IDB Invest

CLIMATE RISK AND PORTS:

A PRACTICAL GUIDE ON STRENGTHENING RESILIENCE

In partnership with IDOM and NDC INVEST

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
Climate risk and ports: a practical guide on strengthening resilience / Margarita Pery, Raquel Navarrete, Pedro Muradás, María Puig, Nora Lambrecht, Adriana M. Valencia, Paula Castillo M.; editor, Janelle Conaway.
p. cm.
Includes bibliographic references.
1. Harbors-Risk management-Latin America. 2. Harbors-Environmental aspects-Latin America. 3. Climatic changes-Risk management-Latin America. I. Pery, Margarita. II. Navarrete, Raquel. III. Muradás, Pedro. IV. Puig, María. V. Lambrecht, Nora. VI. Valencia, Adriana M. VII. Castillo M., Paula. VIII. Conaway, Janelle, editor. IX. IDOM. X. IDB Invest. Environmental, Social and Corporate Governance Division. XI. IDB Invest. Strategy, Planning and Knowledge Division. XII. IDB Invest. Advisory Services Division.

This report was prepared by IDOM and the IDB Invest Divisions of Environment, Social and Corporate Governance (SEG), Strategy, Planning and Knowledge (SPK) and Advisory Services (ADV). The project team authors included: Margarita Pery, María Puig, Raquel Navarrete, and Pedro Muradás (IDOM); Nora Lambrecht (SEG); Adriana M. Valencia and Paula Castillo M. (SPK); with contributions from Malini Samtani (ADV), Chitralekha Deopersad and Juan Carlos Paez (SEG). The publication was edited by Janelle Conaway. Brand and design support were provided by Gustavo González D'Asseo and NDC Invest.

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INTRODUCTION

The accelerating impacts of climate change pose a real and growing threat to global development. Consider this one indicator: In 2020, natural disasters such as hurricanes and wildfires produced estimated losses of $210 billion worldwide, about 60% of which were uninsured.[1] The IPCC Special Report on Global Warming of 1.5 ºC clearly advises that those impacts may be more frequent and severe in the next decades unless the global response is strengthened, in terms of sustainable development and poverty eradication.[2]

Climate events represent the greatest threat to the development gains achieved in Latin America and the Caribbean, according to the Global Center on Adaptation. It estimated that by 2050, 17 million people in the region could be displaced and 1.6% of GDP lost due to climate-related events.[3]

Ports are inherently vulnerable to the effects of climate change. Rising sea levels, storm surges, hurricanes, coastal erosion—these are just a few of the climate-related threats that have the potential to produce ever-more-frequent and ever-more-devastating impacts on port infrastructure and operations.

Because of the central role of maritime transport in today's global economy—more than 80% of trade moves by sea—the impacts of a major climate event can reverberate far beyond the port itself, disrupting supply chains and causing shortages and price increases.

In 2020, The Economist hired a consulting firm to assess some 340 of the largest ports around the globe to get a sense of their exposure to six types of climate-related events. The analysis found that 55% of global trade passes through ports, which have a high risk of at least one type of event. In addition, close to 8% of trade in these ports was vulnerable to three or more climate hazards.[4]

Although some of the world's largest ports have fortified themselves, many ports are unprepared for major climate events, according to The Economist. Many have yet to perform climate risk assessments, institute proper procedures or make contingency plans. Aging infrastructure is sometimes to blame; financing is another common hurdle, especially in developing countries.

Investing early in adaptation will reduce the risks and costs associated with climate-related impacts and prolong the life of a port's assets and services.

Given the magnitude and urgency of climate-related threats, ports must scale up preparedness and make their physical, operational and environmental infrastructure more resilient. Resilience refers to the ability to handle adverse circumstances, to be nimble enough to respond and recover and adapt and move forward. That ability takes on paramount importance when it comes to climate change.

Port developers and operators must anticipate potential climate impacts and make smart investments to protect vulnerable port assets, as well as local ecosystems and populations. Investing early in adaptation will reduce the risks and costs associated with climate-related impacts and prolong the life of a port's assets and services. The costs of failing to act can be catastrophic.

GEARING UP FOR ACTION

Aligned with the **Inter-American Development Bank Group's** strategy on promoting sustainable infrastructure in Latin America and the Caribbean, this report is intended to help port developers and operators create an action plan to build resilience and reduce the adverse consequences of climate-related events in and around port facilities. Derived from an **IDB Invest** project in partnership with **IDOM,** the report – as a three-step methodology - explains how to assess climate risks and how to identify and monitor appropriate actions and investments to tackle them. It provides information and analysis to better understand the climate context of a project, develop a risk assessment, formulate adaptation measures, and establish monitoring and evaluation procedures. It also provides the reader with supplementary materials through links, pop-up tables (indicated with the ↗ symbol), infographics and annexes with supplementary resources.

Climate change is an issue ports can no longer afford to ignore. With this brief user-friendly guide, **IDB Invest** aims to support port developers and operators in incorporating climate adaptation measures as a business-wise decision and an opportunity for development.

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[1] This is according to Munich RE, one of the world's largest reinsurance companies, which monitors risks from climate change (Munich RE. (2021). Record hurricane season and major wildfires – The natural disaster figures for 2020).

[2] IPCC. (2018). Global Warming of 1.5 ºC. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

[3] Global Center on Adaptation. (2020). State and Trends in Adaptation Report 2020. Volume 1: Building Forward Better from Covid-19: Accelerating Action on Climate Adaptation.

[4] Ports are highly exposed to climate change and often ill-prepared. (2020, September 10). The Economist.

[5] IDOM is an independent multinational company that offers professional integrated services in consulting, engineering and architecture around the world.

STEP 1. **RISK ASSESSMENT**

The first step toward making a port project more resilient to climate change is to determine the level of risk. A thorough risk assessment allows decision-makers to determine whether they may need to adapt or modify a project to take into account the impacts of climate change.

A RISK ASSESSMENT CONSIDERS THREE KEY FACTORS:

Figure 1: Risk exists at the intersection of hazard, exposure and vulnerability

Risk arises where these three factors intersect. The higher the level of hazard, exposure or vulnerability, the higher the risk; conversely, risk decreases if all three factors are not present. For example, a river in the area may tend to overflow every year during the rainy season, presenting an annual hazard, but if a building at the port is not close to the river (and therefore is not exposed), or if it has been hardened to withstand flooding (and therefore is less vulnerable), the risk to that structure will be lower.

1.1. ESTABLISH THE CONTEXT

The risk assessment process starts by looking at the big picture to determine the parameters and scope of the analysis. For the benefit of outside consultants, developers, financing institutions or others who may become involved in the project, the port should first put together some basic data, such as the type of project being planned, and the site's geolocation coordinates.

When evaluating climate risk in port development projects, it is important to identify all the areas critical to the functioning of the project and the delivery of related services, as well as all the types of climate-related events that could affect the port and surrounding areas. The risk assessment should cover not just the port infrastructure itself but also related aspects: access routes and operations; nearby environmental features, such as rivers or estuaries; the broader natural environment, including wildlife species and habitats; and the potential impacts and implications for the local population and potential stakeholders.

KEY QUESTIONS ABOUT THE LOCAL CONTEXT

As the examples below illustrate, this initial scoping exercise should cast a wide net to gather any information that may be relevant in assessing climate risk to the port and planning adaptation measures. Environmental information should include details about the geography of the area, including any flora and fauna that may be affected by the project. It is also important to understand the local population and socioeconomic situation.

EXAMPLES OF QUESTIONS TO CONSIDER IN ASSESSING THESE ASPECTS:

ENVIRONMENTAL CONTEXT

- How environmentally sensitive is the project area?
- Are there any natural features that may be affected by port development and exacerbated by the impacts of climate change? (This might include wildlife habitats or nearby rivers.)
- If climate change made it necessary to make changes to port infrastructure (for example, relocation or dredging), what would be the impacts to the environment?
- What steps might be taken at the outset of the project to reduce harm? Is the port working with local environmental groups to identify problems and solutions?

SOCIOECONOMIC CONTEXT

- How important is the project to the surrounding communities?
- How big of a factor is the port in the local economy? Is it a major employer?
- How will the project affect the quality of life in the area, and are steps being planned to mitigate any adverse impacts (for example, traffic or noise)?
- How might the project affect economic activities (such as fishing)?
- Has the port taken steps to invest in the well-being of the local community?
- What is the relationship like between the community and the port?

