ACI ASIA-PACIFIC & MIDDLE EAST
AIRPORTS COUNCIL INTERNATIONAL

GUIDELINE

CLIMATE RISK ASSESSMENT

An approach and practical guidance to help airports identify, assess and respond to climate-related risks

ACI Asia-Pacific & Middle East

The Climate Risk Assessment guideline was undertaken by ACI Asia-Pacific & Middle East, in partnership with AECOM, to support airports in the region to strengthen resilience against the growing impacts of climate change. As extreme weather events and climate-related disruptions continue to affect airport operations and infrastructure globally, this report, supported by maturity tools, aims to help airports in Asia-Pacific and the Middle East adopt a more structured and practical approach to climate adaptation alongside ongoing decarbonisation efforts. The guideline and the tools will provide a comprehensive step-by-step approach for airports to assess climate risks, strengthen resilience planning, engage relevant stakeholders.

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Table of Contents

Acknowledgments

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ACI APAC & MID and AECOM wish to acknowledge and thank the Task Force for their efforts and contributions to this Study and helping to make this Climate Risk Assessment Guideline and accompanying Study materials relevant and representative for airport members.

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Executive Summary

Climate change presents a growing challenge to airport operations, infrastructure, and long-term viability. Extreme weather events, rising temperatures, and sea level rise are intensifying existing risks and introducing new vulnerabilities for airports across the globe. To ensure safety, continuity, and strategic resilience, proactive climate change risk assessment is no longer optional—it is essential.

In response to these evolving threats, Airports Council International Asia-Pacific & Middle East (ACI APAC & MID) has released this **Climate Risk Assessment Guideline**. It is a practical, structured, and comprehensive framework to help airport operators identify, assess, and manage climate-related physical risks, across the variety of airport sizes, locations and capacity.

The Climate Risk Assessment Guideline centres on a clear four-step process and is accompanied by practical tools and supporting materials to make the assessment process structured and comprehensible. Airport operators should feel empowered to use these materials to raise internal knowledge and capability and make informed decisions for the future.

Undertaking a climate change risk assessment provides key insights for airport operators and informs:

- **Strategic risk management**: Understanding how a broad range of climate hazards—from floods and storms to rising temperatures and sea level rise—can impact key airport infrastructure, operations, and service delivery, and using this insight to proactively mitigate those risks.
- **Operational resilience**: Reducing disruptions, protecting passenger and staff safety, and maintaining business continuity by integrating climate adaptation into master planning, infrastructure upgrades, emergency preparedness, and maintenance practices.
- **Management of stakeholder expectations**: Governments, aviation partners, and the broader community increasingly expect airport operators to be climate-ready and actively planning for physical climate risks. Demonstrating capability and preparedness is becoming a core part of an airport's social license to operate.
- **Climate risk disclosure obligations**: Around the world, climate-related risk reporting is becoming a regulatory and market requirement. This includes alignment with standards such as the IFRS Foundation's *S2 Climate-related Disclosures* and other international and national frameworks. Airports must be prepared to assess, disclose, and act on climate risks in a credible and defensible manner.
- **Ongoing climate resilience**: Airport operators can build on the climate change risk assessment process to undertake more progressive actions over time, improving their ability to anticipate, withstand, respond and recover from the effects of climate change.
- **Sector-wide continuity**: The interconnected nature of the aviation sector means that disruptions at one airport can cascade across the entire network. Climate change risk assessments inform coordinated, sector-wide resilience planning that benefits the entire system.

Climate change is rapidly shifting the operating environment for airports. Senior leaders must act decisively to protect assets, maintain continuity of service, and demonstrate responsible stewardship of critical infrastructure in the face of intensifying climate risks. This Guideline provides a clear approach for identifying climate risks and adaptation measures, to that airport operators can act strategically and confidently in a changing climate.

Introduction

Climate change risk assessment is essential for maintaining the operational integrity, safety, and long-term viability of airports.

Climate change is increasing exposure to extreme weather events such as storms, flooding, and heatwaves, as well as causing or extending stresses such as droughts and sea level rise. This heightens existing risks and poses new risks to infrastructure, operations, safety and reputation. Assessments provide critical insights into potential hazards, enabling airports to quantify risks and prioritise mitigation measures.

The rising frequency and intensity of climate hazards necessitate comprehensive assessments to identify vulnerabilities and inform adaptive strategies. By systematically evaluating risks, airports can implement targeted interventions to minimise operational disruptions, prevent infrastructure damage, and ensure safe operations. Evolving regulatory frameworks also require robust climate risk management to meet compliance obligations and maintain stakeholder confidence.

The interconnected nature of the aviation sector emphasises collective resilience. Disruptions at one airport can cause compounding or cascading impacts across the network, underscoring the need for sector-wide preparedness. Climate change risk assessments provide a foundation for proactive resilience planning and adaptive management, integrating findings into strategic planning, infrastructure design, and operational protocols. This structured approach not only mitigates risks but also strengthens sector-wide resilience against emerging climate threats.

In response to the needs of its members, Airports Council International Asia-Pacific & Middle East (ACI APAC & MID) has released this Climate Risk Assessment Guideline to help airport members identify, assess and respond to climate-related physical risks. It is the hope of ACI APAC & MID that this Guideline can support airport members to build on and improve their preparedness and response to climate risks, while also building capability and climate resilience across the region's airports.

Purpose and structure of the Guideline

The purpose of the Guideline is primarily to enable informed decision-making for airport planning, investment and asset management, by offering a clear and structured approach to recognising how climate change could affect the running of an airport. In tandem, by going through the steps of this Guideline, airport operators also ready themselves to respond to climate change reporting requirements, including the International Financial Reporting Standards (IFRS) Foundation's *S2 Climate-related Disclosures.*

The key audience for reading and applying the Guideline is anticipated to be climate change and sustainability subject-matter experts working at an airport operating in the APAC & MID region.

The Guideline is organised into four sections:

Section 1 Introduction

Introduces the Guideline and its purpose, including navigational aids for reading and interpreting the Guideline. Introduces a stepped approach to climate resilience, demonstrating how climate response efforts can build resilience over time.

Section 2 Climate change and airport context

Explains key concepts of a climate change risk assessment, including climate risk, hazards, exposure, vulnerabilities and adaptation. Summarises the unique airport context and provides examples of key hazards and climate risks that airports may face.

Section 3 Climate change risk assessment process

Core section of this Guideline, detailing the four-step climate change risk assessment process:

Section 4 Additional resources

Provides links to reference materials and further information on climate change concepts to support airports in delivering their climate change risk assessments.

How to use this Guideline

This Guideline adopts a four-step climate change risk assessment process intended to be:

- Practical: Scalable and applicable to airports of different sizes, maturity, capacities, and locations
- Structured: Logically sequenced to ensure each step builds on the last
- Actionable: Focused on generating outputs that can inform adaptation planning and investment decisions.

Additional prompts and in-depth information are called out in breakout boxes. Look out for these icons throughout the Guideline:

Additional information

Provides the definition of a technical term or further explanation on application of the Guideline.

Covers more in-depth insight and technical information on climate or aviation concepts.

Provides a case study as an example of the concepts or process being discussed.

Signposting and prompting

Stakeholder engagement is likely to be required or strongly encouraged as part of the climate change risk assessment process.

The accompanying tools (the **Climate Risk Maturity Check Tool** or **Climate Risk Assessment Tool)** can be used.

Future considerations

Additional steps or guidance for airports to consider as their climate maturity strengthens (or for those who are already at an elevated level of maturity).

This Guideline is accompanied by two practical tools which can used by airport stakeholders – the **Climate Risk Assessment Tool** to record the inputs and analysis of your risk assessment, and the **Climate Risk Maturity Check Tool**, a questionnaire-style tool to help airports understand their readiness to respond to climate-related physical risks. The Guideline and tools are also each supplemented by **supporting guidance packs** that help users navigate each document (see Figure 1).

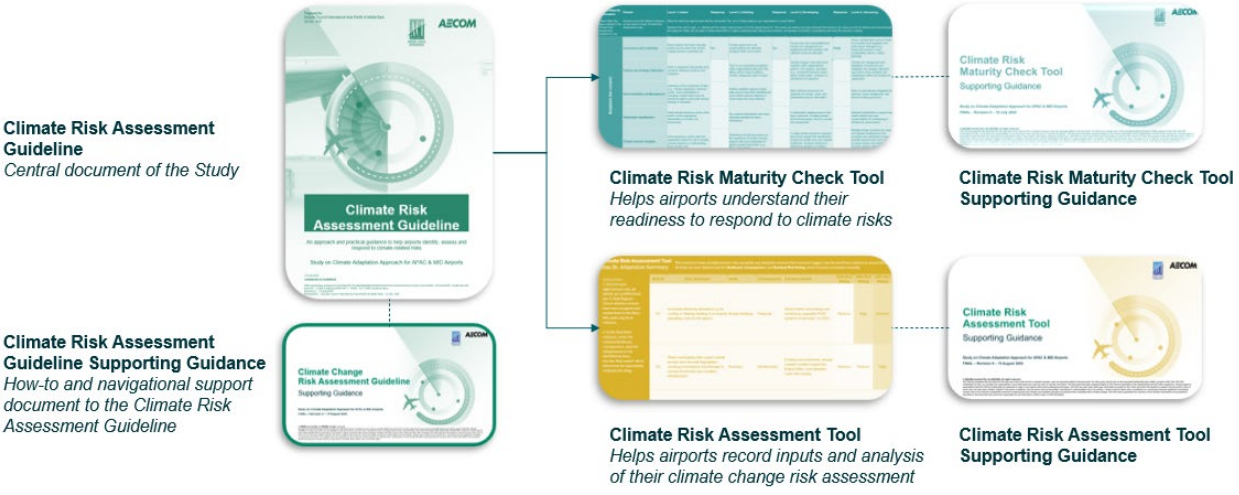


Figure 1 Introduction to Study materials

Applying the Guideline in practice

This Guideline has been developed to support airport operators undertaking a climate change risk assessment, in order to identify areas of potential impact and disruption, so that appropriate responses can be implemented to reduce risk. In practice, the outputs of a climate change risk assessment can go on to inform a variety of other processes and decisions across an airport, including:

- Informing airport planning processes such as masterplans, capital works programs and annual budgeting through the inclusion and integration of climate adaptation actions.
- Supporting adaptive and flexible investment decisions based on climate-related thresholds and changing level of risk over time.
- Linking to emergency planning processes to ensure climate-related triggers are identified and anticipated, to then inform emergency response.
- Informing broader sustainability initiatives and reinforcing their investment case where climate and sustainability co-benefits exist.

Principles for governance and engagement

To ensure that climate change risk assessments are effective, comprehensive and credible, the following overarching principles are proposed to guide the assessment process' governance and engagement.

