such as the use of road and rail networks when maritime transport is severely disrupted.



Environmental performance

Disposal sites for dredged material which are not climate resilient could lead to off-site pollution through overtopping of dikes or containment walls.

The capacity of drainage systems, filters and oil/water separators may be insufficient in light of more intense rainfall and lead to on- or off-site pollution. Flooding can wash pollutants from contaminated land or storage areas into water bodies unless there are adequate control measures.

The frequency and intensity of poor air quality episodes could also be affected and ports may be required to minimize Volatile Organic Compound (VOC) emitting activities such fuel handling.

Coastal or marine habitats within the zone of influence of ports will be increasingly affected by climate change, including mangroves, salt marsh, sea grass and coral reefs. It may be difficult to determine whether climate change or a port's operations are the primary factors resulting in impacts on species and habitats.

On-site management and action plans for mitigation, clean up and restoration of uncontrolled releases should take into account changing rainfall patterns. Pollution control equipment should be placed in low-risk locations, especially hazardous material storage areas.

Bunding for liquid storage tanks should add safety margins, accounting for tank failure occurring during extreme rainfall events.

Monitoring is a vital tool in building resilience, to assess the current state of water and air quality, and the health of local ecosystems.

API Manzanillo is responsible for obtaining and/or maintaining the 'Certification of Clean Industry or Environmental Compliance' for the port area. API Manzanillo is certified to ISO 14001, which demonstrates a strong commitment to environmental protection.

API Manzanillo's environmental management commitments could increase under climate change, particularly with respect to the maintenance of mangrove habitat, such as the Laguna de las Garzas to the north of the port (Figure 14).

Potential climate change issues for API Manzanillo's environmental performance are:

- Increased pressure on mangroves through sea level rise, high temperatures and drier conditions.
- Increased levels of dust creation and dispersion inside and outside the port as conditions become drier and hotter.
- Increased maintenance dredging and disposal of dredge material affecting water quality and benthic habitat.
- Increased energy use for cooling and associated greenhouse gas emissions.

API Manzanillo is insured against environmental non-compliance e.g. for mangrove habitat. This insurance is determined by SEMARNAT and can increase if port activities and expansion result in additional disturbance of protected species.

Adaptation options include managing the mangroves within the port to help them adapt to sea level rise, and reducing negative stressors on mangroves. Current protocols for dust management can be enhanced.

Measures that can be applied to reduce GHG emissions from use of reefers and cold storage warehouses include photovoltaic power generation, a port-wide review of energy efficiency in the light of climate change, and development of an energy management system.

FIGURE 14

Laguna de las Garzas mangrove habitat and avifauna

Source: API Manzanillo. (2014). Proyecto: 'Puerto de Manzanillo, Programa Maestro de Desarrollo 2000-2010.' Informe Annual 2014.

Social performance

Ports, commonly located near economic centers and communities, can be in competition with others over land and other resources. Some ports may already be restricted in the land available to them due to erosion and sea level rise. Climate impacts on water resources and supply of utilities can all act as additional stressors on port-community relationships.

Higher temperatures, heavier rainfall and increased wind speeds can create additional health & safety risks for workers.

Climate change may also affect worker exposure to air pollutants, generation and dispersion of dust, ozone and volatile organic compounds. Impacts on pollution risk have the potential to affect the health and livelihoods of the surrounding community.

Safety management systems regulating movement of vessels within harbors and protection of the wider community could fail under more extreme climatic conditions.

Previous social impacts should be analyzed to determine cause-effect pathways and how weather has interacted with these.

Operational, health & safety plans should be modified for managing heatwaves, extreme precipitation events and storms, and adequate safety equipment and emergency refuge areas provided.

Ports should liaise with emergency planners and the local community to ensure site evacuation procedures are aligned with community evacuation procedures.

Climate change impacts affecting the port and the city of Manzanillo can affect port workers and members of the wider community.

Dengue fever is becoming more prevalent in Mexico. The number of people affected has grown from less than 1,000 per year in the late twentieth century to more than 100,000 per year in recent years, as the disease appears in large cities including Cuernavaca, Morelos and Guadalajara, Jalisco. This can affect workers at the port and the wider community.

Recorded cases of dehydration and heat stress for workers at the Port of Manzanillo are generally low, and future increases in maximum temperatures due to climate change do not indicate a large increase in risk.

High winds and rainfall can lead to hazards for port workers. Reduced annual and seasonal mean rainfall is expected at the port in future, with more rain falling in heavy events. The number of days per year with rain is likely to reduce, so risks of rain-related worker accidents are unlikely to increase. While is expected that tropical storms, and hence extreme wind speeds, will become more intense in the future, the port is closed by the Harbor Master when impending tropical storms pose a safety risk.

Climate change may exacerbate existing challenges in the relationship between the port and the local community, such as dust and traffic congestion: Hotter and drier conditions will increase dust generation; increased flood risk on the port access road could worsen congestion problems.

In terms of adaptation actions, API Manzanillo should monitor dengue cases and keep in touch with health authorities on future forecasts of potential epidemics.

API Manzanillo should also provide warnings of extreme high temperatures to minimize heat stress risks for workers.

To ensure the harmonious development of the city-port relationship, future developments will benefit from closer collaboration between port and city authorities, and integrated adaptation initiatives that bring benefits to both. Within this context, management of dust outside the port and traffic movements to avoid congestion during extreme weather events will be important aspects to consider.

Demand and consumption patterns

Globally, changes in productivity of climate-sensitive systems will lead to changing prices and competitiveness of different countries. This will drive changes in world trade, with impacts varying considerably across sectors and regions.

Climate change impacts on trade, reflected by demand and consumption patterns, is therefore a potentially significant risk and opportunity area for ports.

Ports should monitor changes in supply and demand that can be caused by climate change, particularly on highly sensitive commodities such as agricultural products. Business forecasts and strategies should take into account these potential changes.

Global GDP and revenue flows at the Port of Manzanillo are strongly correlated. For every 1% fall in global GDP, revenue at the port falls by 1.5% (Figure 15). Hence the port´s economic output could be negatively affected by the impacts of climate change on the world´s economy. Based on the findings of the Stern Review , this could result in revenue losses ranging from -0.30% to -0.95% by the 2020s, -0.38% and -1.88% by the 2050s and between -0.75% and -2.82% by the 2080s. By the mid-2030s, the port could see annual revenue losses of 4 million to 10 million MXN, and 6 million to 15 million MXN by the mid-2040s.

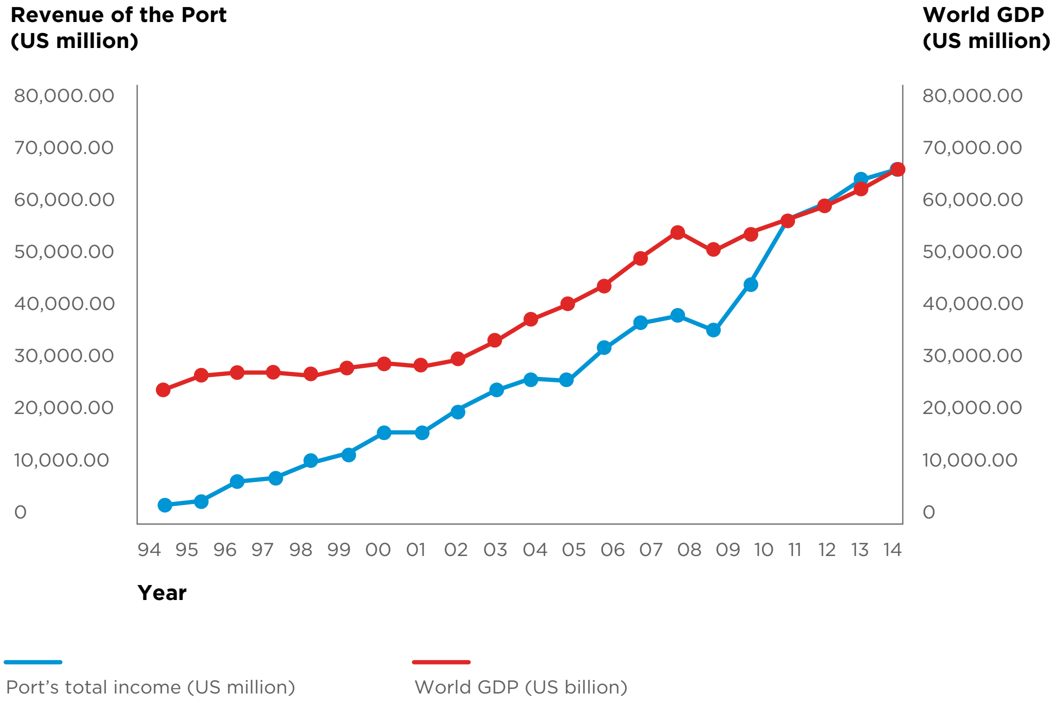
As the port is strongly dependent on trade flows with key trading partners such as China, Japan, and South Korea, climate change impacts on the economies of these countries can affect the port.