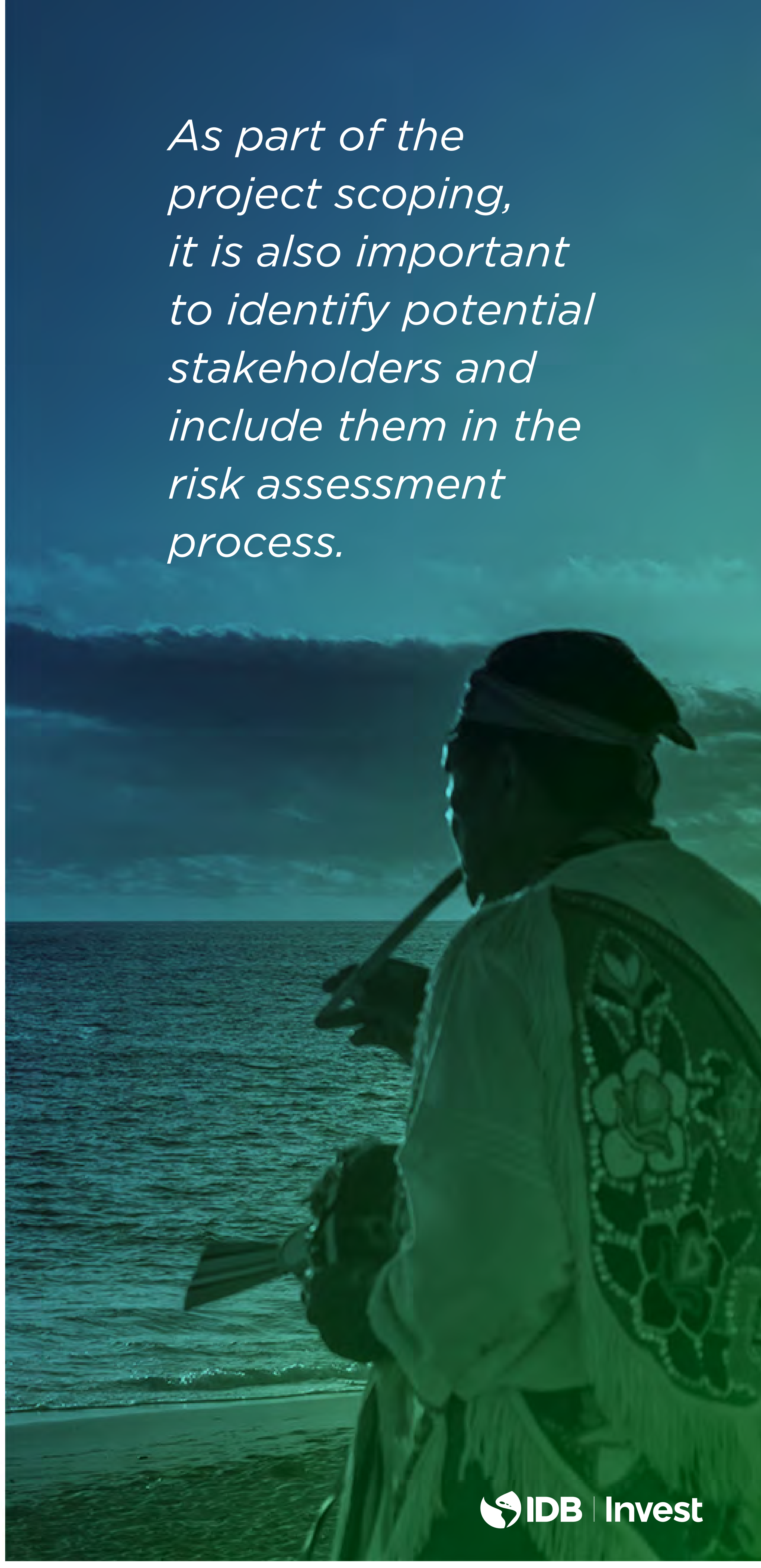
As part of the project scoping, it is also important to identify potential stakeholders and include them in the risk assessment process. This is crucial for a successful project outcome. Stakeholders may include members of the supply chain, such as transport operators, infrastructure providers or road logistics planners; regulators, such as port authorities, or local government officials; and residents of the local community.

1.2. IDENTIFY PAST, CURRENT AND FUTURE CLIMATE TRENDS

This step seeks to get a sense of the extreme weather events and chronic climate conditions experienced in the project area in the past, seen in the present or modelled to occur in the future. An assessment of historical climate impacts can provide insights into current exposure. It can also indicate how the project might be affected moving forward, as climate change increases the intensity or frequency of existing hazards. Creating a list of the most relevant hazards is essential for this step.

Information about past extreme weather events may be available from local meteorological data records or previous models and studies. **Annex 4** includes a list of websites and databases that may provide a useful starting point, as well as resources on climate scenarios.

It is critical to collect information about significant climate events in the area as far back as possible—at least over the past few decades—with an eye on both frequency (the number of times a major climate event occurred) and intensity (how severe it was). These adverse impacts should also be analyzed in terms of any damage to port infrastructure, or the other related aspects detailed in Infographic 1 (Potential Climate Change Events and Impacts) on page 7, as well as other costs such as lost days of service.



POTENTIAL CLIMATE CHANGE EVENTS AND IMPACTS

EXAMPLES OF EVENTS THAT CAN AFFECT PORTS:

1 sea level rise · 2 storm surge · 3 saltwater intrusion · 4 strong winds · 5 heavy rains · 6 electrical storms · 7 river flooding · 8 extreme temperatures · 9 sedimentation · 10 drought · 11 reduced river flows · 12 coastal erosion

ELEMENTS / **POTENTIAL AREAS OF IMPACT**

PORT INFRASTRUCTURE

Such events can damage, deteriorate or destroy port infrastructure including, but not limited to, buildings.

- Breakwater
- Quay
- Yard
- Goods storage area
- Equipment
- Buildings
- Electrical infrastructure
- Drainage infrastucture

PORT ACCESS

These types of events can also hamper port access or cause accidents or disruptions that could limit port operations or result in higher costs.

- Roads/pavement
- Railways
- Inland waterways
- Reduced navigability
- Dredging requirements
- Restrictions to vessel size

PORT OPERATIONS

- Navigation conditions
- Berthing and mooring
- Loading and unloading activities
- Inland transport beyond the port
- Goods storage
- Energy costs
- More difficult working conditions

PHYSICAL ENVIRONMENT

The physical environment in the area around the port can also be altered by climate-related events.

- Coastline
- Estuary area/shoreline
- River area/riverbanks

SOCIOECONOMIC FACTORS

Socioeconomic impacts may include displacement of local populations or disruption of livelihoods.

- Population (e.g. displacement)
- Marine economic activity
- Inland economic activity
- Demand/ trade/market patterns
- Social performance
- Fisheries and related infrastructure

NATURAL ENVIRONMENT

The natural habitat can also be affected, for example by changes in the distribution, growth and reproduction of species

- Habitats
- Protected habitats
- Species (e.g. fish, birds)
- Protected species

OTHERS

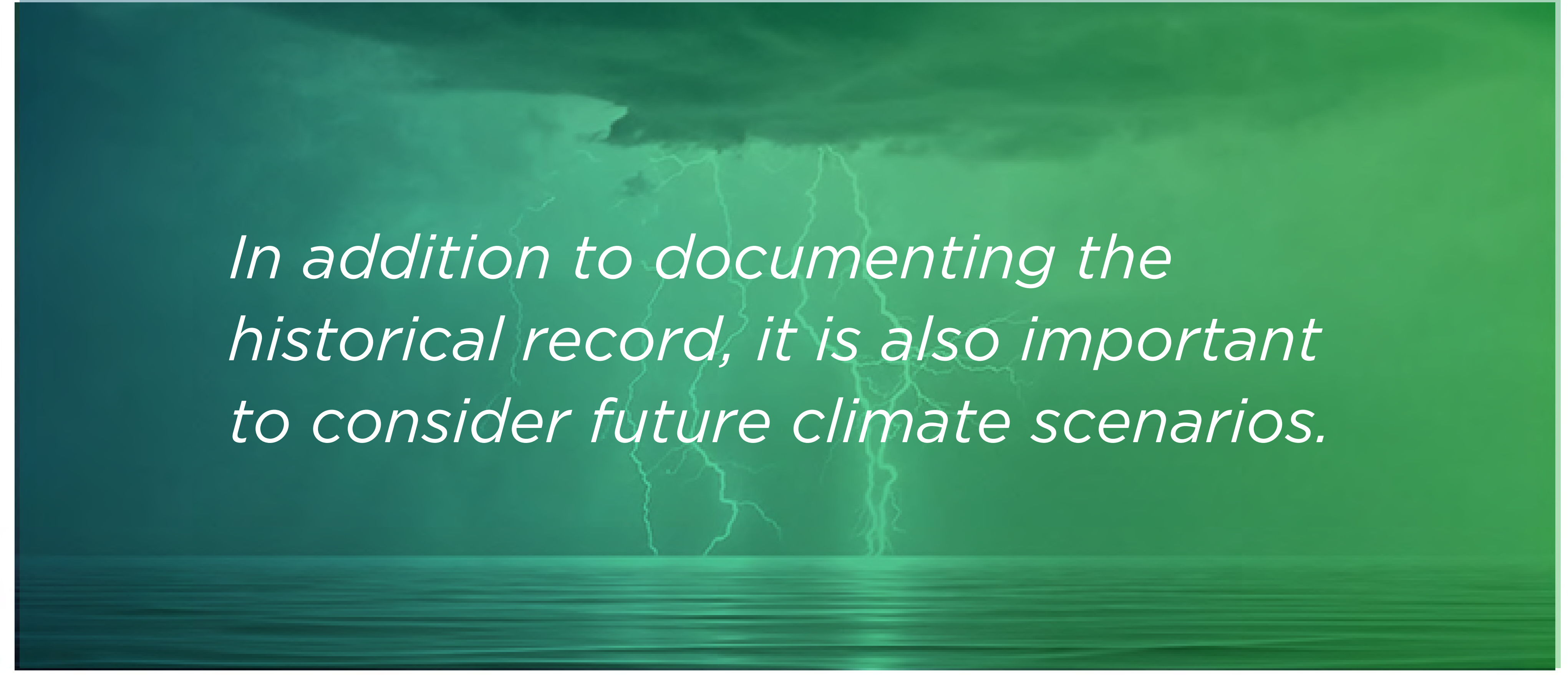
Any and all of these impacts can result in higher costs and further affect other aspects of ports.

- Insurance cost or availability
- Port reliability
- Port reputation
- Increased fire risk

In addition to documenting the historical record, it is also important to consider future climate scenarios. The Intergovernmental Panel on Climate Change (IPCC)—the United Nations body for assessing the science on this topic—has developed a system to categorize different scenarios based on projected volumes of future greenhouse gas emissions. These scenarios, called representative concentration pathways (RCPs), include one projection in which emissions are stringently mitigated, one in which they are very high and two with intermediate levels of emissions.[6]

The IPCC scenarios, along with geographic information systems, provide the foundation for sophisticated modeling tools that are used to identify and quantify climate risks. In some cases, these are proprietary tools developed by private companies for their clients; however, open-source software such as Think Hazard! may yield some valuable initial insights.

Climate change scenarios may also be developed at the regional and local level—applying data from global scenarios—to get a more detailed, accurate picture of potential future conditions.