- Endorsement from senior or executive leadership is gained as a demonstration of commitment to recognise and respond to climate-related risks.
- Roles and responsibilities for those involved in and coordinating the assessment are articulated and understood, to ensure ongoing progress in the assessment.
- Engagement is widespread across the organisation to hear from and collate diverse perspectives and experiences that enrich the inputs of the risk assessment.
- Sufficient resources (human, capital, time) are afforded to the assessment to maximise its outputs and provide clear and representative findings.
- Reporting to senior leadership and/or board-level committees is undertaken to share findings and promote oversight of key risks at the highest levels of the organisation.
- Engagement with external stakeholders such as contractors, local councils, authorities, utility providers and consultants occurs during the assessment to ensure all aspects of operation are covered in the process.

It is recognised that airport operators may be working within constrained timeframes or with constrained resources. For this reason, the Guideline is intended to establish a robust baseline of understanding and identification of climate-related risks, from which airports can then carry out more in-depth, or location- or asset-specific assessments based on their risk appetite and capacity.

Where airport operators experience capacity constraints, the support of external climate change and resilience advisory consultants may be beneficial, as well as accessing data and resources from locally relevant scientific and research organisations to support the collation of climate data, or identification of climate risks and adaptation measures. Some examples of tools and resources are also made available at the end of this Guideline.

A stepped approach to climate resilience

Climate resilience refers to the capacity of connected systems to anticipate, withstand and recover from climate-related hazards. This resilience is developed and reinforced over time, through progressive and structured actions and the improvement of internal capabilities as those actions are implemented. Figure 2 demonstrates a stepped approach to resilience, where actions of one step build on the previous one to improve resilience over time. While the steps focus on an airport's internal journey to climate resilience, there is opportunity to involve external stakeholders, including airport partners, regulatory authorities, or government representatives, to support the identification of climate risks and response measures, or contribute to or validate certain approaches. This stepped approach is intended to be an indicative roadmap for airport operators to build up and improve their capacity to recognise, withstand, respond and recover from climate change.

Box 1 presents a Case Study of Heathrow Airport's ongoing progression in identifying and responding to climate-related risks through various assessments and adaptation planning.

1. **Recognition:** Recognition: The airport operator is aware of the impacts of climate change and has completed the Climate Risk Maturity Check Tool to build understanding of gaps and strengths related to climate response.
2. **Assessment:** A climate change risk assessment has been conducted across the airport, involving diverse internal stakeholders and identifying both direct and indirect physical risks.
3. **Adaptation:** An adaptation strategy or plan has been developed to respond to priority physical climate risks.
4. **Operational Integration:** Climate risks and adaptation measures are integrated into enterprise and asset-level risk processes, forming a part of routine operational preparation and response efforts.
5. **Strategic Integration:** Climate risks are elevated to inform strategic planning and relevant adaptation measures inform future master planning and investment decisions. Climate scenarios are used to test the resilience of corporate strategies.
6. **Measurement:** Metrics and targets are developed and reported publicly to share performance and progress of airport climate response.
7. **Extension:** Climate risks and response measures are considered beyond the boundary of the airport, with efforts made to collaborate with external stakeholders, airport partners and the community to improve resilience at a network or community/city level.

Figure 2 Stepped approach to climate resilience

Airport operators are encouraged to use the **Climate Risk Maturity Check Tool** to gather information about the existing processes underway and assessments conducted that would support climate resilience across the airport. Airport operators may then be able to gauge where they sit along the climate resilience journey, and consider the next steps required to improve climate response and maturity over time.

Box 1 Case Study - Heathrow Airport

Heathrow Airport – Climate Change Risk Assessment and Adaptation Planning

Since 2011, Heathrow Airport Limited (HAL) has progressively embedded climate risk into its core planning and operations. This began with the first Climate Change Adaptation Report in 2011 issued by the United Kingdom government as Heathrow Airport Limited (HAL). The report identified key weather-related risks—flooding, high temperatures, fog, and wind direction changes—and used a risk matrix to prioritise responses. Initial analysis suggested these risks would not significantly impact operations in the short (to 2020) or medium term (to 2040), affirming that existing resilience measures were largely adequate.

This initial work laid the foundation for a more comprehensive adaptation journey. A progress update followed in 2013, and by 2016, HAL had submitted a detailed report outlining short-, medium-, and long-term actions aligned with its evolving understanding of climate risk. Many short-term measures were already in place by then, particularly for current climate variability. HAL's strategy became more data-driven, incorporating climate modelling across high, medium, and low emissions scenarios for time horizons extending into the 2050s. This modelling helped refine its risk assessments, identifying 34 significant risks, with particular emphasis on temperature rise, increased extreme rainfall, and changing wind patterns—especially important due to Heathrow's two parallel runways and lack of a crosswind runway.

In 2014, Heathrow developed an Operational Resilience Plan, emphasizing infrastructure risk assessments, robust business continuity, coordinated disruption response, and passenger welfare during incidents. A strong focus was placed on managing capacity during disruptions, given Heathrow's status as a high-density hub with limited flexibility for delay absorption.

Since 2015, Heathrow has completed more detailed risk assessments at the asset level and published a Climate Adaptation Report in 2024 which presents the risks from the most recent Climate Risk Assessment. HAL is also developing an Adaptation Strategy, which is scheduled for completion in 2025, encompassing the objectives, goals, strategies, targets and metrics required for Heathrow to be a well-adapting airport.

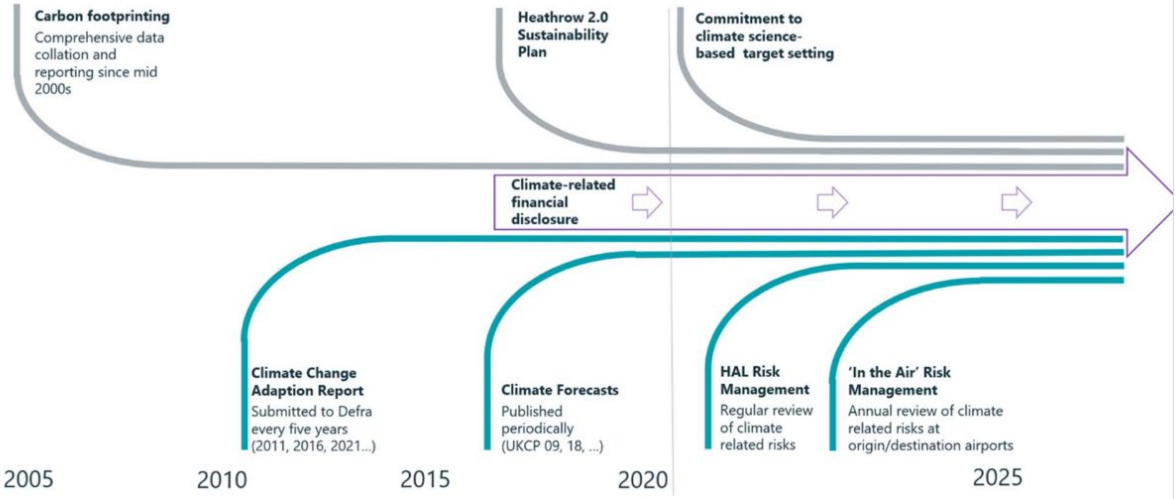


Figure 3 Heathrow Airport's progression in climate-related risk and sustainability over time. Source: (Heathrow Airport Ltd, 2022)

Over time, HAL institutionalised climate adaptation into its governance structure. Climate resilience is now a key component of its annual strategic capital business plan, integrated within its ISO 14001:2015-certified environmental management system, and tracked through its corporate risk process, which continues to monitor and reassess the original 34 climate-related risks. This phased approach reflects Heathrow's shift from standalone adaptation efforts to mainstreaming climate resilience across operations, planning, and long-term investment strategies.

Climate Change and Airport Context

Understanding climate-related risk

Climate-related risk refers to potential negative or positive impacts of climate hazards and variability under the influence of rising global greenhouse gas emissions. Impacts can be event-driven (acute shocks) or longer-term shifts (chronic stresses) in climate patterns. Climate risks are typically categorised as either physical or transition risks. Transition risks are those which result from policies, market and technological trends and changing stakeholder expectations to reduce energy and emissions. This Guideline focuses on physical risk.

Physical risks include the direct and indirect impacts from rising aggregate global temperatures and the effects and influence on other climate variables. For example, direct impacts include damage to assets or infrastructure and health impacts from periods of extreme heat, whereas indirect impacts include supply chain disruption caused by regional flooding and increased insurance premiums as a result of more frequent extreme weather events. Physical risks can be determined by considering historical and projected occurrences of climate **hazards**, extent of **exposure** of the airport, and potential **vulnerability** in the face of the climate hazard. Figure 4 shows this interplay between these determinants.

A **climate hazard** is a weather or climate event, or a long-term trend, that has potential to cause harm to people's health or lives, damage property and infrastructure, disrupt jobs and essential services, and harm ecosystems and natural resources**.** Climate hazards are discussed further in *Climate hazards covered by this Guideline*.

Exposure in the context of risk assessments refers to the presence of things that could be adversely affected by climate and weather-related hazards. Things that could be impacted include people, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be harmed.

Vulnerability refers to the likelihood of being negatively affected or harmed, based on both how sensitive something is to harm (**sensitivity**) and its ability to cope, adapt or recover (**adaptive capacity**). Vulnerability is therefore one of the main factors that influence climate risk, alongside climate hazards and the presence of people, infrastructure or systems in places that could be harmed (exposure). Figure 4 shows how these four determinants (vulnerability, hazards, exposure and adaptive capacity) connect to produce a risk.