Within Mexico, climate change may negatively affect economic production in the States of Jalisco, Estado de México, Colima and Distrito Federal. These states account for 65% of the import market and 83% of the source of goods for export.

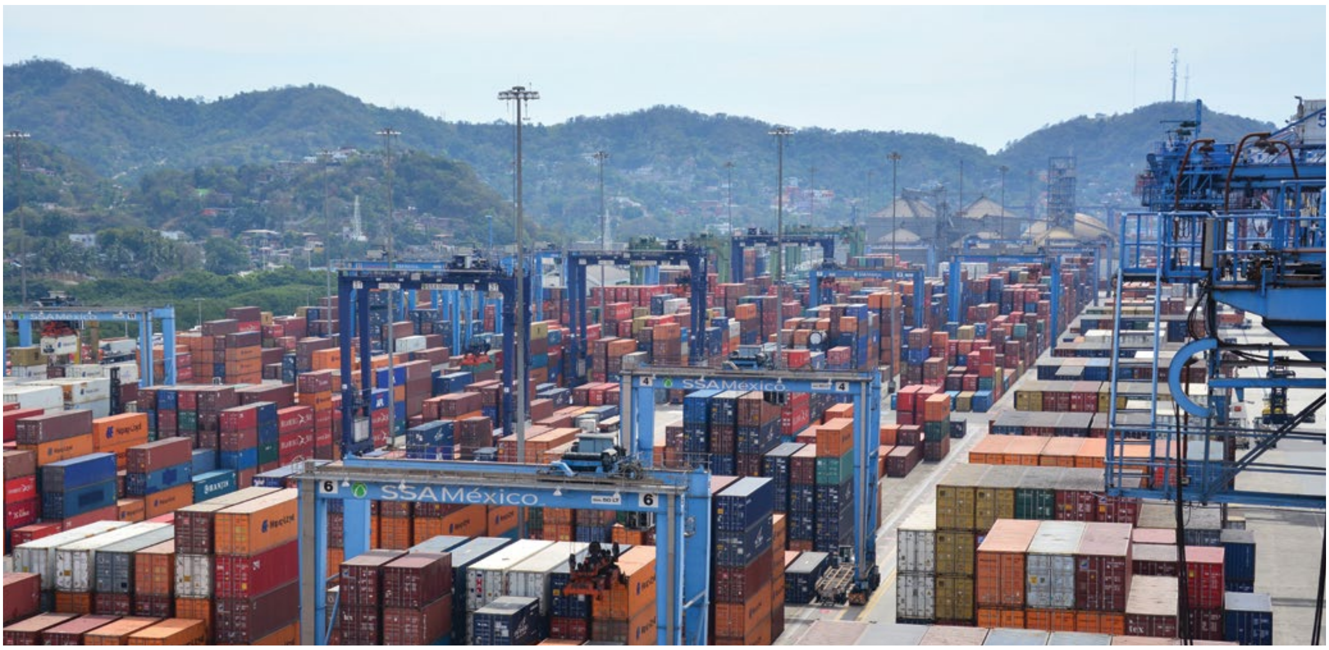
Adaptation options include diversification of trading partner countries and growing a broader range of business lines. Diversifying the number and location of trading partners can help with managing the potential for reduced trade flows from countries that are more affected by climate change impacts. Expanding the portfolio of business lines can help to spread the risk of business lines being affected by climate change and to profit from emerging and expanding markets driven by climate change. These opportunities would need to be further investigated as part of strategic analysis carried out to support the development of future Port Master Plans. For instance, the port can explore opportunities to increase the import of agricultural commodities where there is high demand in Mexico and where domestic production can be adversely affected by climate change, in particular the trade of corn.

FIGURE 15

Comparison between world GDP and Port of Manzanillo revenue from 1994 to 2014



Source: IMF World Economic Outlook Database (2014), API Manzanillo PMDP



Competition with other ports

The use of port facilities may become more dependent on: customers' perceived reliability of the port in the face of extreme weather events; the performance of climate-sensitive industries which ports are heavily reliant on (such as tourism, agriculture and manufacturing); and the ability of ports to keep up with changing conditions in other industries and their related service and facilities requirements.

Ports should monitor their competitors who may have the opportunity to provide access to new markets and benefit from changes in trade volumes. Customer expectations in terms of reliability of port services and negative effects of climate-related disruptions should be monitored.

There are six major ports in Mexico: Ensenada, Manzanillo, and Lázaro Cárdenas from north to south on the Pacific coast, and Altamira, Tampico and Veracruz on the Atlantic coast.

Manzanillo faces some disadvantages compared to its competitors. It suffers from difficult access and traffic congestion on major trucking routes and is located in some of Mexico's most environmentally sensitive areas e.g. the Laguna de Las Garzas. It is also approaching the limit of the area available for further expansion with the current port perimeter.

The Pacific ports experience much lower annual closure to vessels from tropical storms compared to the Atlantic ports. Annual closures for Pacific ports occur on average 0.5% of the time for vessels >500 gross tonnage (UAB), and 5.5% of the time for vessels <500 UAB. At Manzanillo, annual closures are 0.4% and 6.6% respectively, and they are lower at Ensenada, but higher for Lázaro Cárdenas. Annual closures for Atlantic ports average 5.4% of the time for vessels >500 UAB, and 21% of the time for vessels <500 UAB.

Tropical cyclones are migrating poleward, at a rate of about 50 km per decade. For the Pacific ports, this poleward movement is not sufficient to bring Ensenada under the influence of storms currently experienced at Manzanillo, so Ensenada will retain its competitive advantage in this respect.

Rates of future mean sea level rise are similar across all six ports and will not give any port a competitive advantage.

Implications of national and international agreements or commitments to reduce greenhouse gas (GHG) emissions

It is becoming apparent that current efforts to reduce the concentration of greenhouse gases in the atmosphere will not be sufficient to keep global temperature increases below the 2°C target.

This is recognized by both the Intergovernmental Panel on Climate Change (IPCC) in its last two reports, (2007 and 2013), and the international community, as noted in in the Copenhagen Accord negotiated within the framework of COP15 in 2009.

The 2014 United Nations Environment Programme (UNEP) Emissions Gap Report indicates that in 2012 global greenhouse gas emissions were 45% higher compared to 1990 levels (54 Gt CO_2e in 2012) with a 2020 trajectory estimation of 55 Gt CO_2e if countries do not go beyond their existing climate change policies.

Changes in regulations, standards and investors' expectations in Mexico due to international and Mexican commitments to reduce greenhouse gas emissions (Figure 15) may have implications for the port's business lines. The Conference of the Parties (COP) in Paris in late 2015 is seeking to achieve a legally binding and global agreement on climate. However, there is considerable speculation about the outcome of the COP.

According to Mexico's Intended Nationally Determined Contributions (INDC) the country is committed to reduce unconditionally 25% of its Greenhouse Gases and Short Lived Climate Pollutants emissions (below Business As Usual) for the year 2030. This commitment could increase up to 40% conditional on the COP reaching a global agreement.

Mitigation commitments have the potential to affect the price of petroleum products traded through the port. Other cargoes where demand could be affected include vehicles and minerals.