1.3. DETERMINE HAZARD, EXPOSURE AND VULNERABILITY LEVELS

The information collected in the previous sub-steps forms the basis for assessing the hazard, exposure and vulnerability levels—the three key factors that add up to risk. The task here is to evaluate each of these factors, based on a series of indicators, and come up with a score that will go into determining the overall risk level.

HAZARDS: The historical overview and projected future scenarios explained in the previous section will form the basis for a more precise assessment of potential climate hazards in the project area. The focus should be on priority hazards—those that are likely to increase and to have adverse impacts on the port.

In some cases, a port developer or operator may use screening tools from public data sources to determine the hazard level, as indicated above; in other cases, it may be advisable to have site-specific models developed for the project.

Such models should integrate all the data collected up to this point, including the historical overview and potential future conditions based on climate change scenarios. **The idea is to produce a set of hazard maps reflecting the likelihood that specific climate-related events will occur, along with their average return period—in other words, the estimated time interval between these events.** Once hazards have been modelled, the results for each indicator may be assigned a simple score to indicate a low, medium or high hazard level.

EXPOSURE: The level of exposure to the identified hazards is determined by analyzing where the assets—both physical and environmental—coincide in location and time with potential hazards. Results may be obtained by plugging in the geolocation of the asset into a geographic information system map. As with the hazard level, a simple template may be used to score the level of exposure.

VULNERABILITY: The next step is to assess the vulnerability of the project—that is, the likelihood of adverse impacts to the port infrastructure and other assets laid out in Figure 1 on page 5, given the hazard level and degree of exposure.

This vulnerability assessment should consider adverse impacts from severe climate events in the past and potential impacts from future hazards identified through modeling exercises. As with hazards and exposure, a simple form can be used to report each potential impact. A good starting point would be the list of impacts laid out in Infographic 1 (Potential Climate Change Events and Impacts) on page 7 of this report. Gauging project vulnerability is a crucial part of risk assessment, and it is highly specific to each site and asset. It encompasses a variety of concepts, including sensitivity or susceptibility to harm, as well as resilience. Assessing the vulnerability of each impact area enables the project developer or operator to understand how sensitive an area is and what the options are for adaptation. Site- and asset-specific indicators will make it easier to track and score the level of vulnerability.

[6] These scenarios come from the IPCC's Fifth Assessment Report (AR5), released in 2014. The Sixth Assessment Report, which is expected to be completed in 2022, will update and expand the scenarios. For more information about the current scenarios, see "Planning with climate scenarios in mind" in **Annex 2** of this report.

In the case of a breakwater, for example, one indicator of how sensitive the structure would be to a climate event is its load-carrying capacity—how much force (such as from pounding waves) it is built to resist. Additional indicators can evaluate the capacity to make the breakwater more resilient through adaptation; measures enhancing adaptive capacity include new technologies, budgeted upgrades or climate insurance to protect against losses in the case of breakwater failure. Such factors go into scoring each asset to determine whether its vulnerability level is low, medium or high.

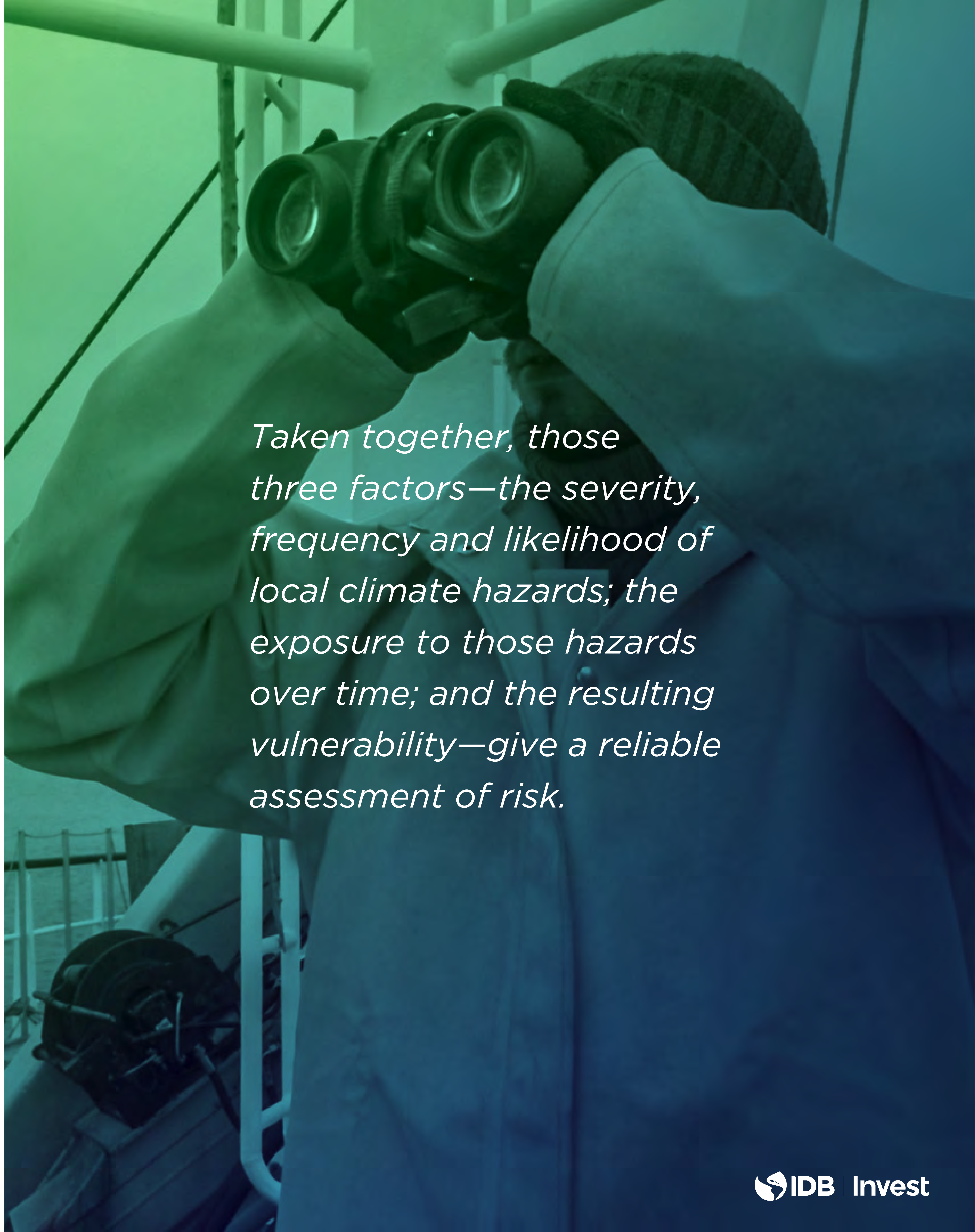
1.4. EVALUATE RISK

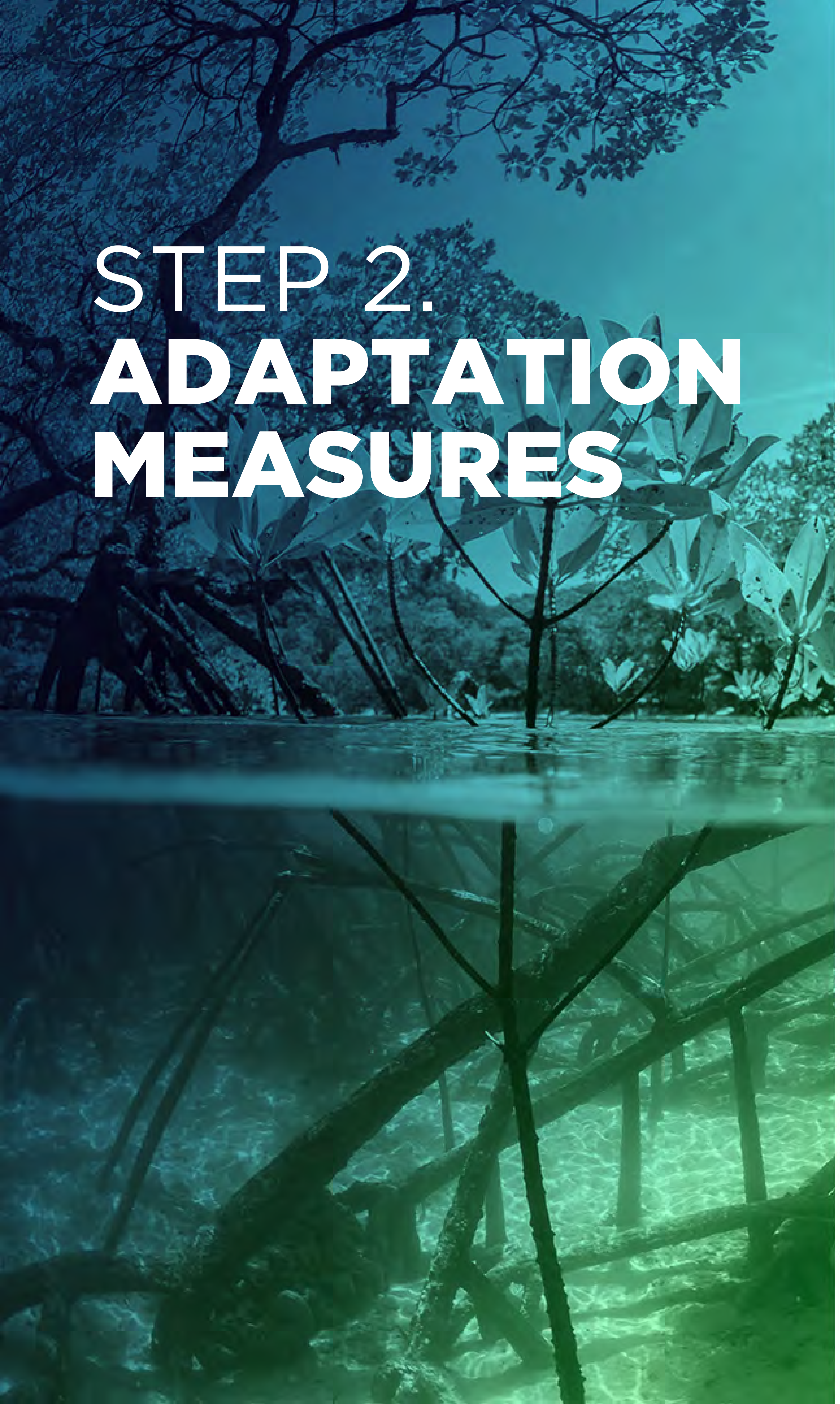
Taken together, those three factors—the severity, frequency and likelihood of local climate hazards; the exposure to those hazards over time; and the resulting vulnerability—give a reliable assessment of risk. Scoring each asset or impact area based on these parameters will bring to light the areas of highest risk and will suggest priorities for increasing preparedness.[7]

Assessing project risk can be done from both a qualitative and a quantitative standpoint; both approaches are useful to produce the most complete picture possible. A qualitative risk assessment, such as the process described in the previous section, can be applied to any project, asset or impact area. It looks at hazard, exposure and vulnerability factors to document what climate-related risks exist and to what extent these have been sufficiently addressed. This process can identify areas of priority or concern. (Annex 2 includes sample questionnaires for qualitative evaluations.)