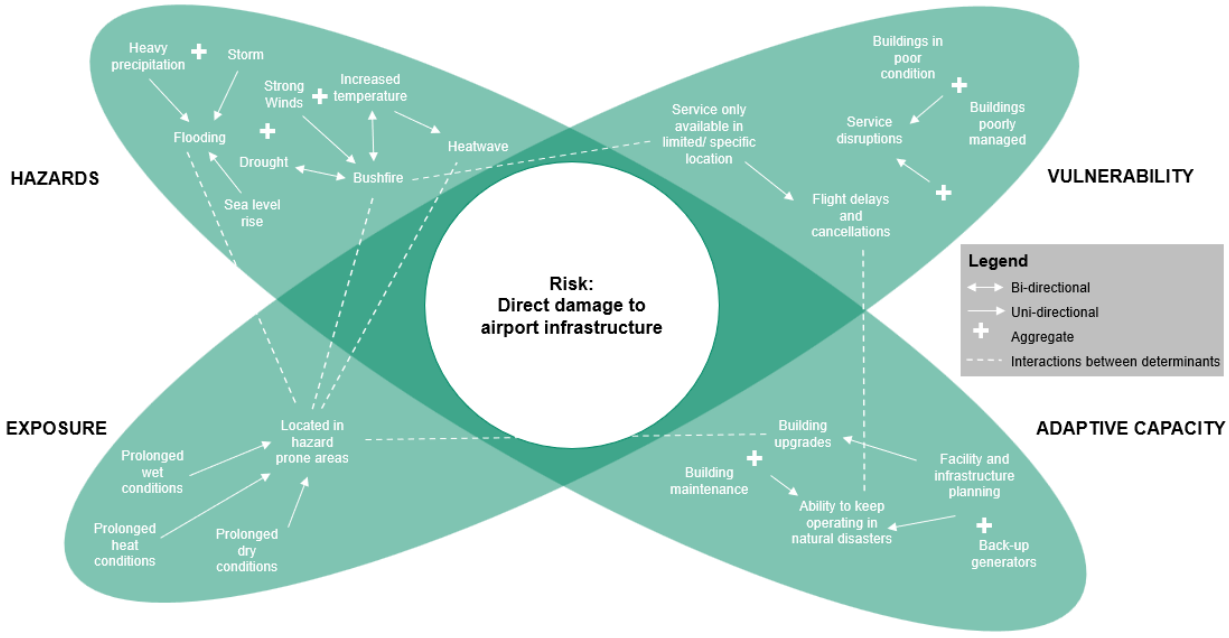


Figure 4 Determinants of climate risk. Adapted from (Intergovernmental Panel on Climate Change (IPCC), 2022)

To address and respond to climate risk, a systems approach is recommended to enhance an airport's resilience to climate hazards, reduce exposure and limit vulnerabilities. A systems approach moves beyond the identification of risks at single assets, to understanding the interconnections and interdependencies between assets to identify potential risks.

Measures implemented to respond to climate risks are termed **adaptation** measures. This refers to actions undertaken to manage or reduce the adverse consequences of climate change, as well as to harness any benefits or opportunities. Adaptation measures are implemented with the intention to enhance **climate resilience**, or the ability to anticipate, prepare for, respond and adapt to acute and chronic climate change, so as to continue delivery of services and assets, and meet community expectations.

Articulation of climate-related risk

In order to bring the different determinants of climate risk into a coherent statement, it helps to form the statement into a risk impact chain, with the following elements:

1. Climate hazard – description of the external event or trend that occurs in the environment (e.g. *extreme rainfall event*)
2. Outcome – description of what happens at the airport site as a result of the hazard, or at a location that provides interconnected services to the airport (e.g. *inundation and overland flow across airport paved surfaces*)
3. Impact – description of the resultant effect on the airport's capacity to function and operate (e.g. *reduced access and egress for passengers entering the terminal*)

This is summarised visually in Figure 5 below, where the *hazard* leads to an *outcome*, resulting in an *impact*.

Figure 5 Determinants of climate-related risks presented visually in a risk impact chain

Examples of climate risk statements are provided within the **Climate Risk Assessment Tool**, for airport operators to consider and assess if those particular risks are relevant for their sites and operations. Climate risk statements within the Tool are articulated in the same format as shown in Figure 5. A few examples have been included for ease of reference below:

- Increasing temperatures and frequency of hot days leads to degradation of hardstand assets (i.e. taxiways, aprons, pavements, roads and carparks) resulting in increased maintenance expenses and shortening lifespans.
- Extreme heat leads to increased heat exposure (e.g. as a result of HVAC failure) resulting in heat related injuries towards staff and/or passengers.
- Increased instances of drought leads to increased frequency of dust storms resulting in impacts to visibility and disruptions to flight schedules.
- Storm event leads to complete failure of mechanical and electrical infrastructure resulting in operational disruptions and major capital works programme.

Climate hazards covered by this Guideline

This Guideline addresses a broad range of physical climate hazards that may impact airport systems, as described in Figure 6. Airport operators should consider which of these hazards they may be exposed to as part of the climate change risk assessment. Figure 7 considers the potential impacts of these climate hazards on common airport assets and systems.

The **Climate Risk Assessment Tool** features these climate hazards and provides publicly available climate projection data to inform airport operators of the long-term climate trends modelled for each hazard. Airport operators can use the Tool to confirm which hazards they are exposed to and then identify how climate risks may come about if those hazards were to occur.

Climate Hazards

Extreme rainfall and flood (pluvial and riverine) **events**
intense precipitation leading to surface flooding, drainage system overloads, and water ingress

Storms and high wind events
includes cyclones, typhoons and strong wind gusts or changing wind direction, affecting airside safety, takeoff and landing and infrastructure integrity

Snow, ice, and extreme cold
affects aircraft handling, runway conditions and de-icing operations, and performance of fuelling systems

Sea level rise
gradual increase in baseline sea level leading to coastal inundation, increased salinity of groundwater, salt water intrusion and associated corrosion

Extreme heat
acute heat spikes that can affect integrity of pavements, building facades and electrical components, and impact passenger and workforce comfort and aircraft performance

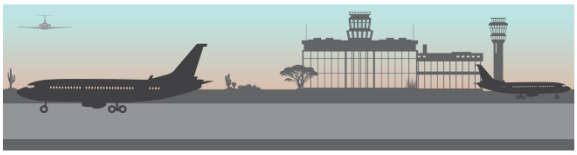
Wildfire
direct fire threats, smog, haze or smoke impacts on visibility and health, disruption of take-offs, landings and surface movements and interruption of access roads or utilities

Desertification
loss of vegetation and soil moisture in arid semi-arid zones, affecting visibility, temperature variation and ecosystem services

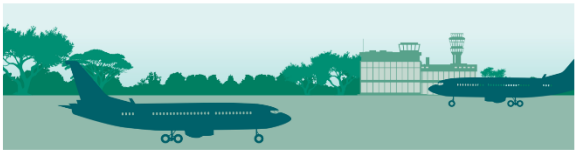
Drought
prolonged dry periods of no or minimal rainfall, affecting water availability for critical services, soil moisture and absorption

Rising average temperatures
long term temperature increases that degrade assets and strain cooling and ventilation systems, requiring change to operational and maintenance procedures over time

Coastal airport impacts
Coastal airports in tropical or semi tropical regions can be exposed to high winds and tropical storms that can limit operations and cause damage to critical assets. In particular, it is when climate hazards combine together to create compounding impacts - tropical storms, combined with sea level rise, can create storm surges that inundate runways and buildings, leading to operational disruption and potential closure. Sea level rise can also increase salinity of groundwater, affecting underground systems and water supply.



Arid and semi-arid airport impacts
These airports can be vulnerable to dust accumulation on runways and equipment as a result of low rainfall and desertification. Groundwater reservoirs can become more quickly depleted during periods of drought, or affected by salinity where there is an interaction with sea level rise. If these airports do experience intense rains, existing drainage infrastructure may not be adequately sized to manage more significant downpours.



Small and regional airports
Smaller airports may lack dedicated assets and equipment to manage certain climate hazards, or may be financially constrained to undertake significant upgrades, such as the installation of mechanical cooling and ventilation and additional shading to combat extreme heat events. Some regional airports may also be located in proximity to wildfire zones, experiencing either direct fire and ember damage, or being disrupted by smoke and haze.

Figure 6 Climate hazards covered by this Guideline and examples of impacts for coastal, arid and regional airports

What makes airports unique in the climate change context

How are airports impacted by a changing climate?

Airports operate as a network of critical infrastructure assets and systems, where even brief operational disruptions can result in significant economic, safety and reputational consequences. Airports are governed by complex regulatory frameworks, which are beginning to introduce requirements or commitments to recognise and adapt to climate change.

Operational interdependencies add further complexity to managing risk at airports. Airport operators must coordinate with multiple stakeholders, including airlines, ground handlers, security services and logistics providers, and operational models can vary from complete in-house management to being heavily outsourced. Disruptions in one area can cascade throughout the system, amplifying operational and financial impacts across the interconnected networks.

Furthermore, the operational interdependency between airports, ground operations staff and airlines calls for coordinated risk management strategies that support both infrastructure-based resilience, as well as operational resilience through flight scheduling and network operations. Runway closures or delays impact airline schedules and passenger satisfaction, whilst staff unavailability impacts airport-wide operations, underscoring the need for comprehensive, system-wide climate change risk assessments.

Airports incorporate fixed assets which typically cannot be relocated. Adaptive capacity to external disruptions like climate hazards thus comes in the form of asset redundancies (additional equipment, multiple runways), or operational measures (crisis management responses, operating without curfews). Long infrastructure lifespans necessitate forward-looking risk assessments, as decisions made today will influence resilience capacity for decades to come. Airports are the gateways to their host cities, and the capacity to manage operational disruptions can go on to influence city branding, tourism, trade and investment and economic development.

Vulnerabilities in airport systems

Airports consist of interconnected assets and systems that can be individually affected by climate hazards, or can be triggered by multiple concurrent or cascading impacts across the airport site. The image below depicts how assets and systems across an airport can be affected by climate hazards, whether due to their exposure (e.g. being located outside or above-ground), or sensitivity (e.g. due to material selection or sensitive componentry).

Terminals

Terminals operate across a large area and are made up of varied construction materials including extensive glazing, which can be vulnerable through damage or degradation to prolonged heat exposure, or high wind and rainfall events. Terminal upgrades are typically staged to allow for continued operations, so there is a broad range of asset design life that must be monitored and maintained.

External transport systems

External transport systems: These systems, including rail, metro and bus networks, are critical for bringing people to and from the airport. Disruptions or closures due to rainfall, flooding, or snow and ice conditions can prevent passengers and staff from reaching the airport, leading to missed flights, operational delays from ground staff unavailability, workforce shortages, overcrowding, and increased pressure on airport-managed transport services.

Access roads and carparks

Internal roads and carparks can be affected by climate hazards through physical damage and degradation as well as operational disruption where access becomes blocked, e.g. due to surface flooding or snow and ice conditions. This can lead to delays or, under extreme conditions, people being isolated or stranded.

Energy supply

Airport operations depend on a stable energy supply for critical systems such as lighting, HVAC, security, communications and air traffic control. Extreme heat, storms and high energy demand can cause instability, outages or equipment failure across the electricity grid and to onsite solar generation, leading to operational disruptions, safety risks and potential closures in backup systems are insufficient.