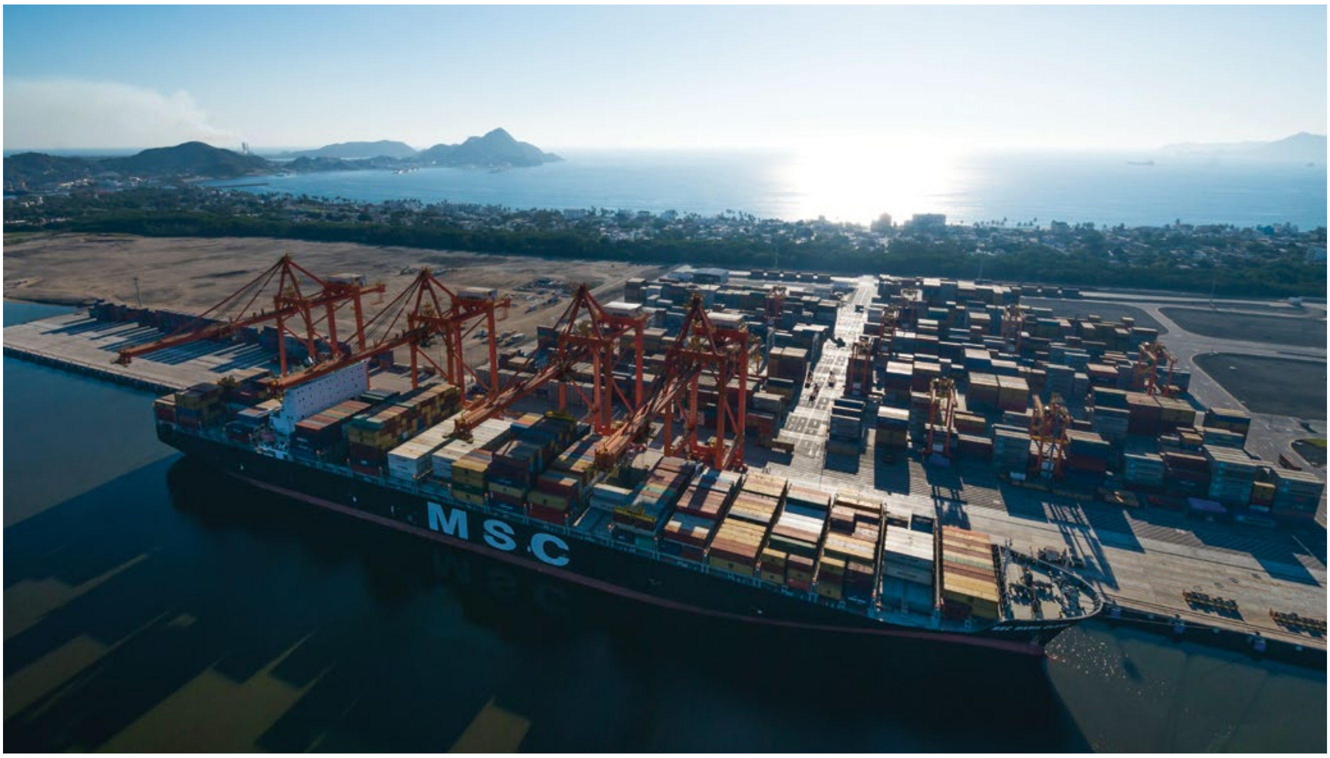
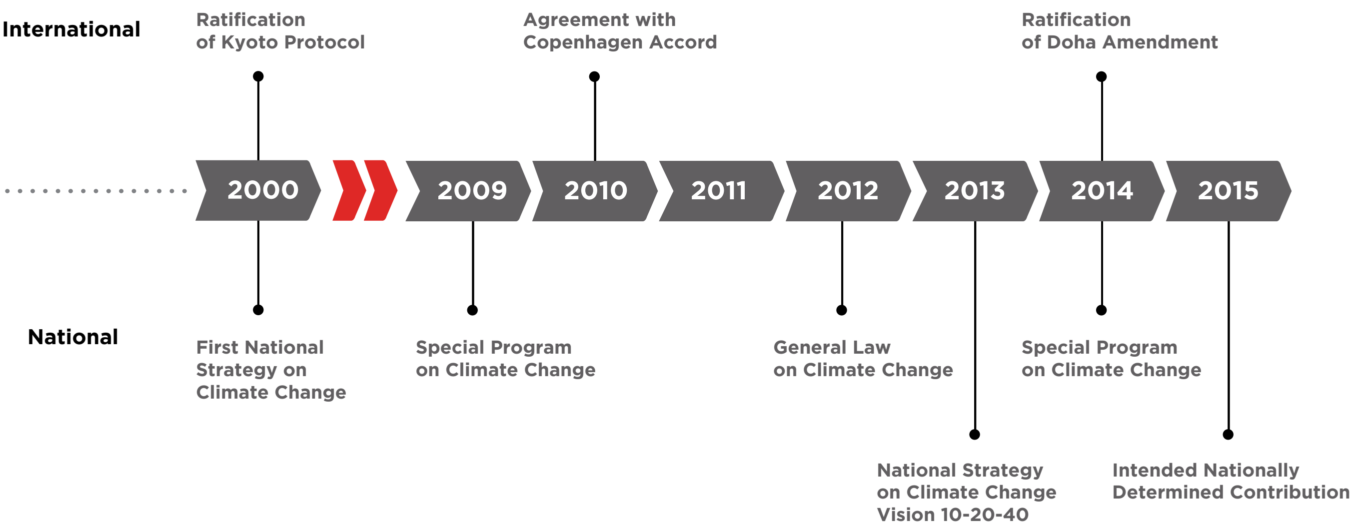


FIGURE 16

The development of climate change mitigation instruments internationally and in Mexico



Source: Report authors

Future evolution of the insurance market

The insurance industry globally is recording increasing insured losses due to weather-related catastrophes.

Since the 1980s, the number of loss-relevant weather-related catastrophes has almost tripled.

In 2013 Mexico was the seventh most affected country worldwide in terms of number of weather-related and the sixth most affected in terms of overall losses (Figure 17).

The insurance industry has been vocal about climate change for more than a decade, expressing its concerns that, without strong action to reduce global greenhouse gas emissions, there will be major shifts in risk landscapes worldwide and threats to human and economic wellbeing.

Ports, along with other sectors, may face higher premiums and higher deductibles if they make more claims for weather-related losses, as events become more frequent due to climate change.

API Manzanillo has a comprehensive insurance package which covers it against asset damage, costs relating to temporary relocation of port services in case of operational disruptions, public liability, smaller vessels and vehicles. It is not apparent from API Manzanillo's policy documents that business interruption is included.

From 2010 to 2014 two weather-related insurance claims were made by API Manzanillo, for damage to electrical equipment affected by electrical storms.

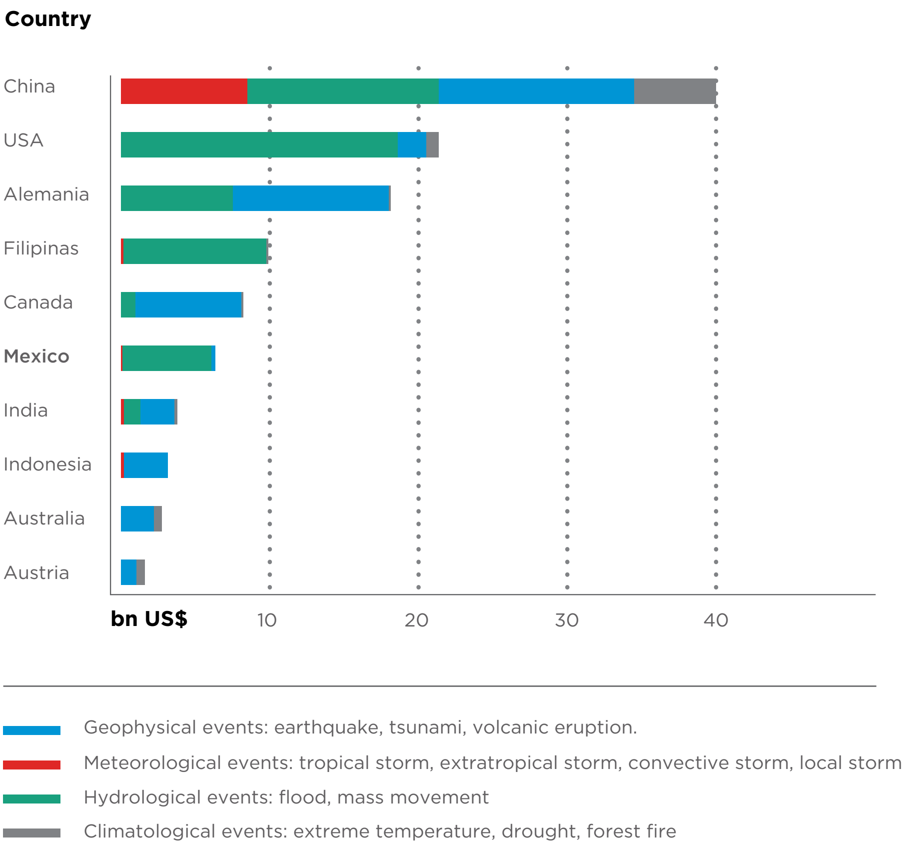
Terminals that provided insurance details hold commercial insurance policies which typically covers asset damage and third-party (civil) liability. Some also have business interruption cover.

Future increases in the frequency of weather-related events and associated insurance claims may result in increases in premium costs and higher deductibles for API Manzanillo and the terminals. API Manzanillo and the terminals should monitor changes in premium costs and deductibles for policies covering weather events.

With its Adaptation Plan in place and adaptation actions being implemented, API Manzanillo and the terminals could request that insurers provide more favorable insurance terms.

FIGURE 17

Loss events worldwide in 2013 by overall losses Mexico ranks in sixth place



Source: Munich Re (2014). Available from: http://www.munichre.com/site/corporate/get/documents_E-529855854/mr/assetpool.shared/Documents /5_Touch/Natural%20Hazards/NatCatService/Annual%20Sta titics/2013/MunichRe-Nnatcatservice-Naturaldisasters2013-Countries.pdf

Financial and economic summary of climate change risks for the Port of Manzanillo

The climate change risks with the most significant financial impacts for the Port of Manzanillo as a whole are:

- Increased surface water flooding of the port. This affects the terminals road and rail movements, and increases maintenance costs for API Manzanillo.
- Increased sedimentation of the port basin due to increased intense rainfall. This reduces draft clearance for vessels and increases maintenance dredging, both of which disrupt terminal operations and cost API Manzanillo.
- Impacts of climate change on the global economy, which in turn, could affect trade through the port.