Based on the information gleaned from a qualitative risk assessment, port operators may decide to carry out a quantitative assessment for certain assets or impact areas, to produce a more detailed, technical climate risk profile. This could include, for instance, conducting a probabilistic study of infrastructure failure given various return periods of an extreme weather event—or perhaps using a computational model to simulate the effects of sea level rise on a port facility. Such an approach may be warranted to analyze the costs, benefits and viability of a proposed project. The costs associated with such a study, as well as the availability of information and the technical complexity, may pose a challenge to many port operators. A detailed evaluation by an independent engineer is recommended to shed light on the most important questions relevant for the risk assessment process.

[7] This approach applies risk assessment principles laid out in IPCC's AR5.





STEP 2. **ADAPTATION MEASURES**

Once the risk assessment is complete, the project developer or operator can identify, analyze, select and prioritize steps that would enhance the port's resilience in the face of climate change. These may include actions to share risk, reduce or avoid exposure, or build capacity to withstand climate-related threats.

ADAPTATION ACTIONS VARY WIDELY, DEPENDING ON THE SCOPE OF THE PROJECT, BUT THEY GENERALLY SEEK TO BUILD RESILIENCE IN THREE ASPECTS:[8]

The implementation of climate adaptation actions will vary widely in terms of cost and economic, social and environmental benefits; hence, it is essential to conduct a careful analysis and establish clear priorities. In many cases, such measures may be implemented incrementally to make them more feasible.

2.1. IDENTIFY POTENTIAL MEASURES

Potential adaptation measures can be identified based on the risk assessment that has been completed. If possible, the port should engage key stakeholders in a brainstorming exercise so that they can get an overview of the assessment process and contribute their ideas for adaptation. Such an exercise can pinpoint meaningful areas of action and obtain public buy-in from the outset.

Adaptation actions to address risks should comprise the three dimensions mentioned above: structural or physical, social and institutional. Examples of adaptation actions include climate data collection and hazard assessments; preparedness plans and insurance management; specific infrastructure design or operation and maintenance activities; measures to protect the coast-line, riverbanks and estuaries, including nature-based solutions such as mangrove restoration; and efforts to strengthen local community involvement. Infographic 2 (Adaptation Actions) on pages 12 and 13 of this report lays out a series of possible adaptation measures.

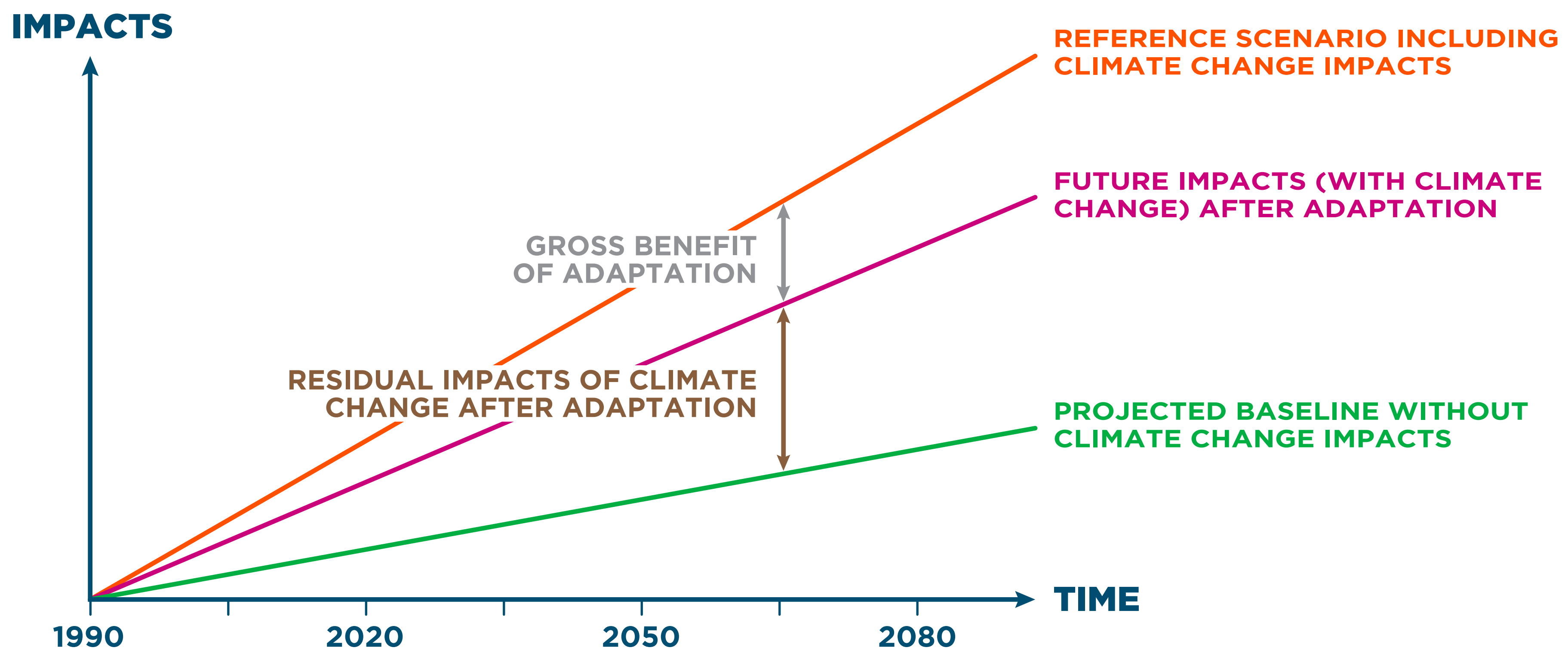
[8] These categories are derived from those laid out in the IPCC's AR5.

2.2. CONDUCT A FINANCIAL AND COST-BENEFIT ANALYSIS

Once a potential adaptation action is identified, a comparative financial analysis can shed light on whether its implementation would generate an economic benefit for the project and therefore whether it should be pursued. Such an analysis typically compares three financial scenarios: **i)** a baseline scenario with projections ignoring the effects of climate change on port infrastructure; **ii)** a scenario considering the financial implications of climate change impacts with adaptation measures; and **iii)** a scenario that takes into account climate change impacts on port infrastructure without adaptation actions.

As the figure below illustrates, climate change can have substantial financial impacts over time; however, investing in adaptation can significantly mitigate the losses.

Figure 2. Financial Model Schematic.[9]



A crucial consideration in a financial analysis is the time factor. A climate-related impact or the implementation of an adaptation measure will have a very different effect on the bottom line depending on when it occurs. The optimal timing for adaptation strikes a balance between investment and risk. Suppose, for example, that a decision is made to raise a causeway to avoid future impacts from flooding. If sea levels are projected to rise slowly, it may seem reasonable to put off the expense into the future and have more cash on hand for other investments; if sea levels rise more quickly, however, the costs of postponement could be unacceptably high.

Every type of investment involves some type of calculation about whether the future benefits that will be derived outweigh the opportunity cost of the capital invested. Determining the value of an investment made in climate adaptation today is particularly complicated because it requires making assumptions about potential benefits and avoided costs far into the future.

Financial models apply what are known as discount rates to assess the current value of such an investment based on expected future cash flows. The longer it takes to realize a return on the investment, the greater the decline in the current value of that investment. In the private sector, the discount rate is usually tied to the expected return on alternative investment opportunities or the weighted average cost of capital.

Such considerations must be part of the decision-making process about investments in adaptation. The optimal adaptation strategy is one that maximizes future revenue streams—as measured by earnings before interest, taxes, depreciation and amortization (EBITDA)—with the adaptation costs included. Using EBITDA rather than cash flow or profits is helpful because it excludes aspects that depend on factors beyond the scope of a climate change study.

The Inter-American Development Bank (IDB) has prepared a summary of the steps involved in conducting this type of financial analysis, which can be found in **Annex 3**, along with a list of key assumptions to be considered.