Runways

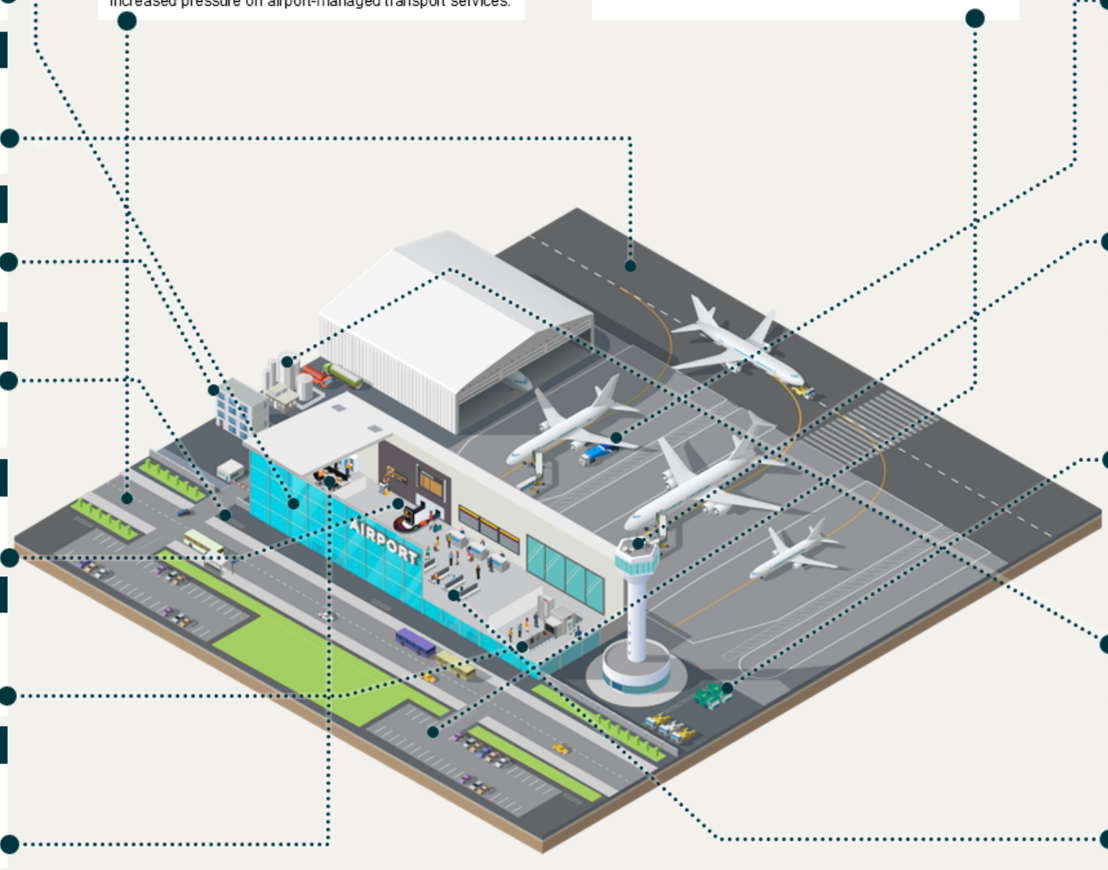
Runway surfaces are vulnerable to ponding from intense rainfall and to heat-related softening or cracking of asphalt. These conditions can elevate safety concerns and increase the potential for foreign object debris, impairing aircraft performance and flight planning, or require temporary closures for repairs.

Telecommunications

Reliable telecommunications infrastructure is critical to airport operations, including air traffic control, security systems, internal coordination, and passenger communications. Extreme weather events such as storms, high winds, heatwaves, and flooding can damage physical infrastructure (e.g., cell towers, underground cables) or disrupt data transmission, leading to loss of connectivity, delays in communication, and compromised safety and security operations.

Power and fuel systems

These systems can be overloaded during peak heat periods when cooling demand is high. Extreme temperatures may lead to equipment degradation or outages, affecting takeoff and landing procedures or refuelling processes.



Supply chain (fuel and food)

Climate hazards such as flooding along transport routes, or port closures due to intense tropical storms, can interrupt critical supply chains including aviation and ground transport fuels, food and beverage services and other logistics. This can lead to flight schedule disruptions, reduced service quality for passengers and airlines and customer dissatisfaction.

Drainage networks

Drainage systems can be overwhelmed during heavy rainfall events or blocked by debris, leading to surface flooding. This can disrupt access routes, affect runway usability, and cause water damage to airport infrastructure.

Water supply

Droughts, sea level rise, heatwaves and changing precipitation patterns affect water availability and quality. Airports may face restrictions on non-essential potable water use, or may face an increased need for desalination, impacting operational costs and maintenance of land and infrastructure assets.

Baggage handling

Baggage sensors can have high sensitivity to heat. Where mechanical cooling is not available, this may cause damage or failure of sensors and lead to operational disruptions.

Navigational equipment and radars

Aircraft navigational equipment and radars are sensitive to heat, particularly where these are exposed to direct sunlight during daylight hours. The failure of these systems can cause elevated safety concerns, ground delays and the potential for diversion of flights to other airports.

Workforce and passengers

Airport staff, contractors, suppliers and passengers are all exposed to the impacts of extreme weather, making health and safety considerations critical. People can be physically injured as a result of climate hazards like flooding, or snow and ice conditions, or may suffer heat or respiratory illnesses due to high temperatures or nearby wildfires.

ICT and communications

These systems rely on secure and reliable access to power. Extreme heat or storm conditions can lead to power outages, or damage radios and sensors on the airport site, which can result in system shutdowns, loss of real-time communication and cascading delays or cancellations.

Figure 7 Components of an airport that may be vulnerable to climate-related impacts

Climate-related risks applicable to airports

This section outlines examples of climate risks by hazard to help airport operators identify potential or previously experienced impacts.

Airport operators are encouraged to revisit this section of the Guideline when using the **Climate Risk Assessment Tool**, to help identify a broad array of potential climate-related physical risks. Example risk statements are also provided within the Tool itself. Airport operators can review this list within the Tool and determine which are applicable, based on airport location (and exposure to particular hazards) and the airport's operations.

- **Extreme rainfall and flood [pluvial and riverine] events**: flooding of terminal basement equipment rooms; inundation of runways and ground infrastructure, damage to drainage infrastructure; localised ponding; increased risk of hydroplaning; pollution control failures; temporary or permanent closure of coastal or river airports; water contamination risk; road closures; access and egress issues for staff and passengers; injuries or fatalities; flight delays and cancellations; flight diversions from other airports; baggage delays; elevated insurance costs.
- **Storms and high wind events:** structural damage to buildings, signage, lighting, communications and electrical systems; increased bird strikes due to displaced wildlife; flight delays; injuries or fatalities; increased maintenance; additional emergency planning and response requirements; increased foreign object debris; lightning strikes; airport closures; public transport delays and stranded passengers.
- **Snow, ice, and extreme cold:** Increased de-icing and snow removal needs; snow accumulation affecting aircraft turnaround times; Increased maintenance costs; Cold-related health risks for staff and passengers; exposure to extreme cold during boarding/deplaning; changes to routine maintenance; delays and cancellations due to snow or ice buildup.
- **Sea level rise**: seawater damage; partial or permanent inundation of airport infrastructure or ground transport links; corrosion to underground utilities in coastal airports; rising ground water tables damaging infrastructure; greater risk of storm surge inundation due to sea level rise; potential closure of coastal airports; erosion and loss of land near infrastructure; groundwater contamination from saltwater intrusion.
- **Extreme heat:** accelerated aging of assets; increased demand on HVAC systems; heat-related illnesses among staff and passengers; increased energy and water consumption; passenger discomfort; runway and taxiway surface deterioration or deformation; runway closures; reduced operational efficiency due to heat.
- **Wildfires:** reduced visibility due to smoke; flight delays or cancellations; closure of runways or airports due to fire activity; damage to infrastructure from heat or flames; disruption of power supply and communication; evacuation of staff and passengers; reduced air quality; health risks to staff and passengers; access and egress issues; ash and debris accumulation resulting in maintenance requirements; reduced operational efficiency; increased need for advanced navigation and landing systems; traffic accidents and delays; flight diversions from other airports.
- **Rising average temperatures:** heat damage on airport surfaces; take-off weight restrictions and resulting changes to runway length; impact on ground operations; changes to maintenance requirements.
- **Desertification:** increased risk of soil erosion; dust or sandstorms disrupting operations, increased maintenance requirements; increased wear and tear on ground support equipment and infrastructure, soil instability around runways and foundations, changes to wildlife distribution.
- **Drought:** increased dust and impacts on aircraft lifespan; increased maintenance requirements; vegetation dieback; water shortages; dependency on groundwater; changes to bird distribution.

Box 2 presents a Case Study from Sydney Kingsford Smith Airport that describes impacts the airport experiences from strong south and westerly winds that generate windshear and turbulence.

Box 2 Case Study - Sydney Kingsford Smith Airport

Sydney Kingsford Smith Airport – Windshear	
Hazard:	Changing wind patterns
Outcome:	Softening and rutting of runway asphalt, unsafe working conditions
Impact:	Increased maintenance requirements, health and safety concerns

Sydney Kingsford Smith Airport (SYD) is the busiest airport in Oceania and serves as a major hub for Qantas, Virgin Australia, and Jetstar. SYD is regularly exposed to strong south and westerly winds that generate windshear and turbulence, particularly during aircraft approach and departure phases. Windshear—defined as a sudden and sustained shift in wind speed or direction—can alter headwind or tailwind conditions, causing aircraft to deviate from their intended flight path. These effects pose a significant safety risk, especially at low altitudes.

A prominent local weather event is the Southerly Buster—a fast-moving cold front that can rapidly shift wind direction by up to 180 degrees. It brings sharp temperature drops, thunderstorms, strong gusts, and frequent windshear. Operationally, it often necessitates sudden runway reconfigurations, leading to delays of up to ten aircraft during the transition. To monitor and manage these hazards, SYD operates a Low-Level Windshear Alerting System (LLWAS) supported by two Light Detection and Ranging (LiDAR) units. These sensors measure headwind profiles along final approach paths in real time. One unit is positioned at the threshold of Runway 34R, and the other near the intersection of Runways 07/25 and 16R/34L, ensuring coverage of all active runways. The LLWAS detects significant changes in headwind conditions within a 3-nautical-mile radius and issues automated alerts to air traffic control and pilots.

While LiDAR is effective in detecting windshear under clear atmospheric conditions, its range is limited during periods of rain or low cloud. To complement its in-house systems, SYD also receives forecasts and warnings from the Bureau of Meteorology, including observed or expected windshear, SIGMETs for turbulence, and real-time pilot reports relayed by air traffic controllers. Alerts are communicated to aircrafts by the ATC and through the Automatic Terminal Information Service (ATIS). Together, these detection and communication systems help SYD maintain operational safety and disruption during adverse wind conditions.

Box 3 presents a Case Study from King Khalid International Airport that describes impacts the airport experiences from dust and sandstorms that arise as a result of desertification and storms.