If no action is taken, significant financial impacts will be borne by both API Manzanillo and the terminals for these key issues. However the impacts are not considered severe enough to pose risks to the continuity of business at the port over the medium or long term (2050s to 2080s). A comparative summary of the increase in costs due to climate change by 2050, if no action is taken on adaptation, is given in Figure 18.

Surface water flooding

A 50% increase in storm intensity is considered a maximum scenario for the study's sensitivity analysis. By 2050 this would result in increased loss of annual revenue due to surface water flooding for all terminals of 41.5 million MXN. Hydrological analysis shows a doubling in the frequency of drain surcharge by the 2050s.

Surface water flooding can be viewed as a port closure issue for API Manzanillo. On average the port is closed 0.5 days per year due to flooding. Average costs of port closure for API Manzanillo are 0.12% of annual income per 24 hours of closure. Figure 19 shows the potential change in annual losses for API Manzanillo for port closure due to flooding under changing storm scenarios.

Increased sedimentation

Increased sedimentation of the port basin and drainage system due to increased intensity of rainfall has several financial impacts:

- An increased requirement for maintenance dredging.
- Increased drain maintenance e.g. clearing of sediment traps.
- Impacts of increased dredging activities on vessel access to terminals.

An increase in 8% of sediment load due to increased rainfall intensity would cost 864,000 MXN extra per year for dredging by the 2050s. Mean sea level rise would reduce these additional costs by between 86,400 and 108,000 MXN per year.

Total annual costs in 2014 for drainage maintenance were around 19.5 million MXN (4.5% of API Manzanillo's operating expenditure). A proportional 8% increase in sediment deposition would cost an extra 1.6 million per year by 2050. A 50% increase in storm intensity would result in an additional 9.7 million MXN per year.

Delays for the terminals due to dredging vessel movements are estimated to cost 233,884 MXN per hour across all terminals a present. An 8% increase in delays and associated costs is estimated by the 2050s.

Climate change Impacts on total trade

Impacts of climate change on the global economy could affect total trade through the port. Based on the strong correlation between global GDP and revenue at the port, estimated projected revenue losses at the port range from -0.30% to -0.95% by the 2020s and -0.38% and -1.88% by the 2050s. This translates into annual revenue losses of 4 million to 10 million MXN by 2035, and 6 million to 15 million MXN by 2045.

Cost effectiveness of adaptation options

For the priority risks, a high level analysis of the cost effectiveness of identified adaptation measures was conducted. Low, medium and high ratings for cost and effectiveness were assigned to each adaptation measure. For example, for surface water flooding affecting road/rail connectivity, the adaptation measures considered are:

- P1 Upgrade drainage system inside port.
- P5 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.

High-level conclusions from the findings of the cost effectiveness analysis are:

- Engineered (grey) measures are often the most effective at reducing risk, but are generally more costly and have few positive (beneficial) additional consequences.
- Ecosystem-based (green) options have more positive additional consequences, but they are typically not as effective as engineered options at reducing risk.
- Hybrid options tend to be in the middle in terms of cost effectiveness, and can have positive additional consequences.

Financial analysis of upgrades to drainage system

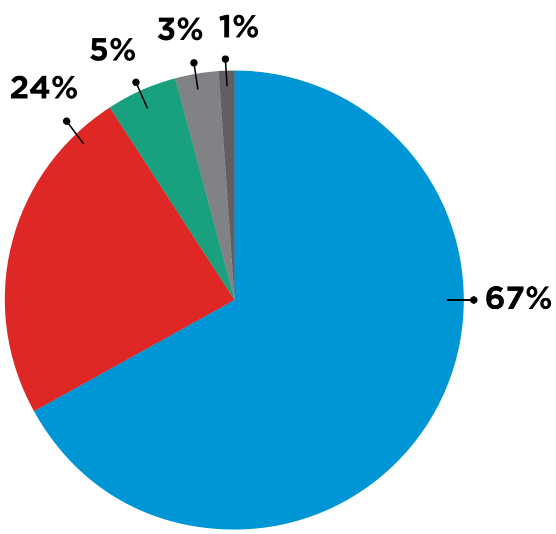
To evaluate the issue of surface water flooding and sedimentation in more detail, the financial performance of physical upgrades to the drainage system was assessed, to enable it to cope better with increased rainfall intensity. Estimated costs for upgrading the capacity of Drain 3 were around 93 million MXN, and for installation of an additional sediment trap in all drains, around 7 million MXN.

The savings for API Manzanillo from these investments were the avoided total losses / costs for surface water flooding assuming adaptation was not undertaken, (i.e. port closure, maintenance dredging and drainage maintenance combined.) It is assumed the upgrades could offset 75% of these cost.

Figure 21 shows that undertaking the drainage upgrade leads to a noticeable reduction in API Manzanillo's Earnings before interest, taxes, depreciation, and amortization (EBIDTA) in 2019 to 2023 (green line) as the drain

FIGURE 18

Increase in costs/loss of revenue by 2050 for climate change risks with the greatest financial impacts

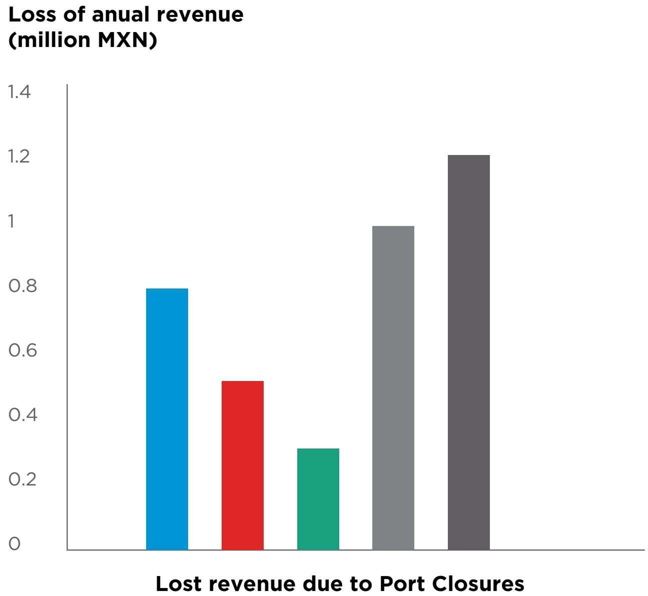


- Increased surface water flooding of the port
- Increased dredging costs
- Increased drain maintenance costs
- Loss of vessel access to terminals
- Impacts of climate change on the global economy

Source: Report authors

FIGURE 19

Loss of annual revenue to API Manzanillo from port closure due to flooding under changing storm scenarios

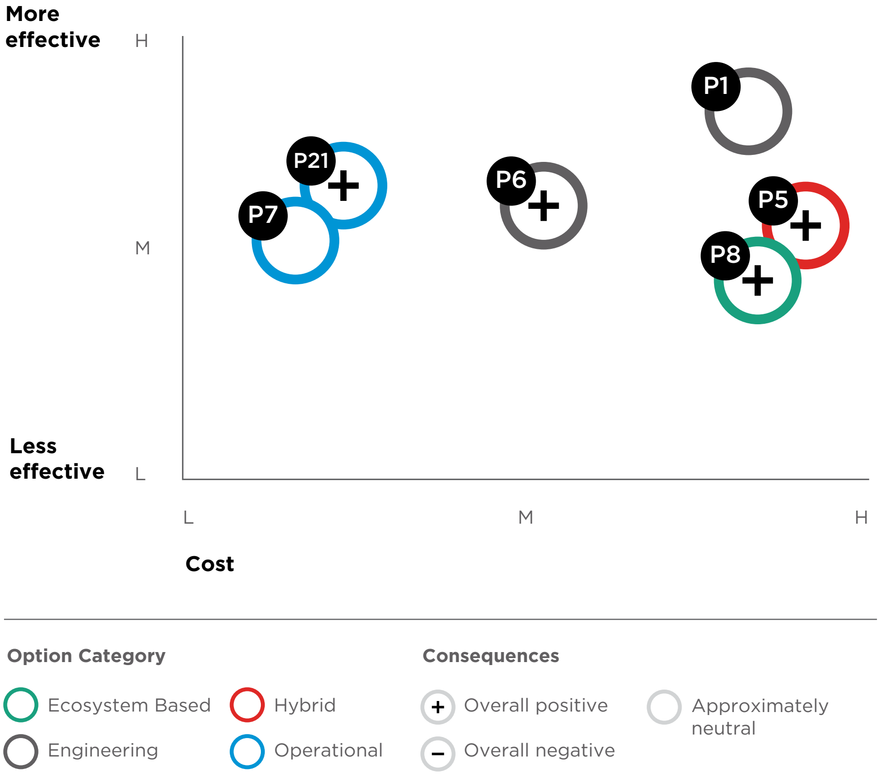


- Historical average
- 25% decrease in frecuency
- 50% decrease in frecuency
- 25% increase in mean lifetime of maximum intensity
- 50% increase in mean lifetime of maximum intensity