The comparative financial analysis should be complemented with a cost-benefit analysis. Here the aim is to quantify, in monetary terms, the costs of a project with climate adaptation action included, as well as its benefits, both monetary and non-monetary (such as environmental and social benefits). The cost-benefit analysis determines whether there is a net benefit associated with the adaptation and thus if it makes sense to undertake it.[10]

2.3. SELECT ADAPTATION ACTIONS

Once the financial study and cost-benefit analysis are performed, it is time to select and prioritize the most suitable adaptation measures to be carried out. One of the most common approaches is to use a multicriteria analysis, which assesses options based on a range of factors, including the following:

- **Urgency vis-à-vis existing threats**
- **Financial feasibility, political will, social opposition and environmental impact**
- **Effectiveness in reducing climate risk**
- **Cost-benefit analysis**
- **Associated benefits (for example, cost savings, climate change mitigation)**
- **Time effectiveness**

No-regret options, which are those that generate net social or economic benefits irrespective of whether or not climate change occurs, should be identified and prioritized. Trade-offs need to be assessed and avoided during the decision-making process as well. The criteria used and the weight given to each factor will differ from project to project. Involving stakeholders in this process may help ports select and prioritize options with a high level of acceptance.

[9] Adapted from Metroeconomica (2004). Costing the impacts of climate change in the UK: overview of guidelines. UKCIP Technical Report. Oxford: UKCIP.
[10] The IDB has developed a portal on cost-benefit analysis that is available here.

ADAPTATION ACTIONS IN PORTS[11]

1 COMPILE CLIMATE RECORDS, BEGIN CLIMATE CHANGE MONITORING AND DOWNSCALE CLIMATE CHANGE MODEL TO THE LOCAL LEVEL

PURPOSE: to increase knowledge of historical data, climate trends and possible future climate conditions, so as to more accurately evaluate the likelihood, severity and magnitude of potential impacts and the timeframe required for implementing mitigation and adaptation measures.

POTENTIAL ACTIONS: search historical climate records and analyze trends; invest in data collection (buoys, thermometers, anemometers, water characteristics analysis, etc.); regularly evaluate climate change projections (IPCC or others).

USEFUL TIPS: gather several years, or even decades, of available data; collect data using different metocean variables (wind, waves, climate, ice); downscale the data as much as possible to evaluate specific impacts to key port areas; conduct continuous data collection.

2 PREPARE HAZARD ASSESSMENTS FOR INFRASTRUCTURE, ASSETS AND OPERATIONS

PURPOSE: to regularly assess possible hazards that could affect existing or planned infrastructure and assets, in order to identify possible changes and upgrades needed in design, adaptation or operations.

POTENTIAL ACTIONS: analyze design parameters for each critical infrastructure to identify thresholds; address maintenance issues; take corrective actions to reduce operational incidents and increase resilience.

USEFUL TIPS: increase the number of assets evaluated, the frequency of evaluation and the number of potential hazards considered.

3 ADJUST INFRASTRUCTURE, DESIGN, OPERATIONS AND MAINTENANCE ACTIVITIES IN LINE WITH POSSIBLE HAZARDS (I.E. SEA LEVEL RISE, STORM SURGES, STORM FLOODING, HEAVY RAIN, EXTREME WAVES, RIVER FLOODING, STRONG WINDS)

PURPOSE: to adapt, modify or strengthen existing or planned infrastructure, operations and maintenance in anticipation of future climate change conditions of sea level rise, storm surges, storm flooding, heavy rain, extreme waves, river flooding, strong winds and other hazards so as to minimize impacts.

POTENTIAL ACTIONS: raise aprons and breakwaters to protect against flooding and wave overtopping; design decks with relief slots, drain holes, valves or wave walls; raise critical assets (e.g. back-up generators, pumphouse); and relocate or raise elevation of access roads and storage facilities.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate cost reductions, including reductions in annual cost of damages related to specific hazards ($/year) and reductions in lost days of operation due to these hazards (%).

4 DESIGN ACTIVITIES, OPERATIONS AND MAINTENANCE RELATED TO COASTAL OR BANK EROSION

PURPOSE: to adapt, modify or strengthen existing or planned infrastructure, operations and maintenance in line with future climate change conditions related to coastal or bank erosion, to minimize impacts.

POTENTIAL ACTIONS: raise or strengthen bridges, decking, jetties, revetments, dams, spillways, superstructures, roads, railways; provide surface protection to banks and other structures to resist internal and external erosion, including under asymmetrical loading; use nature-based resilience, for example by creating offshore berms or barrier islands or supplementing or enhancing marsh, mangrove or other intertidal habitats; divert excess flows to flood storage areas; provide hydraulic structures of an adequate capacity to pass water under a canal; co-locate critical systems.

USEFUL TIPS:
establish appropriate indicators to monitor and evaluate the area of port lost due to coastal erosion or bank erosion per year; calculatereductions in annual cost of damages related to coastal or bank erosion ($/year) and reductions in lost days of operation due to coastal or bank erosion (%).

5 DESIGN ACTIVITIES, OPERATIONS AND MAINTENANCE RELATED TO HEAT WAVES

PURPOSE: to adapt existing or planned infrastructure, operations and maintenance to future conditions of heat waves, with benefits that include reduction of damages and improved working conditions.

POTENTIAL ACTIONS: incorporate heat- or drought-resistant vegetation; provide shade, using nature-based solutions where practicable; improve thermal efficiency; design for temperature regulation; improve insulation or ventilation; install air-conditioning or cooling systems on vessels and in offices, storage facilities, etc.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate reductions in annual cost of damages related to heat waves ($/year), reductions in lost days of operation related to heat waves (%), reductions in number of employees at high risk of heat stress (#) and variations in work productivity related to heat stress (%).

6 DESIGN ACTIVITIES, OPERATIONS AND MAINTENANCE RELATED TO SEDIMENTATION AND REDUCED RIVER FLOWS

PURPOSE: to adapt existing or planned infrastructure, operations and maintenance to future conditions of sedimentation and reduced river flows, with co-benefits such as cost optimization and port reliability.

POTENTIAL ACTIONS: remove redundant structures that promote deposits of sediment or debris; educate local communities about consequences of trash disposal around watercourses; prevent debris washing into navigable areas; introduce diversions, one-way systems or temporary closures of ports or waterways.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate reductions in annual cost of damages related to sedimentation and reduced river flows ($/year) and reductions in lost days of operation due to sedimentation and reduced river flows (%).

[11] Adapted from The World Association for Waterborne Transport Infrastructure (PIANC). (2020). Climate Change Adaptation Planning for Ports and Inland Waterways.

ADAPTATION ACTIONS IN PORTS[11]

7 DESIGN ACTIVITIES, OPERATIONS AND MAINTENANCE RELATED TO INCREASED SALINITY, ACIDIFICATION, SEA TEMPERATURE CHANGES, SEA SPRAY AND OTHER HAZARDS

PURPOSE: to adapt existing or planned infrastructure, operations and maintenance to future conditions that result from changes in salinity, acidification, sea temperature changes and sea spray, among others, with co-benefits that include reducing the number or severity of damages to port infrastructure.

POTENTIAL ACTIONS: select construction materials tolerant to salinity and acidification; review, revise and prioritize maintenance for assets that are vulnerable to these conditions; develop contingency plans covering future loss of protective role of coral reef (wave attenuation).

USEFUL TIPS: establish appropriate indicators to monitor and evaluate reductions in annual cost of damages related to increased salinity, acidification, sea temperature changes, sea spray and other such hazards ($/year) and reductions in lost days of operation due to these hazards (%).

8 PROTECT COASTLINE AND RIVER OR ESTUARY BANKS THROUGH BOTH HARD AND SOFT ADAPTATION MEASURES

PURPOSE: to protect the shoreline or riverbanks from wave energy to avoid adverse impacts in the project area, with co-benefits that include reducing or avoiding exposure to coastal flooding or fluvial flooding, mitigating social and environmental impacts, and adding recreational and aesthetic value.

POTENTIAL ACTIONS: analyze and adopt both soft and hard engineering measures to improve adaptation. Soft engineering measures are actions that do not radically change the environment or counteract natural processes. Examples include adding sediment to beach areas with shoreline erosion; restoring natural and artificial dunes; restoring ecosystems (i.e., saltmarshes or mangroves and seagrasses) or planting riparian vegetation; and protecting coral reefs. Hard engineering measures involve human-built, rigid and complex infrastructures that intervene in coastal processes by altering wave energy. Examples include shore-parallel detached or offshore structures (breakwaters) to reduce incoming wave energy at the shoreline; dikes to protect adjacent low-lying areas from inundation under extreme conditions; and jetties at the banks of tidal inlets and river mouths to trap a portion of the longshore sediment to stabilize the inlet and prevent silting of the channel.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate reductions in annual cost of damages related to modification of coastline and river or estuary banks ($/year) and reductions in lost days of operation related to this indicator (%).

9 LOCAL COMMUNITY INVOLVEMENT

PURPOSE: to involve local communities to ensure that the project meets local requirements and enhances opportunities for employment, benefiting the local economy and improving quality of life.

POTENTIAL ACTIONS: devise plans for stakeholder and community engagement, outreach activities, regular focus group meetings and capacity-building.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate increases in local household income (%), available jobs in the port area (%), diversity of businesses (%) and growth of port-related local companies (%).

10 WORK IN PARTNERSHIP WITH OTHER RELEVANT STAKEHOLDERS

PURPOSE: to build partnerships and networks with relevant stakeholders (e.g., local governments, civil society, academia, supply chain logistic stakeholders) and collaborate in developing strategies to adapt to climate change.

POTENTIAL ACTIONS: design connected logistics hubs; create local knowledge related to climate change; develop innovation tools and practices for vulnerability and risk management. Co-benefits include resource efficiency and more effective outcomes.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate such factors as the number of collaborative strategies developed with key stakeholders and resource efficiency (in economic terms) in implementing climate change adaptation actions.

11 CREATE DIVERSIFIED PORTS THROUGH THE DEVELOPMENT OF SUSTAINABLE BUSINESS OPPORTUNITIES THAT HELP TO PROTECT THE NATURAL ENVIRONMENT AND BENEFIT THE LOCAL ECONOMY

PURPOSE: to create sustainable businesses in the port areas in order to protect the natural environment, increase awareness and provide socioeconomic benefits through new development opportunities.