Box 3 Case Study - King Khalid International Airport

King Khalid International Airport – Dust and sandstorms	
Hazard:	Desertification and storms leading to dust and sandstorms
Outcome:	Reduction in visibility and take-off/landing concerns
Impact:	Flight delays, cancellations and diversions to other airports

King Khalid International Airport (RUH) is a major international gateway located approximately 35 kilometres north of Riyadh, Saudi Arabia. King Khalid International Airport in Riyadh is frequently affected by dust and sandstorms, which are especially common during the spring months. These storms significantly reduce visibility, often forcing delays, cancellations, and diversions of flights to other airports such as King Fahd International in Dammam or King Abdulaziz International in Jeddah. The rapid onset and intensity of these storms pose substantial safety risks for aircraft during take-off and landing, as well as logistical challenges for airport operations.

Beyond operational impacts, dust storms also present serious health risks. Fine particulate matter in the air can trigger respiratory issues among passengers and airport staff, sometimes resulting in an increase in medical incidents during storm events. To address this, the airport deploys dedicated medical response teams and distributes protective masks as part of its health and safety protocols.

In response to these recurring hazards, RUH employs a combination of early-warning systems and real-time air quality monitoring. The Polludrone system, an advanced sensor network, monitors environmental conditions and pollutant levels, providing actionable data that supports operational decisions.

The airport also prioritizes passenger communication during these events, issuing timely updates through digital displays, announcements, and social media platforms. These efforts aim to reduce passenger confusion and maintain trust during weather-related disruptions.

To limit the effects of dust infiltration, airport buildings are designed with sealed windows and doors, complemented by high-efficiency air filtration systems. Indoor spaces are maintained through increased cleaning frequency, particularly after storm events. During any ongoing construction or renovation, physical barriers are installed to contain dust and prevent its spread into public and operational areas. Additionally, runway and taxiway surfaces are regularly cleared of accumulated dust and sand to ensure safe and continuous airside operations.

Climate Change Risk Assessment Process

The climate change risk assessment process is the heart of this Guideline, written in a structured, practical and actionable manner to support airport operators to conduct their own assessment.

The climate change risk assessment process developed for this Guideline has been informed by the review of numerous aviation and non-aviation climate change assessment frameworks and other guidance documents. The process and underpinning tasks are broadly consistent with international standards on climate change, including ISO 14091:2021 *Adaptation to climate change – guidelines on vulnerability, impacts and risk assessments*, and aviation guidance issued by the International Civil Aviation Organisation (ICAO).

The process has also been shaped by practical feedback and validation from a selection of representatives of ACI APAC & MID's airport members. This ensures the process reflects both the latest climate risk thinking and the operational realities of airports across the region.

The process follows four key steps, with core tasks under each of these steps: **Establish the context**, **Identify, analyse and evaluate risks**, **Develop and implement adaptation measures**, and **Monitor, review and report**. These four steps and core tasks are visually illustrated in Figure 8.

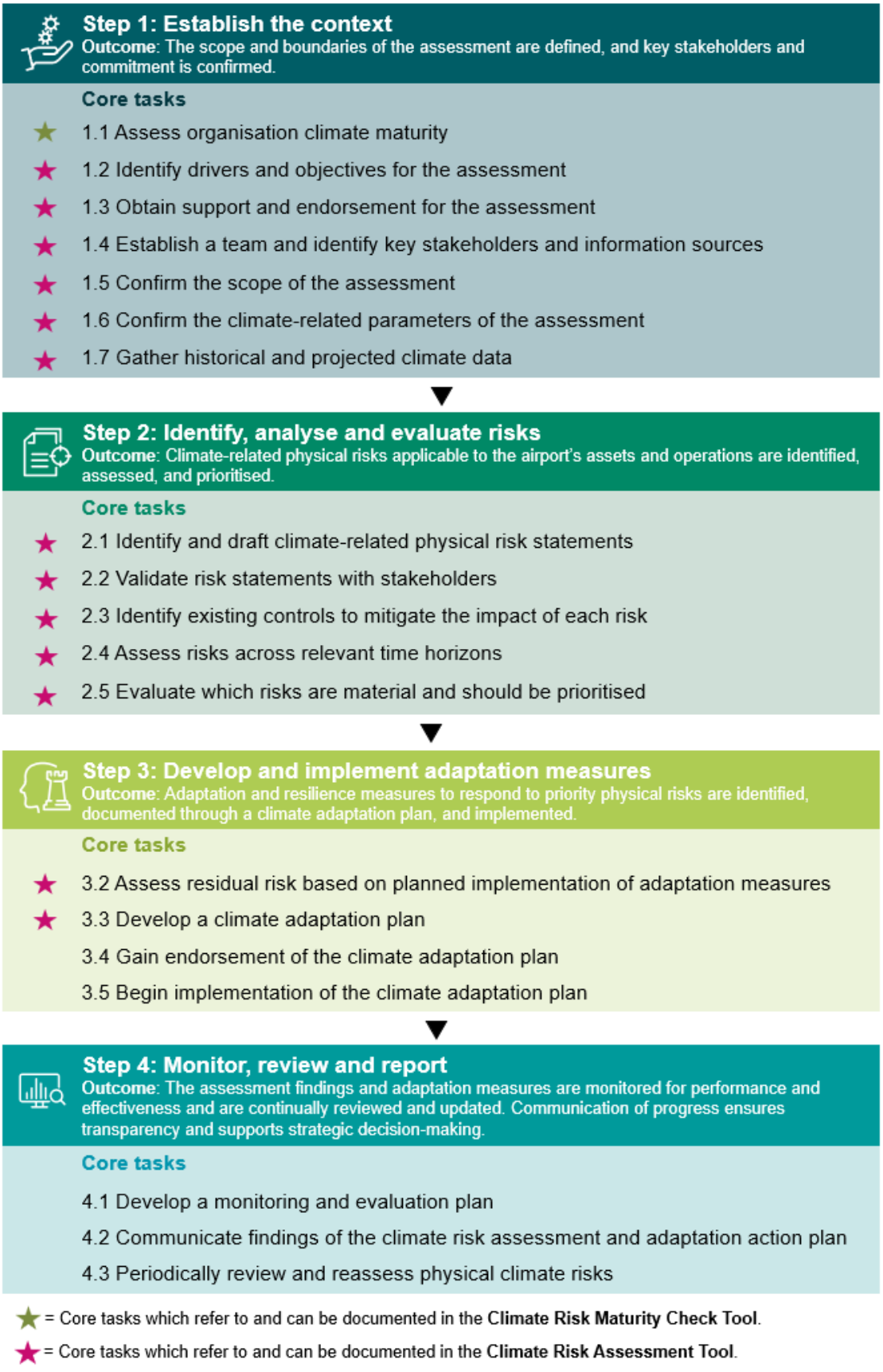


Figure 8 Visual illustration of each step of the methodology

Step 1: Establish the context

Purpose of this Step

To define the scope, parameters, and governance of the climate change risk assessment. This ensures that the assessment is purpose-driven, aligned with internal priorities, and supported by leadership and stakeholders.

Expected outcome

The scope and boundaries of the assessment are defined, and key stakeholders and commitment is confirmed.

Task summary

	Task	Output
1.1	Assess organisational climate maturity	☐ Completion of **Climate Risk Maturity Check Tool** ☐ Understanding of organisational readiness
1.2	Identify drivers and objectives for the assessment	☐ Clear documentation of assessment drivers ☐ Defined assessment objectives
1.3	Obtain support and endorsement for the assessment	☐ Formal leadership endorsement
1.4	Establish a team and identify key stakeholders and information sources	☐ Documented roles and responsibilities of project team ☐ Identification of key stakeholders for engagement ☐ List of information sources to be used in the assessment
1.5	Confirm the scope of the assessment	☐ Confirmed physical boundary ☐ Confirmed operational boundary ☐ Confirmed temporal boundary
1.6	Confirm the climate-related parameters of the assessment	☐ Selection of climate scenarios ☐ Selection of time horizons ☐ Selection of climate hazards
1.7	Gather historical and projected climate data	☐ Understanding of past climate including long-term averages and past extreme weather events ☐ Sourced climate projection data across the selected climate scenarios, time horizons and climate hazards where available

The **Climate Risk Assessment Tool** offers a place to document the initial content of your assessment, including responses to the core tasks 1.2 to 1.7 under *Step 1 Establish the context*. Refer to the tab within Tool titled ‘Step 1a. Assessment Details’ to fill in relevant responses to this and other core tasks under Step 1.

Core task

1.1 Assess organisational climate maturity

A **Climate Risk Maturity Check Tool** has been developed as part of this Study to help airport operators understand their current level of readiness and capacity to respond to climate-related risks. The Tool seeks airport operators to respond to a set of questions that reveal existing governance structures, risk management and adaptation practices, as well as monitoring and reporting mechanisms, along growing levels of maturity.

It is recommended to complete the **Climate Risk Maturity Check Tool** prior to commencing a climate change risk assessment as it provides insight on areas of strength that can be leveraged for the assessment, or areas for improvement. This may include the presence or absence of relevant policies, roles and responsibilities governing climate change risk management, past studies or investigations on climate-related impacts and internal skills and experience.

It is recommended to apply the Tool to one airport only, so the results are indicative of maturity at the airport level. For operators who manage multiple airports, one Tool should be completed for each airport. Results may then be aggregated to provide regional or organisational insights. Where an airport is part of a larger multi-asset or multi-airport organisation with enterprise-wide policies, strategies or assessments relating to climate risk, these may be considered in the assessment, where those documents are actively used in the management of the airport.

It is also important to note that maturity determined through the Tool represents a point in time; efforts to better understand, evaluate and respond to climate-related risks will support an improved maturity over time. There is equally an opportunity to use the Tool as a mechanism of evaluating how maturity changes between two points in time.

Access the **Climate Risk Maturity Check Tool** to complete the questionnaire and determine your airport organisation's overall maturity level. Using this Guideline, it is anticipated that airport operators would reach a maturity level of **Developing**.

It is recommended to complete the **Climate Risk Maturity Check Tool** with other internal stakeholders within the airport organisation, so that a diversity of experience and knowledge can be shared, and a comprehensive and representative output is delivered. Stakeholders should include representatives from climate change or sustainability, risk, property and asset management and both airside and landside operations. Refer to the **Climate Risk Maturity Check Tool** Supporting Guidance for further information.

Core task

1.2 Identify drivers and objectives for the assessment

As climate change can cause largescale and systemic impacts, it is important to engage in preventative actions to minimise long-term costs. As such, conducting a climate change risk assessment helps to identify potential risks and associated adaptation measures. Climate change risk assessments may be triggered or driven by regulatory requirements, executive direction, or recent events that generated adverse outcomes (e.g. significant asset damage or operational disruption, or reputational damage from a recent incident). It is helpful to note down what is driving the need for the assessment prior to beginning, as this offers a point of reference that stakeholders can come back to, making sure they are addressing this need.