Source: Report authors

FIGURE 20

Cost effectiveness of adaptation measures for surface water flooding



Source: Report authors

TABLE 4

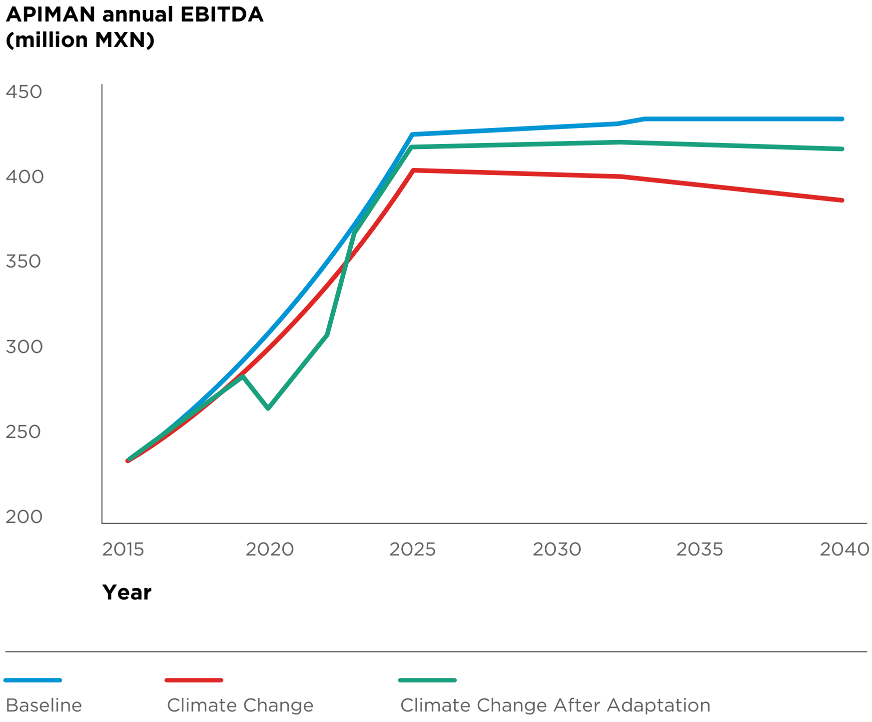
Scenarios studied for financial analysis of drain upgrades and installation of sediment traps

Scenario	Sand trap installation	Drain upgrades
Base case	Takes place over 3 years from 2016 to 2018	Takes place over 3 years from 2020 to 2022
Adaptive management	Takes place in 3 phases, in 2016, 2018 and 2020	Takes place in 3 phases in 2021, 2025, and 2029
5 Year delay	Takes place over 3 years from 2021 to 2023	Takes place over 3 years from 2025 to 2027
10 Year delay	Takes place over 3 years from 2026 to 2028	Takes place over 3 years from 2030 to 2032

Source: Report authors

FIGURE 21

Effects of drainage-related climate change impacts and upgrades to drainage system on API Manzanillo's annual EBITDA (2015 MXN)



Source: Report authors

upgrade investments are made. From 2023 onwards, EBIDTA with the adaptation measures in place is greater than EBIDTA without adaptation (red line), as the impacts of climate change are reduced.

Four scenarios for implementation of these adaptation measures were analyzed to explore how the finances are affected by completing the projects in phases or delaying the projects, as set out in Table 4.

Financial performance under each of these scenarios is summarized in Figure 22.

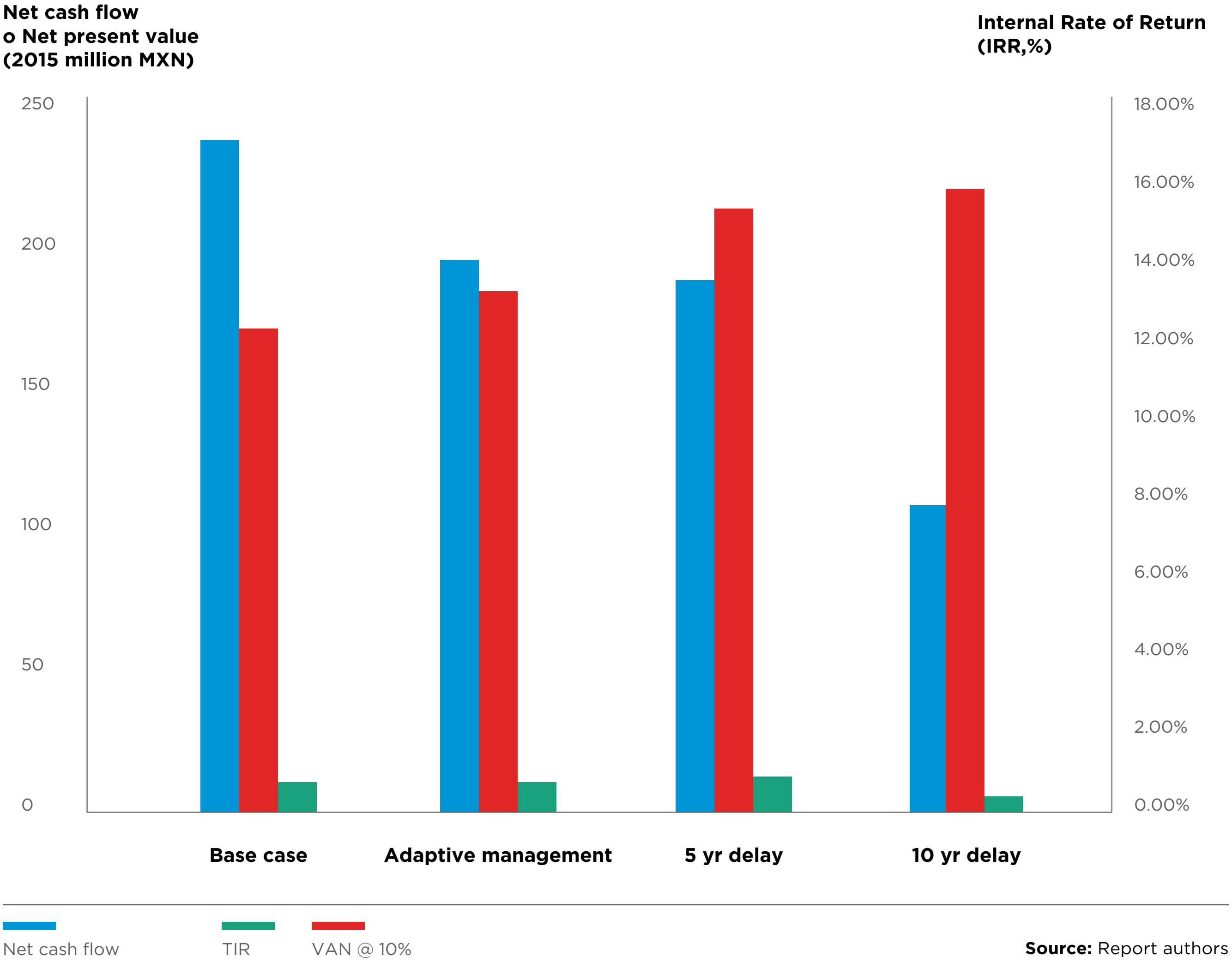
The investments are shown to be financially worthwhile based on the assumptions made to undertake the analysis. The costs of implementation are not large compared to API Manzanillo's overall annual OPEX, particularly if the projects are implemented in phases over several years. These results are preliminary, additional engineering and design work is required to clarify further.

Scenarios where the investments are delayed lowers the net cash flow (because it leaves the port exposed to climate change impacts for longer) but improves the rate of return on the investment.

At API Manzanillo's discount rate of 10%, the NPV of the base case ("one-off adaptation") and adaptive management scenarios is roughly equal. Lower discount rates favor the base case, and higher discount rates favor adaptive management.

FIGURE 22

Comparison of financial performance of adaptation implementation scenarios for upgrades to drainage system



Source: Report authors

Adaptation Plan

Alignment with government policy

This Adaptation Plan sets out the measures to manage climate-related risks and opportunities for the Port of Manzanillo and the port community, whilst being in alignment with key adaptation policy instruments at the Federal, State and Municipal levels.

Mainstreaming adaptation

In line with good practice, the measures in the Adaptation Plan need to be mainstreamed within existing plans and processes at the port where relevant. Mainstreaming is an efficient way of ensuring that actions in the plan have owners, and are delivered and monitored effectively.