POTENTIAL ACTIONS: promote the development of tourism businesses such as whale watching, scuba diving centers and boat excursions. Co-benefits include promoting environmental conservation and improving the local economy.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate the number of sustainable business created; the growth of local companies related to the port (%); the number of ecosystems and species recovered; and the increase in tourism.

12 INSURANCE MANAGEMENT

PURPOSE: to analyze financial exposure in light of the probability of climate change impacts and identify maximum loss value of assets or revenue, in order to manage insurance costs and coverage, reduce exposure and optimize costs.

POTENTIAL ACTIONS: conduct a risk assessment to analyze the potential exposure of each asset to the main potential hazards; determine acceptable levels of risk (risk tolerance) for each hazard; verify and strengthen insurance coverage, including replacement and business interruption coverage; document the port's assets via video or photo in the case of claims; establish or improve crisis management plans to take into account priority hazards.

USEFUL TIPS: establish appropriate indicators to monitor and evaluate the number of operations with insurance for extreme weather events and the percentage of uncovered risks (%).

[11] Adapted from The World Association for Waterborne Transport Infrastructure (PIANC). (2020). Climate Change Adaptation Planning for Ports and Inland Waterways.

STEP 3. MONITORING AND EVALUATION PLAN

The final step is to develop a plan for monitoring and evaluation (M&E), to ensure that any climate adaptation actions implemented in the port project are effective and efficient. M&E plans should be part of any project, of course, but in the case of climate-related interventions, it is important to develop a plan that includes indicators and metrics relevant to climate risk, adaptation and resilience.

Monitoring focuses on performance, provides feedback on project progress and indicates whether the actions that have been proposed in the action plan will increase the project's resilience. Evaluation assesses whether the planned targets have been met through the implementation of the project.

M&E indicators need to be defined at the planning stage. The selected indicators should be specific, measurable, achievable, relevant and timely, as shown in Figure 3.

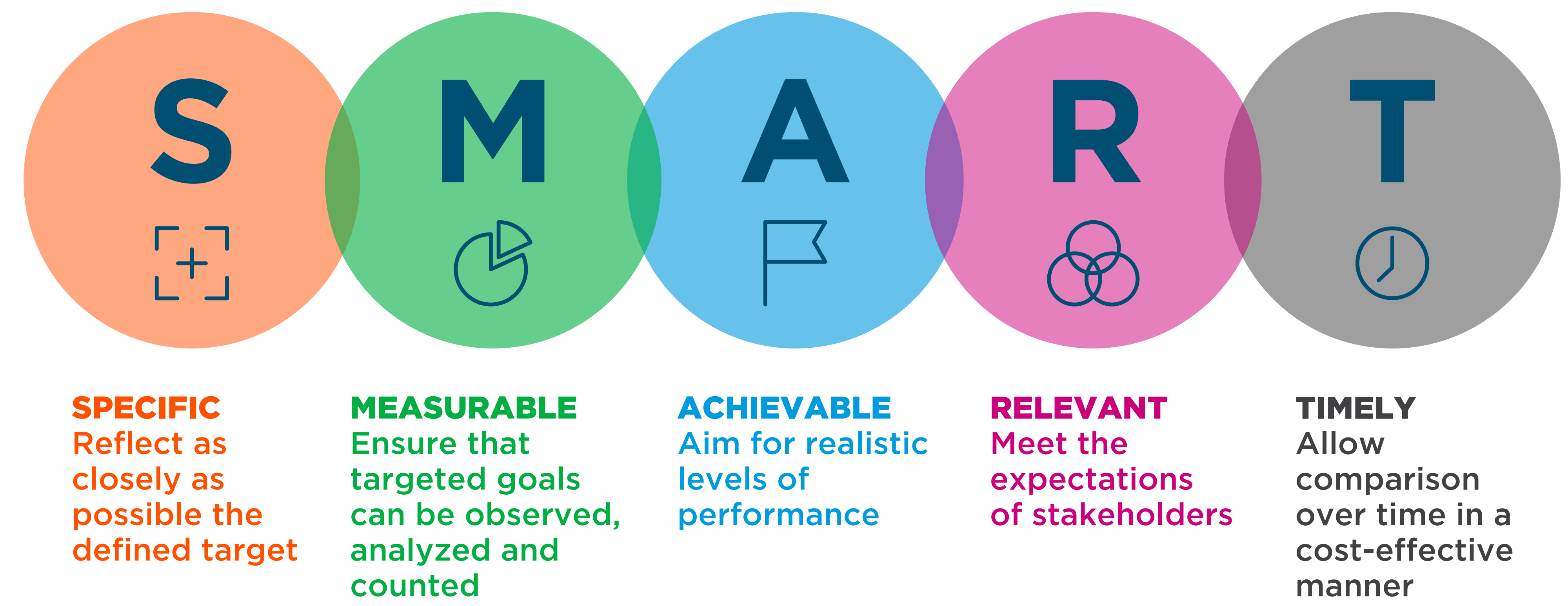


Figure 3: SMART Indicators. IDB, 2011

The local context and adaptation objectives will differ for each port and each project, so choosing the right M&E indicators will require a careful review. To get the most out of the monitoring and evaluation process, some typical indicators may need to be adjusted and others developed specifically for the project in question. Indicators related to climate change should consider potential long-term effects and should be as specific as possible. For example, one indicator might track instances of breakwater overtopping, or transport disruptions due to extreme weather events. Metrics could also be applied to monitor the long-term performance of an area reforested with mangroves.

For ease of tracking, selected indicators should be included in a datasheet that contains information such as the name, unit of measurement, data needs, calculation methodology, relevance and potential limitations.

EXAMPLES OF M&E INDICATORS IN THE CONTEXT OF CLIMATE CHANGE IMPACTS, ADAPTATION AND RESILIENCE.

EXAMPLES OF MONITORING INDICATORS

- Degree of integration of climate change into development planning
- Number of policies and coordination mechanisms explicitly addressing climate change resilience
- Number of financial mechanisms identified to support climate change adaptation
- Funding for climate-adapted construction and refurbishment.
- Number of installations with retrofitted flood resilience measures
- Number of new local jobs created

EXAMPLES OF EVALUATION INDICATORS

- Area of port lost due to coastal erosion per year
- Days of service lost due to structural damages to infrastructure
- Losses of operating revenue in percentage per year due to extreme climate events
- Reduced work productivity due to heat stress, in percentage terms
- Percentage of area of ecosystem that has been disturbed or damaged
- Decline in fish habitats due to changes in sea temperature
- Decreased annual average fish catch as a result of temperature change
- Reduction of flood damage due to improved flood emergency preparedness and flood protection measures

CONCLUSION

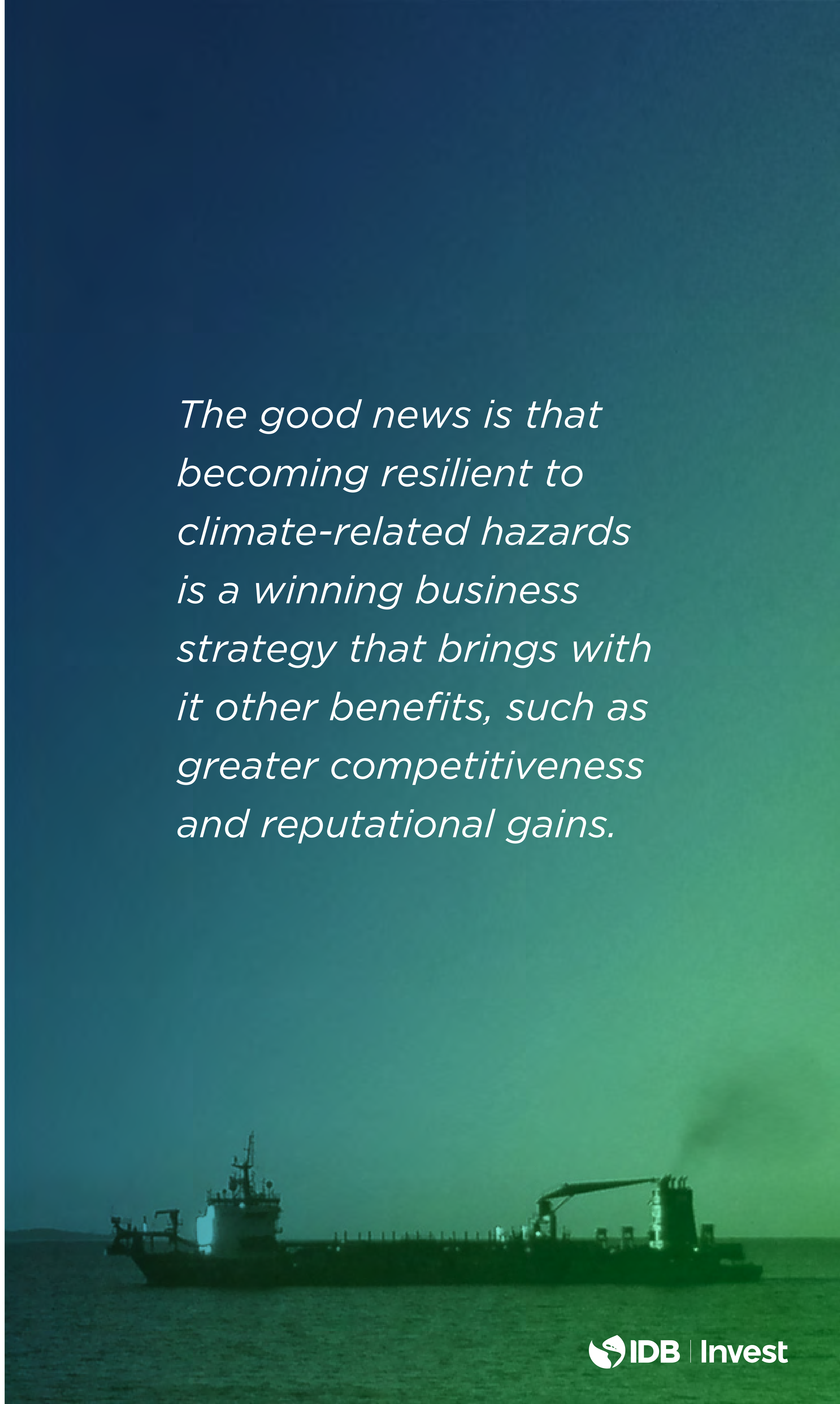
Climate change is occurring at an accelerating pace. Rising seas, warmer temperatures and increasingly extreme weather events are already causing higher operating costs, business disruptions and lower asset values. To prepare for the consequences, countries and companies alike must step up their climate action now. As European Commission President Ursula von der Leyen has put it, the 2020s are the “make-or-break decade.”