After the drivers are identified, it is helpful to document the objectives of the assessment – what is intended to be achieved and delivered. This may be done by consulting with various internal stakeholders or groups. Objectives can outline both outputs and outcomes, for example:

- Output: a climate change risk register is developed outlining all climate-related physical risks that could impact the airport.
- Outcome: there is greater awareness and understanding of climate change concepts and risks across operational and executive teams.
- Output: a comprehensive list of adaptation options is developed for further assessment and prioritisation.
- Outcome: there is improved integration of climate-related risks within operational and asset maintenance decisions.
- Output: a climate change report is developed for internal or external communications.

To begin using the **Climate Risk Assessment Tool,** you are required to select your country and airport within the Tool's tab titled 'Step 1a. Assessment Details' to access relevant climate projections applicable to your location. Listed airports are based on ACI APAC & MID's membership base as at Nov 2025. If your airport isn't listed, select one that is geographically close by to access representative climate projections, and note your actual airport name and IATA code in Section F on this Tab.

Core task

1.3 Obtain support and endorsement for the assessment

Regardless of the driver of the assessment, formal endorsement from senior leadership should be sought before starting the assessment. Leadership support enables appropriate resources to be allocated so the assessment can be completed in a comprehensive way. Seeking this endorsement can be done through existing approval mechanisms and channels established within your organisation, for example documenting a business case for the climate change risk assessment, noting resources and program required, and expected outcomes and benefits. Once secured, this support should be communicated across the organisation, along with a clear explanation of the rationale for undertaking the assessment and any preliminary information about how internal stakeholders may be involved.

Core task

1.4 Establish a team and identify key stakeholders and information sources

Once the climate change risk assessment has been approved as a project, establishing a team with roles and responsibilities is the next task. This should include a central coordinator or project manager to lead the assessment, supported by an executive champion to sponsor and potentially review outputs (e.g. the project approver from Step 1.3), as well as a broader team of internal stakeholders. Climate change is a systemic challenge and requires the input of representatives across disciplines, functions and levels of an organisation.

Roles and responsibilities could be documented in a charter or Terms of Reference document. Below are some example responsibilities which may be considered for your own assessment:

Role	Responsibility
Project manager	Leads the assessment, coordinates various assessment activities and is central contact point for the project within the organisation. Ideally should have some experience or background in climate risk management or be familiar with core climate change concepts.
Executive champion/endorser	Supports the project manager to communicate and advocate for the assessment and helps with internal approvals. Can also be a reviewer of assessment findings, subject to skillset and experience.
Core assessment team	Small group of internal stakeholders (e.g. 2-4) who assist the project manager by gathering relevant data, completing preliminary analysis, and preparing for stakeholder workshops as part of the assessment.
Consulted internal stakeholder	Representatives from diverse operational areas and functions who participate in stakeholder workshops and offer their technical insight and experience to identify and assess climate-related risks and adaptation measures. Functions may include: • Airport planning • Policy and government relations • Strategy • Risk • Airport operations • Asset management • Commercial and property • Finance • Emergency or crisis management • Project leads for distinct/largescale projects (e.g. new runways or terminals) • Health and safety • IT and telecommunications • Stakeholder relations • Indigenous engagement • Environmental management • Sustainability
Experienced advisor	If the project manager does not have a climate change risk background, the organisation may opt to include an experienced advisor from within or outside of the organisation who can provide technical guidance and advice throughout the assessment. The advisor should possess strong climate change technical experience to guide the assessment and review key outputs and decisions. The advisor may be from a peer organisation, an industry group or an external consultant with a climate resilience advisory background.

A climate change risk assessment is best conducted as an inclusive and collaborative process. When identifying relevant stakeholders, it is useful to consider diversity of perspectives and experience, representativeness, relevant expertise, ability to influence the process, and proximity to potential risks. Staff with a sound knowledge of the local area, environmental conditions, assets and operations, and risk assessment methodology are best suited to be involved.

Information sources that may be relevant to the assessment also need to be gathered. In particular, information that provides the following will be useful:

- Records of how the airport has been impacted by climate hazards in the past
- Information on the current condition and performance of the airport, to understand what it can withstand as well as areas of sensitivity
- Information that reveals how the airport currently controls or reduces risk, whether through hard infrastructure measures, operational procedures, protective devices, warning systems and so on.

This information may typically be sourced from incident reports, asset management plans and condition assessments, policies, operational manuals and procedures and emergency response plans.

As you gather information sources, consider how the outputs of the climate change risk assessment will feed back into those policies, procedures and plans. This may include the incorporation of climate-related risks within existing risk registers, or consideration of climate-related risks as part of capital investment business cases or introducing a section on climate change as part of your airport master plan. Thinking early about the opportunities and obstacles to climate risk integration will help further down the road as you look to embed climate resilience into broader decision-making.

Core task

1.5 Confirm the scope of the assessment

The scope of the assessment includes documenting what will be included in the assessment, based on the objectives you are trying to achieve. A well-defined scope supports effective resource allocation and helps manage stakeholder expectations, and should include consideration of the following:

- **The physical boundary of the assessment**. It is recommended that airport operators begin with an airport-wide assessment, particularly if this is the first climate change risk assessment being conducted. This will produce a good baseline understanding of a variety of risks that could impact the airport's assets and operations.
- **The operational boundary of the assessment**. This is about what makes up the central activities of the airport, including interaction with passengers, suppliers and airport partners, operational systems and equipment in place to conduct those activities. It is recommended to once again take an airport-wide approach – consider what is within operational control and include both airside and landside activities. Where there is co-control or ownership, e.g. co-owned terminal buildings, engagement with other ownership parties may be required prior to starting the assessment, though ultimately it is desirable to include co-owned assets, particularly where they play a critical role in airport operations.
- **The temporal boundary of the assessment**. Consider the planning horizons typically used within the airport to make operational and strategic decisions and use this to inform the selection of timeframes against which the risk assessment will be conducted. Consider also the design life of critical assets, plant and equipment to see if time horizons match or align. This should include short-, medium- and long-term horizons – refer to Step 1.6 for further information.

Core task

1.6 Confirm the climate-related parameters of the assessment

As part of this task, airport operators are required to select various climate-related parameters that form part of the climate change risk assessment, including:

1. Climate scenarios: plausible futures that describe climate conditions under different levels of warming and associated greenhouse gas emissions concentrations.
2. Time horizons: the average time periods over which climate projected observations and calculations are modelled.
3. Climate hazards: the climate-related physical events or trends that may cause loss, disruption or some other adverse effect on the airport.

Recommendations for each of these parameters are made below, followed by a deeper look at climate scenario information.

For the selection of **climate scenarios**, it is recommended that a **high-warming scenario, such as SSP5-8.5** is adopted for the identification of physical risks. The high global warming scenario models a

higher temperature increase, which may produce more frequent and severe extreme weather events and climate variability, thus producing greater potential impact to airport infrastructure and communities.

Climate scenarios have evolved over time, from Representative Concentration Pathways (RCPs) to Shared Socioeconomic Pathways (SSPs). For additional information on **climate scenarios** refer to *Understanding climate scenarios and projections* under the additional resources section of this Guideline.

Airport operators may be directed or opt to use alternative climate scenarios. Climate modelling under different scenarios can be reviewed alongside a high-warming scenario to understand how projections change and diverge over time. There is no fixed rule on which scenario to use, though SSP5-8.5 provides airport operators with what is currently modelled as the 'worst-case scenario' regarding climate variability and extremes. This can be helpful for considering how high-impact events (e.g. severe floods or heatwaves) could impact the airport.

The **Climate Risk Assessment Tool** provides climate projection information under two scenarios – SSP2-4.5, a moderate warming scenario, and SSP5-8.5, a high warming scenario. These scenarios were selected to provide two sets of plausible modelled outputs for how climate variables may change over time and serve to support the identification of risks. Airport operators may opt to observe the more moderate warming scenario, or a different scenario altogether, when evaluating and selection adaptation measures, if SSP5-8.5 is considered too elevated in terms of projected warming.

For the selection of **time horizons**, it is recommended to adopt three horizons that align appropriately with the airport's existing planning horizons. While these may differ slightly across airports, proposed timeframes are as follows:

- **Short-term horizon: within the next 5-10 years**. This typically correlates with corporate or strategic plans and associated forecasting and also takes account of the duration of airline partner agreements. The short-term horizon would observe climate projection data under the **2030 timescale** (averaged over the 20-year period 2021-2040).
- **Medium-term horizon: within the next 20-30 years**. This typically correlates with the 20-year outlook of airport master plans and also accounts for the design life of some assets and materials like electrical equipment and pavements. The medium-term horizon would observe climate projection data under the **2050 timescale** (averaged over the 20-year period 2041-2060).
- **Long-term horizon: within the next 60-70 years**. This correlates to what is typically the furthest currently available climate projection timescale and also accounts for the design life for longer-lived assets. The long-term horizon would observe climate projection data under the **2090 timescale** (averaged over the 20-year period 2081-2100).

For the selection of **climate hazards**, it is recommended to review the existing list of climate hazards provided in the Climate Risk Assessment Tool (and described in this Guideline in *Climate hazards covered by this Guideline*). Consider both historical events and previous impacts to the airport alongside climate projection data, to determine which hazards could affect the airport in the future.

The **Climate Risk Assessment Tool** requires airport operators to note down if any previous climate-related events occurred at the airport and describe any impacts. Once complete, airport operators can select which climate hazard is relevant for their airport, based on review of historical climate data and trends of projected data. Those relevant climate hazards should then be considered when identifying risks in *Step 2: Identify, analyse and evaluate risks*.

Core task

1.7 Gather historical and projected climate data

A complete climate change risk assessment will consider historical climate data and projected climate data. Historical data should be sourced to determine the long-term average for each climate variable, as well as any instances of past extreme events, particularly those that impacted the airport. Climate projection data is available in the **Climate Risk Assessment Tool**, sourced from the IPCC WGI Interactive Atlas. This data has been downloaded at approximately 150×150 km grids and geolocated with airport coordinates to bring up relevant projection data based on the airport selected within the Tool.

For detailed analysis of sites and assets, the use of impact studies such as flood modelling are usually required to assess the consequences of extreme events or accelerated degradation of assets over time. These impact studies need to use climate change data as selected in the steps above to inform their results. The results from inundation and erosion impact studies for storm surge events influenced by sea level rise and combined with impacts of increased extreme rainfall events is necessary for detailed climate change risk assessments along the coast. Box 4 presents a Case Study from Hong Kong International Airport on how seawall and drainage studies helped manage flood risk at the airport.