There are two main areas where the adaptation measures fit, namely:

- The Port Master Plan.
- Operational plans and procedures of API Manzanillo and the terminals.

The full report identifies these linkages.

The adaptation measures recommended in the Adaptation Plan contribute either to (Figure 23).

- Building adaptive capacity: helping to understand and respond to climate change challenges. This include measures to create new information (e.g. data collection, research, monitoring and awareness raising) and to support governance or organizational structures. These are low cost, no/low regret adaptation measures and it is recommended that they should start to be implemented as soon as possible as in many cases they can help in delivering adaptation actions.
- Delivering adaptation actions: implementing actions that help reduce climate change risks or take advantage of opportunities. These are further divided into: Gray / Green / Hybrid measures.

Following the findings of the risk assessment of the port, adaptation measures are further divided into two categories:

- Priority adaptation measures addressing priority risks identified in the risk assessment (see Table 5).
- Adaptation measures addressing medium and low priority risks.

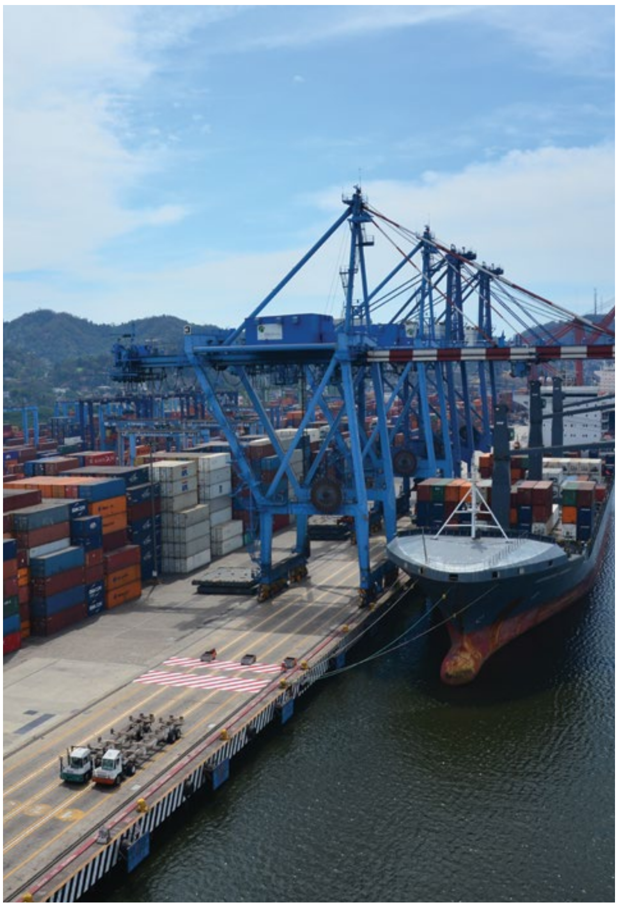
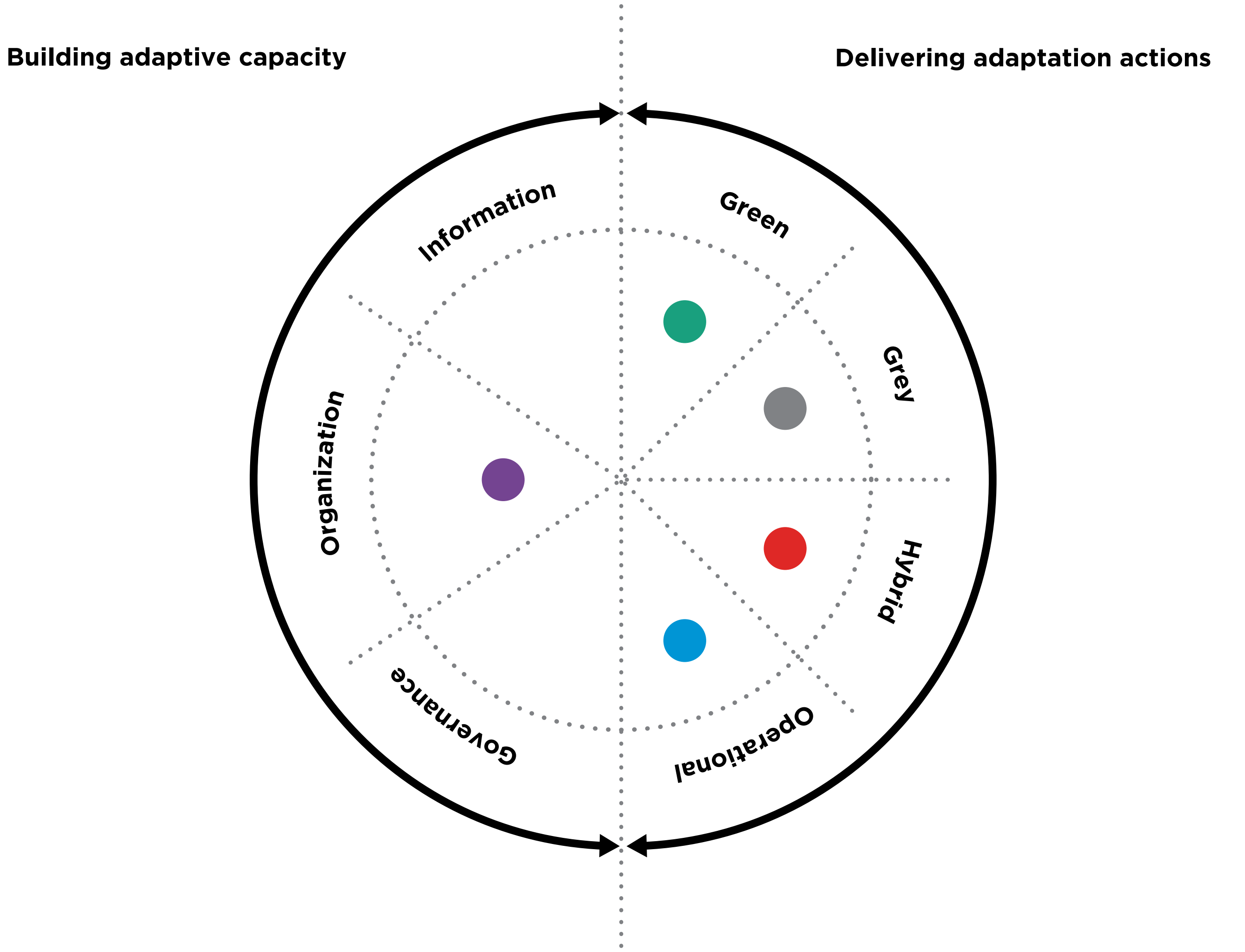


FIGURE 23

Types of climate change adaptation measures recommended for the Port of Manzanillo



Climate adaptation policy and regulation in Mexico

Any climate change adaptation actions recommended for ports must respond to the needs of the port, while at the same time working within the context of adaptation planning and port planning of the country.

This Adaptation Plan takes into account the latest climate change policy developments established at the federal, state and municipal level in Mexico to ensure that adaptation actions at the port are in alignment with policy instruments that already exist in the country.

In Mexico, key Federal level climate adaptation policy instruments include:

- General Law on Climate Change (Ley General de Cambio Climático).
- National Strategy on Climate Change. Vision 10-20-40 (Estrategia Nacional de Cambio Climático. Visíon 10-20-40).
- Special Program on Climate Change (Programa Especial de Cambio Climático).

The key State level climate adaptation policy instrument is:

- State Program on Climate Change for Colima (Programa Estatal de Cambio Climático).