The good news is that becoming resilient to climate-related hazards is a winning business strategy that brings with it other benefits, such as greater competitiveness and reputational gains. While the cost of investment is high, so are the potential returns. According to the Global Center on Adaptation,[12] the Latin America and Caribbean region’s need for investment in resilient energy, water and transportation infrastructure has been estimated at $13 billion per year until 2030, yet such an investment would deliver a net benefit of $700 billion. This type of investment, the report says, would help unlock the “triple dividend” of resilient infrastructure: avoided losses, economic gains, and social and environmental benefits.

While ports are naturally exposed to climate-related hazards, the level of exposure differs significantly from location to location, and the degree of vulnerability depends heavily on infrastructure design and specifications. A site- and asset-specific risk assessment will allow port developers and operators to identify optimal adaptation measures and prioritize investments. Such an assessment is the starting point to take advantage of the triple dividend that climate resilience can deliver.

Financial tools such as comparative financial analysis, cost-benefit analysis and metrics on time effectiveness or associated benefits can provide further clarity and yield insight into which adaptation actions should take priority. These, together with a monitoring and evaluation plan, can help port operators and developers mitigate risks and reap adaptation opportunities, making their investments more resilient today and into the future.

IDB Invest invites readers to become more familiar with the tools described and to use the additional resources that are included throughout the guide. It also invites the port sector to share best practices to tackle climate change-related challenges and increase collaboration. While this guide focuses on ports, some of the tools described here may be useful to conduct similar assessments of other types of infrastructure. As important as climate resilience is for ports, this is a concern that touches every sector of the economy.



[12] Global Center on Adaptation. (2020). State and Trends in Adaptation Report 2020. Volume 1: Building Forward Better from COVID-19: Accelerating Action on Climate Adaptation.

GLOSSARY[13]

Adaptation:
In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.

Adaptive capacity:
The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Climate change:
Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

Climate scenario:
The simulated response of the climate system to a scenario of future emission or concentration of greenhouses gases (GHGs) and aerosols, generally derived using climate models.

Exposure:
The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected.

Hazard:
The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Impacts:
Effects on natural and human systems. These refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period.

Representative Concentration Pathways (RCPs):
Scenarios that include time series of emissions and concentrations of the full suite of GHGs and aerosols and chemically active gases, as well as land use/land cover. The term pathway emphasises the importance of the trajectory taken over time to reach that outcome.

Resilience:
The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.

Resilient infrastructure:
The ability of the asset to anticipate, absorb and recover from weather shocks and slow-moving changes as well as positively adapt and transform in the face of long-term stresses, changes and uncertainty induced by climate change.

Risk:
The potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure.

Sensitivity:
The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change.

Threshold:
The magnitude or intensity that must be exceeded for certain reaction, phenomenon, result, or condition to occur or be manifested.

Vulnerability:
The propensity or predisposition to be adversely affected. Vulnerability depends on the sensitivity to harm and the lack of capacity to cope and adapt.

[13] Adapted from IPCC (2018). Annex I: Glossary. In Matthews, J.B.R. (ed.), Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Further IPCC glossary is available at: https://www.ipcc-data.org/guidelines/pages/glossary

ANNEXES

ANNEX 1: POP-UP TABLES

Pop-up 1: Basic project data parameters

BASIC PROJECT DATA	
• Name of concessionare / port / terminal • Country / region / municipality • Geolocation / coordinates	• Project stage (i.e., planning, feasibility, design, construction, operation and maintenance, decommissioning)

Pop-up 2: Most relevant hazards affecting port projects

MOST RELEVANT HAZARDS	
Sea level rise	Coastal erosion
Storm surge	Heat waves and high temperatures
River flooding	Sedimentation
Storm flooding or heavy rain	Reduced river flows
Extreme waves	Others (e.g., salinity acidification, sea temperature changes, sea spray)
Extreme winds	

Pop-up 3: Template to report assessment of historical impacts

HAZARD	EXPECTED CHANGE IN FREQUENCY	EXPECTED CHANGE IN INTENSITY	IMPACTED ELEMENTS	DESCRIPTION OF IMPACTS
Sea level rise Storm surge River flooding Storm flooding Extreme waves Extreme winds Coastal erosion Heat waves Sedimentation Reduced river flows Others	Increase Decrease No change Not known	Increase Decrease No change Not known	Port infrastructure Port operation Port access Physical environment Socioeconomic factors Natural environment Others	Area of affected elements Cost of damage Day of service lost Others

Pop-up 4: Example of how to score a flooding hazard

HAZARD LEVEL	DEFINITION	SCORE
Low	Water level is between 0 (meansea level) and 0.5 meters	1
Medium	Water level is between 0.5 and 1 m	2
High	Water level is above 1 m	3

Pop-up 5: Example of how to score exposure to a hazard

EXPOSURE LEVEL	DEFINITION	SCORE
Low	Project asset will not be exposed to a particular hazard	1
Medium	Project asset will be affected at least once during the execution period or the operational life of the project	2
High	Project asset will be affected several times during the execution (construction) period or the operational life of the project	3

Pop-up 6: Example of report of potential impacts

HAZARD	IMPACTED AREAS	DESCRIPTION OF THE POTENTIAL IMPACT
Extreme waves	Navigation	Reduction of operation hours Reduction of port reliability

Pop-up 7: Example of vulnerability indicators

IMPACT AREA	POSSIBLE SENSITIVITY INDICATOR	POSSIBLE ADAPTIVE CAPACITY MEASURE
Breakwater	Load-carrying capacity	New technologies Budgeted upgrades Climate insurance

Pop-up 8: Example of how to score vulnerability to a hazard

VULNERABILITY LEVEL	DEFINITION	SCORE
Low	Project asset will not be affected by a particular hazard	1
Medium	Project asset will be somewhat vulnerable to a particular hazard	2
High	Project asset will be very vulnerable to a particular hazard	3

Pop-up 9: Example of an M&E datasheet

Indicator	Days of service lost due to structural damages to infrastructure
Unit of measurement	Number of days
Adaptation relevance	The indicator is one way to measure the vulnerability of a port building or installation to climate hazards
Potential limitations	Indirect losses from climate hazards may be hard to quantify
Data needs	Definition criteria for extreme climate hazards is required
Calculation of the indicator	Indicator = Number of days of service lost

PLANNING WITH CLIMATE SCENARIOS IN MIND

The Intergovernmental Panel on Climate Change (IPCC)—the United Nations body for assessing the science on this topic—categorizes different scenarios based on projected volumes of future greenhouse gas emissions. Its Fifth Assessment Report (AR5) lays out risks and impacts related to a changing climate and describes four different scenarios based on what it calls representative concentration pathways (RCPs). Two projected scenarios consider possibilities at either end of the spectrum—emissions are either stringently mitigated or very high—and the other two describe intermediate projections. The IPCC's Sixth Assessment Report, which has been several years in the making, is expected to be completed in 2022, with updated and expanded scenarios.

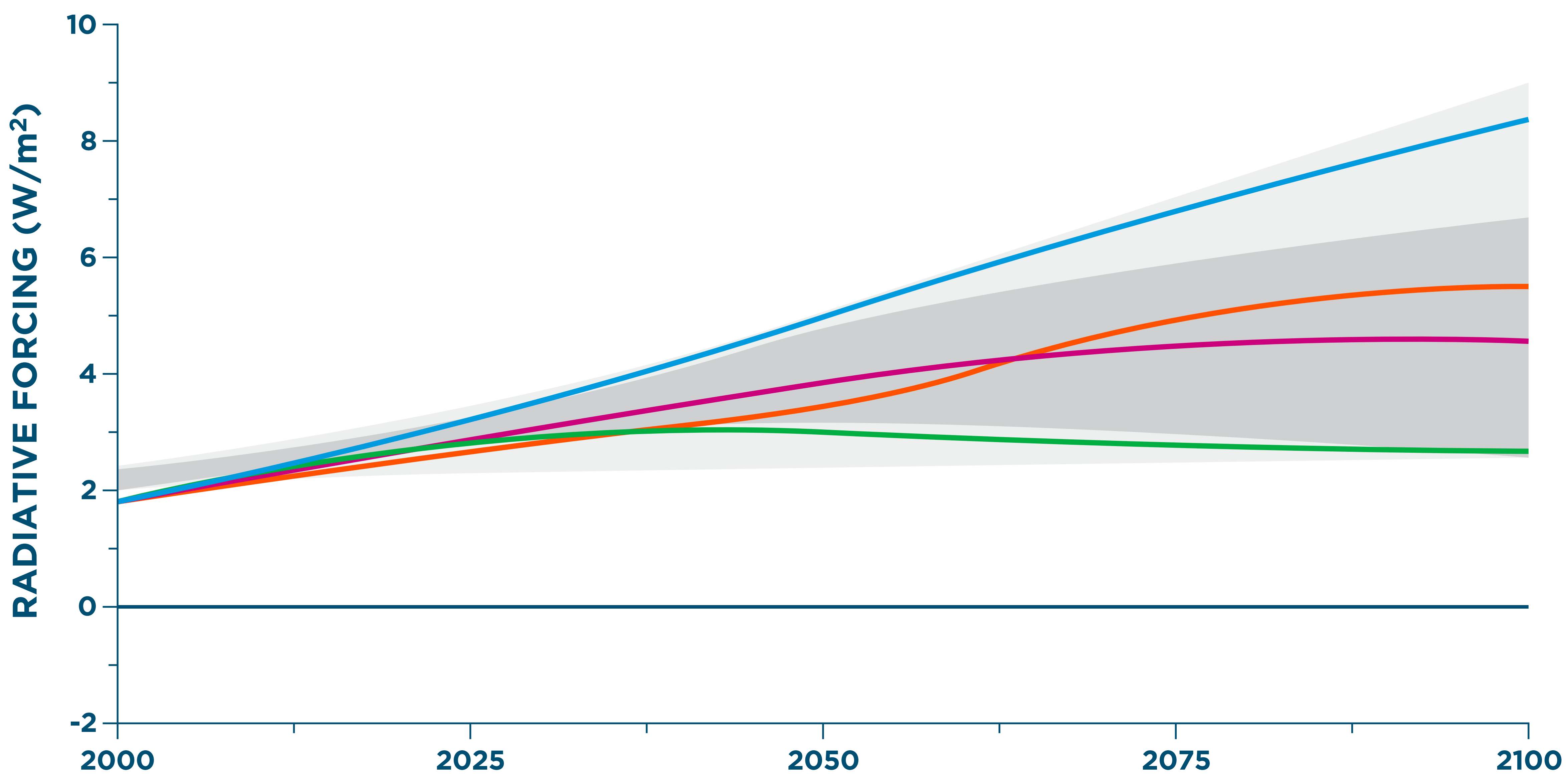
Here are the four scenarios or pathways that currently form the foundation for climate models. Projected changes are described in terms of radiative forcing levels, which are quantified in units of watts per square meters (W/m^2) and are used to measure changes in the energy entering and leaving the Earth's atmosphere.[14]