Box 4 Case Study - Hong Kong International Airport

Hong Kong International Airport – Managing flood risks through seawall and drainage studies

Hazard:	Flooding, typhoons and storm surges
Outcome:	Drainage systems overcapacity, airport inundation
Impact:	Increased maintenance requirements, capital costs

Hong Kong International Airport (HKIA) has taken significant steps to enhance its flood resilience, particularly by conducting various flood-related studies which consider future climate change. The airport, situated on Lantau Island in western Hong Kong and inaugurated in 1998, stands as one of the world's busiest cargo gateways and passenger airports, facilitating millions of travellers annually and serving as a crucial link between continents.

Given its location on reclaimed land near the sea and its flat and low-lying elevation, HKIA faces various flood risks, especially during extreme weather events such as typhoons and heavy rainfall. The airport, however, was designed with modern and robust drainage infrastructure to ensure the sustained continuous operation of airside and landside facilities. The system, designed to manage substantial rainfall and prevent flooding, comprises an extensive network of stormwater drains and culverts.

Given that HKIA is a coastal airport exposed to extreme weather events such as typhoons and storm surges, AAHK commissioned two studies – a seawall study and an airport-wide drainage review. These studies were conducted in conjunction with the Climate Resilience Study to identify and assess flood risks associated with key assets at HKIA.

Back in 2020/21, both studies considered a range of climate scenarios over multiple timeframes (2030, 2050 and 2100), including the IPCC AR5's most extreme scenario RCP 8.5 (95th percentile), as well as the H++ scenario to provide an even more conservative rate of sea level rise, which was used as a sensitivity analysis for critical assets.

The seawall study assessed extreme water levels and extreme wave conditions along the perimeter of the airport for various future climate change projections. It considered extensive data analyses and involved numerical modelling of hydrodynamics and waves, including typhoon simulations.

The output of the seawall study, specifically the overtopping values, were fed into the drainage study, which compared the airport-wide drainage system capability under normal circumstances and in extreme weather events, including sea level rise, tidal surges, typhoons and heavy rainfall.

In 2023/24, a review of the modelling was conducted using the latest climate projections from IPCC AR6 SSP5-8.5 low confidence scenario (83rd percentile) and downscaled data from HKO. This review also incorporated the latest land use information at HKIA to assess the risk of flooding. The studies concluded that HKIA is well-protected from flooding with the existing sea wall and drainage system under the IPCC-tested scenarios at least until mid-century and operational at the end of the century with adaptation measures in place.

Climate projection data featured in the **Climate Risk Assessment Tool** covers a broad range of climate indices or data points characterising either long-term average changes in the climate system, regional trends or extreme, episodic events. This data is provided as a basis for understanding exposure to potential climate hazards. Airport operators are encouraged to review and consider any additional climate data which may provide more granular modelling, as well as considering other variables which provide insight on low likelihood, high impact events (i.e. data indicating climate extremes).

For example, understanding extreme climate indices for precipitation can provide an airport with an indication of the volume of water that would need to be managed by drainage networks under an intense event. This can reveal areas of sensitivity to certain hazards, particularly where existing systems have not had to withstand such significant potential impacts in the past.

At the end of Step 1 you will have:

- ✓ Completed the **Climate Risk Maturity Check Tool** to understand the climate risk management maturity of your airport
- ✓ Identified and documented the drivers and objectives of the assessment
- ✓ Obtained formal leadership endorsement for the assessment
- ✓ Established a project team with documented roles and responsibilities, identified key stakeholders for engagement and listed information sources to support the assessment
- ✓ Confirmed the physical, operational and temporal boundaries of the assessment
- ✓ Confirmed the climate scenarios, time horizons and climate hazards to be used in the assessment
- ✓ Sourced historical and projected climate data

Step 2: Identify, analyse and evaluate risks

Purpose of this Step

To determine which climate-related physical risks are relevant to the airport, assess their significance, and prioritise them for action.

Expected outcome

Climate-related physical risks applicable to the airport's assets and operations are identified, assessed, and prioritised.

Task summary

	Task	Output
2.1	Identify and draft climate-related physical risk statements	☐ Climate-related risks drafted in a consistent manner and captured in **Climate Risk Assessment Tool**
2.2	Validate risk statements with stakeholders	☐ Climate-related risks captured in the **Climate Risk Assessment Tool** are reviewed, updated and validated by internal stakeholders
2.3	Identify existing controls to mitigate the impact of each risk	☐ Existing controls documented against climate-related risks in the **Climate Risk Assessment Tool**
2.4	Assess risks across relevant time horizons	☐ Risk ratings determined for all risks across short-, medium- and long-term horizons in the **Climate Risk Assessment Tool**
2.5	Evaluate which risks are material and should be prioritised	☐ List of priority climate-related risks established referencing the outputs of the **Climate Risk Assessment Tool**

Core task

2.1 Identify and draft climate-related physical risk statements

Identifying climate risks comprises identifying the source of the risk, the event/s that could trigger the risk, and potential impacts to your airport. Risks should be documented in a way that is transparent and easy for others to understand, even if they were not involved in the risk assessment process and should state any assumptions or clarifications underpinning the risks identified. To generate meaningful and context-specific risk statements, consider the following points of reference:

- **Past climate-related events** at your airport (e.g., flooding, extreme heat, wind damage).
- **Known vulnerabilities** in airport assets, infrastructure or operations—especially areas where failure would significantly disrupt safety, continuity, or service (e.g., access roads, baggage handling, runway surfaces).
- **Limited existing capacity or resilience** of critical systems—what would happen if these failed or degraded under climate stress?
- **Impacts experienced by other airports**—ask whether similar risks could reasonably affect your airport given shared exposure, design or geography.

It is not uncommon to find that weather-related risks have already been identified by the organisation under existing risk categories (such as work health and safety, or compliance). Conduct a review of the airport's existing enterprise or operational risk registers and associated documentation to identify any climate-related risks already recorded. These may include risks linked to extreme weather events (e.g. flooding, storms, heatwaves), chronic climate stressors (e.g. sea level rise, temperature increases), or secondary impacts (e.g. supply chain disruption, energy reliability, insurance costs).

Risks may be identified that impact multiple assets or airport-wide operations. In this case, firstly identify the primary asset, or the asset most affected by the identified risk. For this asset, identify the consequence of the risk occurring that is likely to render the greatest adverse impact. If other significant consequences are identified, repeat the risk statement articulating those additional adverse impacts. If other assets may be affected by the same risk, repeat the risk statement with reference to the other assets and adjust the risk description to specifically define the outcome and impact for each asset.

Documenting risks in **Climate Risk Assessment Tool** comprises the risk statement (description) and selection of relevant climate hazard(s), the primary asset affected and the consequence category. The consequence category helps to group risks according to the resultant impact of the risk. A drop-down list is available, based on consequence categories contained in AS 5334:2013 *Climate change adaptation for settlements and infrastructure.* These include:

- Adaptive capacity: ability of the infrastructure/asset to adapt and cope with climate variability.
- Infrastructure: damage and degradation of the asset or need for early renewal
- Service provision: ability to continue delivering service and functional performance
- People: impacts to health and safety of staff or travellers or broader community
- Regulatory: ability to meet regulatory requirements, governance arrangements
- Financial: impacts to revenue, expenditures, capital or loans and asset value
- Environmental: impacts to local and surrounding natural environment
- Economic: impacts to local or regional economic performance and development.

When identifying risks, you may encounter scenarios where one risk sets off a chain of secondary effects beyond the initial event. Alternatively, there may be possible scenarios where multiple hazards or stressors occur together or in quick succession, amplifying the disruption of identified risks. These are considered cascading and compounding impacts and can occur in highly interconnected and time-critical systems such as airports. More information on identifying compounding and cascading impacts is available in *Identifying compounding, cascading and aggregate impacts*

Refer to additional information provided under the Additional Resources section of this Guideline, which provide definition and examples of climate risks including compounding, cascading and aggregate impacts. It may be useful to develop risk impact chains, that visually show the relationship between a hazard, outcome and impact (refer Figure 5 of this Guideline), to increase the understanding and capability of airport stakeholders to identify relevant risks.

Document risk statements within the **Climate Risk Assessment Tool,** including any existing risks identified through review of enterprise and operational risk registers. Review these against the pre-identified list of risks provided within the Tool and edit, refine and consolidate into a final list of potential risks for stakeholder review (as part of Step 2.2). The Tool also provides the ability to identify the primary asset affected and type of impact that may be generated for each risk. This is based on a pre-generated drop-down list of typical airport assets and impacts and can help airports to then identify which assets may be most impacted and the nature of that impact.

Core task

2.2 Validate risk statements with stakeholders

Engage relevant internal stakeholders across key airport functions (such as those identified in Task 1.4) to review and validate the climate-related risk statements developed in Step 2.1. This engagement may take the form of an inter-disciplinary workshop, directed interviews or a collaborative discussion. Facilitate structured discussions to assess the relevance and accuracy of each risk in the context of actual operational conditions and asset performance and potential vulnerabilities. Identify any risks that may have been overlooked or require reframing to align with operational realities or internal risk appetite.

Stakeholder engagement is strongly encouraged to make sure climate-related risks are accurate and representative. Reviewing and validating risks with a diverse set of stakeholders avoids a siloed approach to the assessment and strengthens the credibility and operational relevance of the climate change risk assessment. It also promotes cross-departmental buy-in and lays the foundation for collaborative adaptation planning and resource allocation.

Box 5 presents a Case Study of Singapore Changi Airport, where workshops and other stakeholder collaboration was integral to the identification and mapping of climate-related risks.

Box 5 Case Study - Singapore Changi Airport

Singapore Changi Airport – Airside operational disruption	
Hazard:	Extreme heat
Outcome:	Softening and rutting of runway asphalt, unsafe working conditions
Impact:	Increased maintenance requirements, health and safety concerns

Singapore's Changi Airport is in the Changi district at the eastern end of Singapore, approximately 24 kilometres (15 miles) east of Singapore's Downtown Core. In May 2024, Singapore recorded its highest temperature of 37 degree Celsius in the last 40 years. The Meteorological Service Singapore has also said there is a 70 to 80 percent chance of an El Nino event occurring, which will bring hotter and drier weather. Rising ambient temperatures can pose risks to airport runway conditions and staff working on the airside.

From the period of November 2020 to March 2022, Netherlands Airport Consultants was tasked with helping Changi with their climate adaptation journey. First, a climate scenario modelling was conducted to understand potential climate changes in the airport's vicinity. By combining operational data with weather information from the Meteorological Service Singapore and the Centre for Climate Research Singapore, potential future operational challenges due to climate change were identified. Next, stakeholders were engaged in IPCC WGI Interactive Atlas (CAG)'s climate resilience efforts through workshops to map climate risks. Together with airport stakeholders, the potential impact of disruptive events was assessed and how a single disruption could affect multiple assets and operations was identified. Using the digital tool STAIN, the cascading effects were identified and highlighted the interconnected nature of airport operations. After identifying key risks, CAG collaborated closely with stakeholders to develop measures to mitigate these risks and enhance airport resilience, addressing infrastructure, procedures, and guidelines. The result of this process was a Climate Adaptation Pathway, detailing how Changi Airport can become more resilient to climate change and potential risks in terms of sea level rise, erratic wind patterns and rainfall events, lighting strikes, extreme heat stress, reduced visibility and wildlife. The pathway lays out what steps the airport can take today, in 2030 – and what can be achieved by 2050.