The Plan is aligned with the most recent policies on climate change

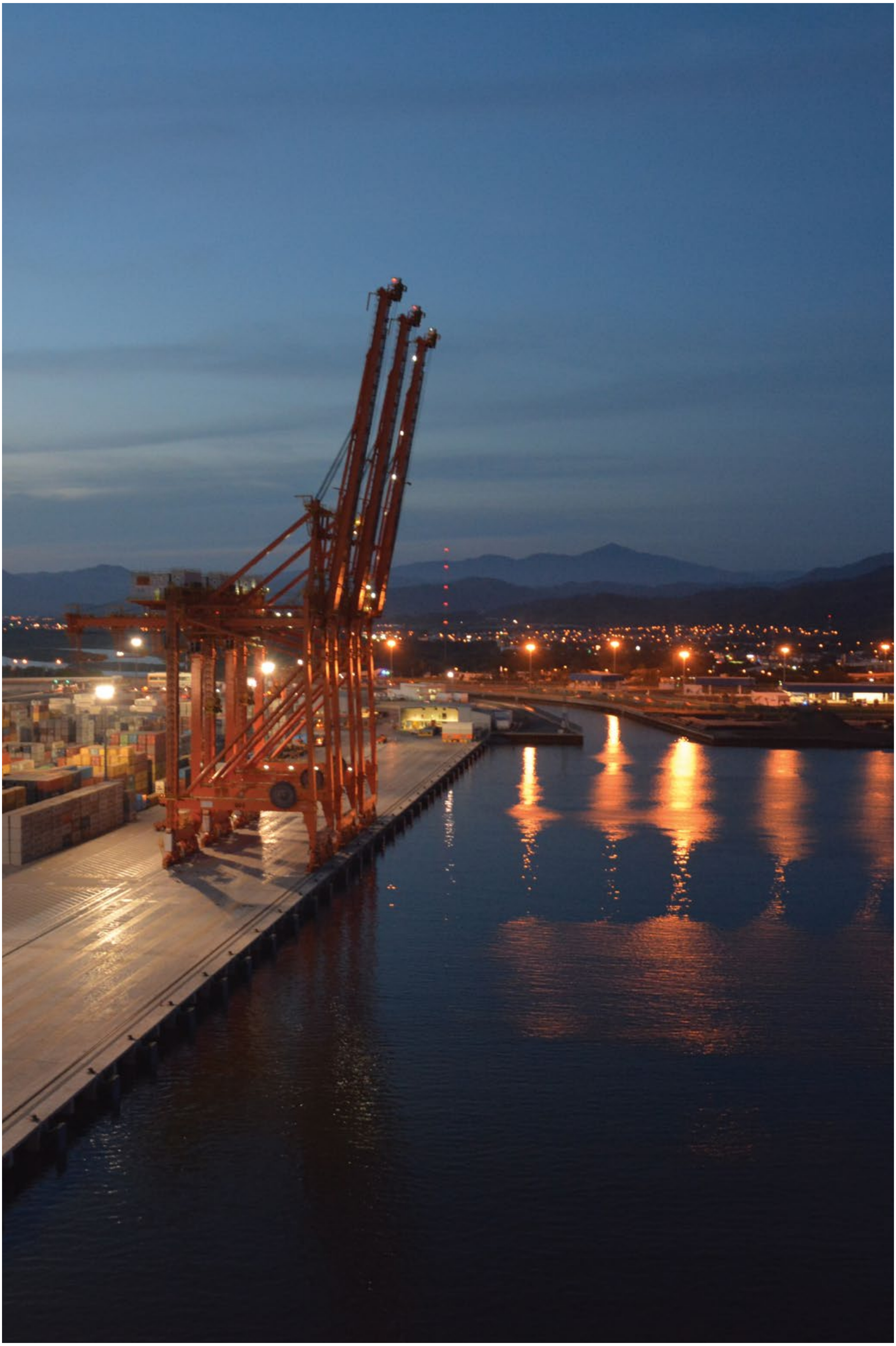
At present, the Municipality of Manzanillo has not yet developed its climate action plan. Nonetheless it is working towards incorporating climate change into key municipal policy instruments, namely:

- Municipal Ecological and Territorial Planning Program (Plan de Ordenamiento Ecologico Municipal).
- Development Plan for Manzanillo (Plan de Desarrollo).

In providing an assessment of climate risks for one of Mexico's largest ports and recommending concrete adaptation measures, this study responds to national strategic objectives including:

"To reduce the vulnerability and increase the resilience of strategic infrastructure and productive systems in the face of climate change".
National Climate Change Strategy Vision 10

"Reduce the vulnerability of the population and of productive sectors and to increase their resilience, as well as the resilience of critical infrastructure".
Special Program on Climate Change



Stakeholder Engagement Plan

Adequate engagement of relevant stakeholders is a critical factor for the successful implementation of any adaptation plan (Figure 24). It can help identify synergies in adaptation objectives and avoid conflicts.

Key stakeholders for API Manzanillo to inform, consult and collaborate on the delivery of the adaptation measures have been identified. They include:

Port community:

- Terminals
- Shipping lines
- Logistics operators
- Unidad Municipal de Protección Civil

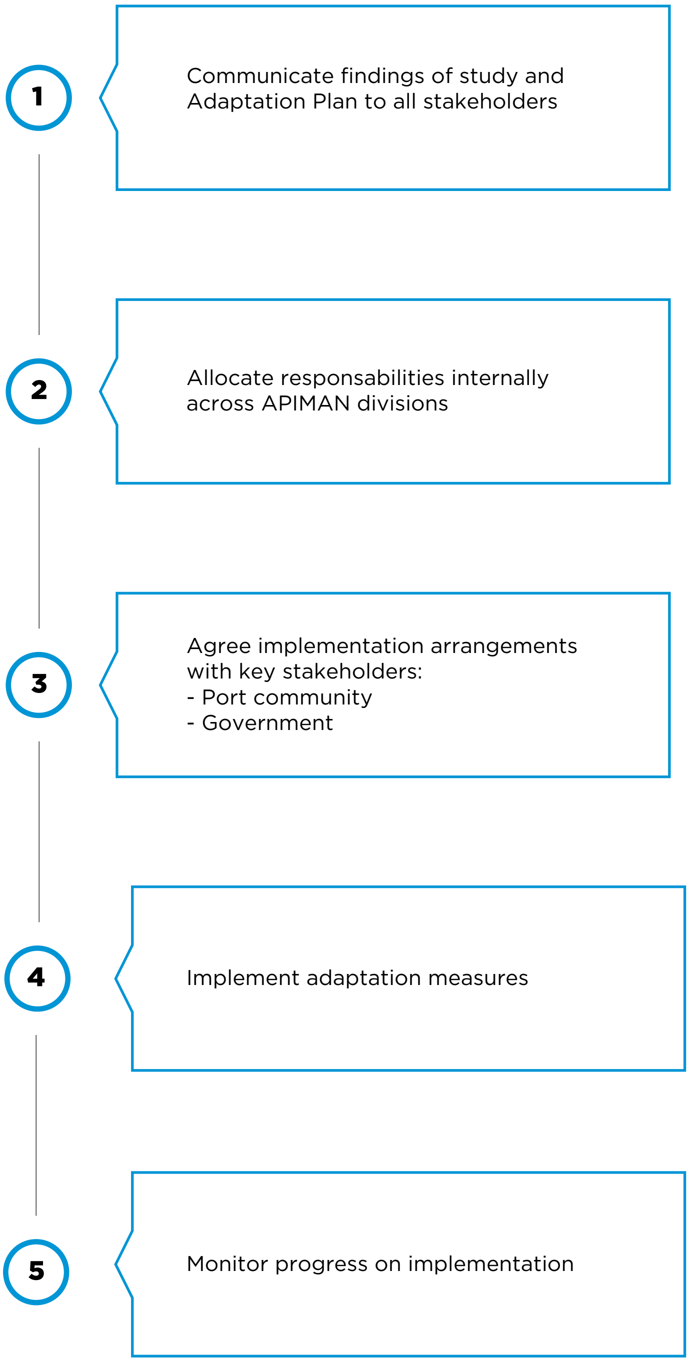
Government:

- Ayuntamiento de Manzanillo
- IMADES
- SEMARNAT
- INECC
- SCT
- IMT
- CONAGUA

The immediate next steps for API Manzanillo are to communicate the study findings and the Adaptation Plan internally, to the terminals, and to the wider port community. To support the implementation of recommendations made in this study, API Manzanillo will need to allocate responsibilities among its divisions and agree implementation arrangements with other key stakeholders. With this in place, API Manzanillo and the terminals can begin incorporating the adaptation measures into their strategic and operational activities. A plan should be developed by API Manzanillo in coordination with the terminals and other key stakeholders to monitor progress in the implementation of adaptation actions and to evaluate their performance, building on the adaptation indicators recommended in the full study report. API Manzanillo should also monitor trends in observed climate and oceanographic parameters at the port to understand how they are changing over time. Finally API Manzanillo is recommended to stay abreast of new developments in climate change projections, through communications with INECC.

FIGURE 24

Next steps in the implementation of the Port of Manzanillo Adaptation Plan



Source: Report authors

TABLE 5.1

RISK AREA FOR PORT

Damage to infraestructure, building and equipment

PRIORITY CLIMATE RISK

Increased frequency of intense rainfall events causes damage to infrastructure and equipment through surface water flooding.

ADAPTATION OBJECTIVE

Increase resilience to floods and intense rainfall events.