This guide recommends taking a conservative approach to decision-making based on the most pessimistic scenario for emissions, RCP 8.5. This is in line with the precautionary principle, which seeks to ensure a higher level of protection by taking preventive decisions in case of risk. However, this approach will likely imply a greater need for adaptation and will result in higher costs.

Other factors to consider when putting together a climate-related project plan:

Timescale refers to when the hazard is projected to occur in the given scenario. It differentiates hazards occurring in the short- to mid-term (2050s) or the long-term time period (2100s). The selection of the timescale should depend on the project's life span.

Spatial resolution of expected hazards will vary depending on the climate model used. The use of higher spatial resolution, for instance using downscaling, will lead to a more precise understanding of hazard exposure.



RCP 8.5 W/m^2: a business-as-usual pathway in which radiative forcing reaches greater than 8.5 W/m^2 by 2100 and continues to rise for some time.

RCP 6.0 W/m^2: intermediate stabilization pathway in which radiative forcing is stabilized at approximately 6.0 W/m^2 after 2100.

RCP 4.5 W/m^2: intermediate stabilization pathway in which radiative forcing is stabilized at approximately 4.5 W/m^2 after 2100.

RCP 2.6 W/m^2: a pathway in which radiative forcing peaks at approximately 3 W/m^2 before the year 2100 and then declines. (This represents a scenario in which global warming likely stays below 2ºC above preindustrial temperatures.)

[14] The figure has been adapted from van Vuuren et al. (2011). The Representative Concentration Pathways: An Overview. Climatic Change, 109 (1-2), 5-31.

Annex Table A: Example of a template for a qualitative hazard evaluation

HAZARD EVALUATION

HISTORICAL AND CURRENT DATA AND INFORMATION AVAILABILITY	Yes	No	Description
Is past or current information about climate data available?	○	✓	
Have historical climate conditions and hazards been studied?	✓	○	
Has the frequency or intensity of hazards changed over recent decades?	✓	○	

CLIMATE CHANGE DATA AND INFORMATION AVAILABILITY	Yes	No	Description
Has your project considered the possibility of impacts from climate-related events?	✓	○	
Is there any global/regional climate model available?	○	✓	
Have global/regional climate models been consulted and analyzed?	✓	○	
Which climate change scenario has been used?			
RCP 2.6	○		
RCP 4.5	✓		
RCP 6.0	○		
RCP 8.5	○		
Which time horizon has been applied?			
Short-term to mid-term: 2050 or earlier	✓		
Long-term: 2050-2100	○		
Which spatial resolution has been applied?			
<25 km	○		
25-60 km	✓		
>60 km	○		

Annex Table B: Example of a template for a qualitative exposure evaluation

EXPOSURE EVALUATION

	Yes	No	Description
Have your project elements or impact areas ever been affected by climate-related events?	○	✓	
Could projected changes in future hazards generate future impacts?	✓	○	

Annex Table C: Example of a template for a qualitative vulnerability evaluation

VULNERABILITY EVALUATION

	Yes	No	Description
Has your project carried out any work to evaluate possible adaptation measures (e.g. early warning system)?	○	✓	
Has your project incorporated weather- or climate-related considerations into planning, design and construction?	○	✓	
Which elements (i.e. infrastructure, operation, access, physical environment, socioeconomic, among others) have been considered when assessing vulnerability?			
Is there any insurance to facilitate the continuation or rapid recovery of the project?	○	✓	

ANNEX 3: FINANCIAL ANALYSIS CONSIDERATIONS

Annex Table D: Including climate risk in financial analysis[15]

STEPS
✔ Determine the business case based on regular commercial assumptions
✔ Select climate risk scenario
✔ Go through each cost item and each revenue item and determine whether climate influences this assumption
✔ For each assumption, define alternative assumptions in line with climate scenarios
✔ If alternative assumptions are unavailable, determine risk mark-ups (or deductions) for overarching cost and revenues by subcategories
✔ Perform a check on double-counting (e.g. only take either insurance payments or material damage/business interruption)
✔ Draw overall conclusions on financial feasibility of project, including outcome of scenarios

Key assumptions for financial analysis:

- Costs and benefits of climate change and adaptation are analyzed in terms of their effect on earnings before interest, taxes, depreciation and amortization (EBITDA).
- Revenue sources are only fixed fees paid for port services and use of infrastructure, and the terminals' variable fees dependent on cargo movements (or the port's simplified scheme for determining revenue sources). This isolates the effects of climate change from other financial effects beyond the scope of the study, such as foreign exchange and interest rates.
- Business-as-usual operating expenses are assumed to be fixed as a percentage of revenue. The only changes to this operating expense would reflect changes due to either the effects of climate change or the effects of adaptation to climate change.
- Factors such as inflation, exchange rate and price escalation can be excluded from the analysis for the reasons mentioned above. The results can later be amended by the port to include these factors.
- For the purposes of investment evaluation, a baseline case discount rate must be established by the port. The implications of this discount rate for decision-making should be explored using sensitivity analysis.

[15] IDB. (2020). Climate Resilient Public Private Partnerships: A Toolkit for Decision Makers.

ANNEX 4: ADDITIONAL RESOURCES

A. INTERNATIONAL REPOSITORIES OF HISTORICAL DATA ON CLIMATE HAZARDS:

- The Centro Internacional para la Investigación del Fenómeno de El Niño compiles climate change projections and specific data about the Pacific Ocean climate patterns known as El Niño and La Niña (http://www.ciifen.org/).
- Desinventar is a disaster information management system that maintains an inventory of losses caused by natural hazards for more than 80 countries (https://www.desinventar.net/).
- The European Climate Adaptation Platform Climate-ADAPT provides interactive access to climate indices in support of climate change adaptation in Europe (https://climate-adapt.eea.europa.eu/).
- The Global Risk Data Platform contains data on past events and risks from natural hazards, including tropical cyclones and related storm surges, drought, earthquakes, biomass fires, floods, landslides, tsunamis and volcanic eruptions (https://preview.grid.unep.ch/).
- The International Disaster Database (EM_DAT) contains information on the occurrence and effects of disasters around the world, from 1900 to the present day (https://www.emdat.be/).

B. OTHER PUBLICATIONS THAT HAVE BEEN USED FOR THIS REPORT AND MERIT FURTHER READING:

- 2020 State of Climate Services: Risk Information and Early Warning Systems, includes data on reported disasters and economic losses in various regions, including Latin America and the Caribbean, and identifies where and how to invest in early warning systems. It is a 2020 publication of the World Meteorological Organization.
- Climate Change Adaptation Planning for Ports and Inland Waterways, published in 2020 by the World Association for Waterborne Transport Infrastructure (PIANC), includes an extensive portfolio of measures for adapting or strengthening port resilience.
- Climate change adaptation for seaports in support of the 2030 Agenda for Sustainable Development, published by the United Nations Conference on Trade and Development in 2020, presents an overview of the main climate change-related impacts on ports, with special considerations for small island developing states. It presents a discussion on cross-cutting issues such as energy use, which is directly affected by climate factors; fisheries and seafood supply chains; and climate finance.
- Climate Change Projections in Latin America and the Caribbean, published by the IDB in 2016, provides climate change scenarios for the years 2040 and 2070, based on such factors as average annual maximum temperatures, precipitation, sea level rise and concentrations of greenhouse gas emissions in the atmosphere.
- Ports Resilience Index: A Port Management Self-Assessment, published in 2016 by the Ports Resilience Expert Committee in the United States provides a self-assessment tool for port authorities and management organizations to understand how prepared they are to maintain operations both during and after a natural or man-made disaster and to develop actions for resilience.
- Port of Manzanillo: Climate Risk Management is a case study of the climate-related risks and opportunities at the Port of Manzanillo in Mexico published by the IDB in 2015. It includes both a risk assessment and an adaptation plan for the port.
- Climate Risk and Business: Ports. Terminal Marítimo Muelles el Bosque. Cartagena, Colombia is a case study that details both general climate-related risks and opportunities for ports as well as those applicable to the maritime terminal in Cartagena. It was published by the International Finance Corporation in 2011.

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