Adaptation measure	Type	Cost	Effective-ness
P1 - Upgrade drainage system inside the port to increase maximum capacity and handle increased flow.		H	H
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
P3 - Engage with stakeholders to plan landscape level flood management options.		No regret	
P4 - Review early flood warning systems and identify areas for improvement in light of increased risk due to climate change.		No regret	
P5 - Review options for using sustainable drainage systems (SUDS) taking into account potential for changes in precipitation.		H	M
P6 - Upgrade and improve sediment traps.		M	M
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
P8 - Consider catchment level landscape planning and ecosystem based adaptation options for reducing risk of drainage overflow.		H	M

Lead entity	Key partners	Adaptation Indicator(s)	Implement in Port Master Plan (PDMP) in:			
			2012-2017	2017-2022	2022-2027	2027-2032
API Engineering	Ayuntamiento de Manzanillo (Commission of drinking water, drainage and sewage), CONAGUA	Drainage system upgraded to accommodate increased flows				
API Engineering		Critical infrastructure vulnerable to flooding is climate proofed				
API Engineering, API Ecology	Ayuntamiento de Manzanillo (Department of Environment, INPLAN), CONAGUA	Landuse planning measures to support flood management are incorporated in Municipal land use planning programmes				
API Engineering, API Ecology	Ayuntamiento de Manzanillo (Department of Environment, INPLAN), CONAGUA	Updated flood early warning system in place				
API Engineering, API Ecology		Options for the incorproation of SUDS at the port are assessed and implemented				
API Engineering		Upgrades to sediment traps completed				
API Engineering		Increased frequency of sediment trap clearance				
API Ecology	Ayuntamiento de Manzanillo (Department of Environment, INPLAN), CONAGUA	Catchment-based approach to managing flood risk is implemented with Municipality				

TABLE 5.2

RISK AREA FOR PORT

Port Services

PRIORITY CLIMATE RISK

Increase in intensity of rainfall causing increased sedimentation of the port basin, reducing draft clearance for vessels and terminal access.

ADAPTATION OBJECTIVE

Reduce risk of sedimentation.

Adaptation measure	Type	Cost	Effectiveness
P9 - Monitor levels of sedimentation and assess trends in historic dredging frequencies and quantities.	Hybrid	No regret	
P10 - Update dredging programmes and schedules to reduce loss of draft clearance.	Operational	M	M
P11 - Upgrade and improve sediment traps.	Capacity Building	M	M
P12 - Review and adjust frequency of sediment trap clearance to maintain efficiency.	Operational	L	M

Cost

H: Significant investment in infrastructure\operations\ecological measures > 10% OPEX

M: Moderate investment in new infrastructure\operations\ecological measures 1 to 10 % OPEX

L: Minor investment, mainly operational\informational measures <1% annual OPEX

Effectiveness

H: Intervention has guaranteed effect against 100 % of the risk\impact

M: Intervention has a minimum guaranteed reduction of 50-99% of the risk\impact

L: Intervention has a minimum guaranteed reduction of <50 % of the risk\impact.

Key colour coding

- Capacity Building (dark grey)
- Green (green)
- Grey (light grey)
- Hybrid (red)
- Operational (blue)

Lead entity	Key partners	Adaptation Indicator(s)	Implement in Port Master Plan (PDMP) in:			
			2012-2017	2017-2022	2022-2027	2027-2032
API Enginee-ring		Monitoring system in place to detect trends in sedi-mentation and dredging				
API Enginee-ring		Updated dredging schedule				
API Enginee-ring		Upgrades to sediment traps completed				
API Enginee-ring		Increased frequency of sediment trap clearance				

TABLE 5.3

RISK AREA FOR PORT

Trade routes

Loss of Port connectivity with land transport routes

PRIORITY CLIMATE RISK

Increased intensity of rainfall causes surface water flooding of internal access road and entrance, causing disruptions to port operations.

Increased intensity of rainfall causes surface water flooding of internal port rail tracks, causing disruptions to port operations.

ADAPTATION OBJECTIVE

Increase resilience to floods and to intense rainfall events.

Adaptation measure	Type	Cost	Effectiveness
P13 - Upgrade drainage system inside the port to increase maximum capacity and handle increased flow.		H	H
P14 - Review options for using sustainable drainage systems (SUDS) taking into account potential for changes in precipitation.		H	M
P15 - Engage with stakeholders to plan landscape level flood management options.		No regret	
P16 - Review flood early warning systems and flood management plans and identify areas for improvement in light of increased risk due to climate change.		No regret	
P17 - Review and update plans for evacuation and business continuity during extreme events.		No regret	
P18 - Undertake review and adjust maintenance program to ensure that maximum capacity of existing drainage system inside the port is being achieved e.g. frequency of drain clearance.		L	M
P19 - Upgrade and improve sediment traps.		M	M
P20 - Consider catchment level landscape planning and ecosystem based adaptation options for reducing risk of drainage overflow.		H	M
P21 - Implement traffic management measures to minimize bottlenecks during extreme events.		L	M

Lead entity	Key partners	Adaptation Indicator(s)	Implement in Port Master Plan (PDMP) in:			
			2012-2017	2017-2022	2022-2027	2027-2032
API Engineering	Ayuntamiento de Manzanillo (Comission of drinking water, drainage and sewage, INPLAN), CONAGUA	Drainage system is upgraded to account for future rainfall scenarios				
API Engineering		Report setting out options for using sustainable drainage systems				
API Engineering, API Ecology	Ayuntamiento de Manzanillo (Comission of drinking water, drainage and sewage, INPLAN), CONAGUA	Landuse planning measures to support flood management are incorporated in Municipal land use planning programmes				
API Engineering, API Ecology		Updated flood early warning system in place				
API Operations	Terminals, Emergency centre, Unidad Municipal de Protección Civil	Updated business continuity and evacuation plans				
API Operations	API Engineering	Uptake of operational adjustments ensuring full performance of drainage system				
API Engineering		Upgrades to sediment traps completed				
API Ecology	Ayuntamiento de Manzanillo (Department of Environment), CONAGUA	Catchment-based approach to managing flood risk is implemented with Municipality				
API Operations	Customs, Terminals , Ayuntamiento de Manzanillo (DirecciAyuntamiento de Manzanillo (Department of Environment), CONAGUAón General de Servicios Publicos Municipales)	Reduced traffic jams and bottlenecks				

Study limitations

Climate change risk assessments and the development of adaptation plans face some limitations, due to the current state of knowledge on climate change and its impacts. The key limitations identified for this study are summarized here. Future studies will benefit from ongoing developments in climate science. Bearing in mind these limitations, the Adaptation Plan emphasizes measures to build adaptive capacity, which are low cost, no/low regret adaptation measures.

- Future changes in tropical storms: A high proportion of climate change risks facing the port are related to changes in regional tropical cyclone and tropical storm activity. At present, scientists are not able to quantify accurately changes in future storm intensity and locations. Therefore, a sensitivity analysis approach was used, evaluating on a range of possible future scenarios.

Any climate change analysis has a margin of error, however, the potential impacts should not be ignored

- Future changes in extreme rainfall events and extreme wind speeds: Due to uncertainty in future changes in tropical cyclones and storms, quantifying changes in rainfall intensity and wind speed is difficult. Therefore, this study analyzed observed trends in these variables and, where those trends were statistically significant, it assumed they would continue linearly into the future.
- Sedimentation rates: The study assumed that sediment discharge varies linearly with flow discharge. However, more frequent and higher-intensity rainfall events could increase sedimentation non-linearly.
- Data availability for financial analysis: Some of the terminals operating at the port were not able to provide data on the costs of current climate-related events and on their future financial projections. Some analyses were therefore limited to terminals who provided data, and/or assumptions were made that data from a limited number of terminals was representative of all of them.
- Drain upgrade estimations: Estimations of the upgrade of Drain 3 included assumptions regarding the flow regime, slope of the drain and depth of the outlet.


IMPSA
SWL
50 LT
60 LT
IMPSA

Map of the installations of the Port of Manzanillo

1	**Cruise ship terminal**
2	**Pemex** *Specialized terminal*
3	**Operadora de la Cuenca del Pacífico, S.A. de C.V.** *Multiple purposa facility (IUM)*
4	**Cemex México, S.A. de C.V.** *Specialized terminal*
5	**Cementos Apasco, S.A. de C.V.** *Specialized terminal*
6	**Frigorífico de Manzanillo, S.A. de C.V.** *Port facility*
7	**Corporación Multimodal, S.A. de C.V.** *Specialized terminal*
8	**Terminal Internacional de Manzanillo, S.A. de C.V.** *Multiple purposa facility (IUM)*
9	**Comercializadora La Junta, S.A. de C.V.** *Specialized terminal*
10	**Granalera Manzanillo, S.A. de C.V.** *Port facility*
11	**SSA México, S.A. de C.V.** *Specialized terminal*
12	**Exploración de Yeso, S.A. de C.V.** *Specialized terminal*
13	**Marfrigo, S.A. de C.V.** *Port facility*
14	**Terminal Marítima Hazesa, S.A. de C.V.** *Port facility*
15	**Contecon Manzanillo, S.A. de C.V.** *Specialized terminal*
16	**Yard Nº3** *Port Authority*
17	**Maneuver yard side "B"**
18	**Maneuver yard side "C"**
19	**Dock Nº14 backyard** *Maneuver yard*
20	**Dock Nº15 backyard** *Maneuver yard*
21	**Maritime customs**
22	**Emergency center**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