CAG's Engineering and Development (E&D) Cluster collaborated with technical experts to enhance pavement resilience against harsher weather conditions. This involved improving the asphaltic mix design and continuing the use of polymer additives to ensure higher runway durability, even under high temperatures. To address the combined effects of rising temperatures and the increasing frequency of tropical storms, CAG introduced a Laser Crack Measurement System (LCMS) to enhance aircraft pavement maintenance. This system uses lasers and sensors to survey runway conditions, even in complete darkness during nighttime runway closures. With the projected increase in rainfall intensity, CAG has also grooved the asphaltic pavements of all three runways at Changi Airport. This reduces the danger of aquaplaning and runway excursions on wet surfaces during thunderstorm events.

Further, to ensure good working conditions for its 30,000 staff working on the tarmac, Changi placed ‘refresh pods’ on the airside. Two cooling devices were recently installed as part of CAG’s new measures to reduce the risk of heat injuries among workers. These pods circulate cool air for approximately 3½ minutes each time, using ultraviolet-light sterilization to clean the air. Each pod stands 2.5 meters high, can accommodate up to five workers simultaneously, and operates throughout the day.

Core task

2.3 Identify existing controls to mitigate the impact of each risk

Referring to information sources identified in Step 1.4, this task requires a review of operational and asset procedures, plans or other documentation to identify existing controls that are in place and could help reduce the probability or potential impact of each risk. These controls may include physical infrastructure (e.g. flood barriers, improved drainage, heat-resistant materials), operational procedures (e.g. extreme weather protocols, maintenance schedules), planning and design standards (e.g. climate-resilient building codes), and management frameworks (e.g. business continuity plans, emergency response systems). Stakeholders supporting the review and validation of risk statements (in the preceding Step 2.2) may also help to identify those controls.

Use the **Climate Risk Assessment Tool** to identify existing controls for each risk identified in the assessment.

Core task

2.4 Assess risks across relevant time horizons

To determine which climate-related risks are of importance or concern for an airport, they must be assessed. A common risk-based approach is to determine the likelihood and consequence of each risk occurring, which then generates a rating based on an establish risk matrix.

Airport operators should review the list of climate-related risks and existing controls, then assess the likelihood and consequence of each risk across the applicable time horizons determined as part of core task 1.6. This allows airport operators to understand the profile of each risk over time and when the rating may increase, subject to the projected changes in climate change.

Assessment of climate-related risks within the **Climate Risk Assessment Tool** should consider the effect of changing climate conditions over time. Projections are provided within the Tool covering two climate scenarios, and it is recommended to observe projections under **SSP5-8.5** for the risk assessment (refer core task 1.6). Whichever climate scenario guides the assessment of risks, this should be recorded in the Tool under the tab 'Step 1a. Assessment Details' Section E for clarity.

For each identified risk and across each time horizon:

- Rate the **likelihood** of the risk occurring (e.g. from 'rare' to 'almost certain') in consideration of the effectiveness of current controls. For future time horizons, consideration should be given to the scale and direction of climate projections and how they may increase or decrease the likelihood of a risk occurring. Assessments of likelihood may be informed by quantitative modelling of hazards or statistical analysis (e.g. flood modelling of multiple AEP events), where these are available.
- Rate the **consequence**(s) of the risk occurring (e.g. from 'insignificant' to 'catastrophic') in consideration of the effectiveness of current controls. Consideration should be given to the potential for cascading impacts from a risk, which may lead to a higher consequence rating. More information on cascading impacts is available in *Additional components and interactions of climate-related risk*. For future timeframes, consideration should be given to the scale and direction of climate projections and whether they may increase or decrease the consequence of a risk occurring. Assessments of consequence may be informed by experience from past events, data on customer usage, penalties from failure to meet service agreements, and knowledge of asset replacement or repair costs.
- Determine the **risk rating** by combining the likelihood and consequence ratings using the risk matrix. This is automatically generated within the **Climate Risk Assessment Tool**.

Continue to use the **Climate Risk Assessment Tool** to document the likelihood and consequence of each risk identified for your airport. The Tool has an in-built risk matrix and likelihood and consequence descriptors, which have been adapted from risk assessment information contained in AS 5334:2013 *Climate change adaptation for settlements and infrastructure*. This Standard is referenced given its relevance specifically to climate change risk assessments, its alignment with risk assessment processes generally, and the availability of a specific example of descriptors that are relevant for infrastructure assets.

Airport operators are encouraged to review this risk matrix and descriptors and adjust details of the risk matrix to make it compatible and comparable to their enterprise risk framework. This will support a consistent approach to rating both climate-related and non-climate risks. The scale of likelihood and consequence, and specific descriptions of each scale, can be updated, as well as the allocation of low, medium, high and extreme risk ratings. Refer to the 'Risk matrix' tab within the **Climate Risk Assessment Tool**.

The risk rating calculated from this step will represent the **inherent risk rating**, i.e. the rating of the risk based on the existing operational environment and without consideration of any potential adaptation measures. Where risks have been brought in from existing risk registers, it may be useful to reconsider the existing risk rating to make sure it adequately captures any change to the likelihood or extent of impact, as a result of climate change. Figure 9 conveys an example of the assessment of likelihood and consequence for one risk, and the inherent risk ratings for 2030, 2050 and 2090.

Risk statement	2030			2050			2090		
	Likelihood	Consequence	Inherent Risk Rating	Likelihood	Consequence	Inherent Risk Rating	Likelihood	Consequence	Inherent Risk Rating
Extreme rainfall leads to inundation and overland flow across paved surfaces resulting in reduced access and egress for passengers entering the terminal	Possible	Moderate	Medium	Likely	Moderate	Medium	Likely	Major	High

Figure 9 Example of the assessment of likelihood and consequence, and inherent risk ratings across three timeframes

Stakeholder engagement is strongly encouraged during the assessment of climate-related risks, like when risks were initially identified and validated. Airport operators may choose to hold a single point of engagement with key stakeholders to validate risks, identify controls and assess risks all at once, or offer a staged engagement approach. Each have their advantages – the former allows for dedicated, focused attention on the climate change risk assessment process, while the latter can help to build capability by reinforcing key concepts over time. A staged approach also allows time for stakeholders to reflect on past discussions and make any necessary updates or changes to the assessment at the next point of contact.

Core task

2.6 Evaluate which risks are material and should be prioritised

Evaluation of risks involves identifying which risks are beyond risk appetite and therefore require some measure of treatment to reduce the inherent risk rating. This task involves reviewing inherent risk ratings and other assessment details to capture which risks should be prioritised for adaptation. Some factors to consider in this prioritisation exercise include:

- The inherent risk rating – priority should be given to risks rated as High or Extreme
- Assets connected to the risk – priority may be given to highly critical asset classes that, if disrupted, could have a significant impact on operations and delivery of services
- Type of impact connected to the risk – priority may be given to certain types of impact for which the airport operator has a very low risk tolerance (e.g. reputational loss, or health and safety impacts)
- The climate hazard(s) connected to the risk – airport operators may have recently experienced impacts associated with a particular hazard (e.g. significant flooding) and may wish to elevate those risks in readiness for future events

Airport operators should work collaboratively through an engagement process to capture the views of internal stakeholders about which risks should be prioritised.

Once again, **stakeholder engagement is strongly encouraged** as part of the evaluation task. The same set of stakeholders can be involved in a workshop discussion or set of interviews or smaller group discussions to confirm which climate-related risks should be prioritised for adaptation.

For airports who are undertaking a climate change risk assessment for the first time, it may also be useful to consider undergoing a **technical review of the completed assessment**, to ensure the information presented in the assessment is comprehensive, consistent and representative. This review would be done by a suitably qualified professional in the field of climate risk and adaptation, and could be an internal or external stakeholder.

Within the **Climate Risk Assessment Tool**, any risk that is rated as High or Extreme, across any time horizon, will automatically be identified as a priority for adaptation. This is reflected in the automated capture of those risks from the 'Risk Register' tab to the 'Adaptation Measures' tab.

Climate change can generate impacts that may be similar to those already described in existing operational risks for the airport, such as damage to assets, flight delays or disrupted access.

Once climate-related physical risks are identified, airports should consider how these risks can be integrated with existing operational or strategic risks, to recognise how climate-related events can alter the likelihood or consequence of these existing risks. Climate hazards may also be added as a causal factor to existing risks, for example those risks related to safety incidents and staff wellbeing. This integration could be presented as a consolidation of climate and operational risks into a single register, integrating individual climate-related risks into relevant departmental or asset registers where relevant, or rolling up priority climate-related risks into a strategic or enterprise-wide risk. Ultimately, risk integration is about recognising climate-related risks so they can be addressed alongside other risks at an appropriate scale and timeframe.

At the end of Step 2 you will have:

- ✓ Identified and drafted climate-related physical risks consistently and captured in the **Climate Risk Assessment Tool**
- ✓ Reviewed and validated risk statements with internal stakeholders
- ✓ Identified and documented existing controls against each risk
- ✓ Assessed each risk across short-, medium- and long-term time horizons
- ✓ A list of established priority climate-related physical risks

Step 3: Develop and implement adaptation measures

Purpose of this Step

To identify, evaluate and implement adaptation and resilience measures that respond to the airport's priority climate-related physical risks.

Expected outcome

Adaptation and resilience measures to respond to priority physical risks are identified, documented through a climate adaptation plan, and implemented.

Task summary

	Task	Output
3.1	Determine adaptation measures to address priority risks	☐ List of adaptation measures identified using the **Climate Risk Assessment Tool** ☐ Adaptation measures selected
3.2	Assess residual risk based on planned implementation of adaptation measures	☐ Residual risk ratings for priority climate-related risks are determined within the **Climate Risk Assessment Tool**
3.3	Develop a climate adaptation plan	☐ Climate adaptation plan documented
3.4	Gain endorsement of the climate adaptation plan	☐ Climate adaptation plan endorsed
3.5	Begin implementation of the climate adaptation plan	☐ Implementation of the climate adaptation plan begins

Core task

3.1 Determine adaptation measures to address priority risks

Adaptation measures are a suite of interventions that airports can undertake to further reduce the likelihood or consequence of climate-related risks occurring. These may include physical infrastructure upgrades, operational changes, new technologies, contingency measures and planning or capability, training and procedural measures.

It is important to think broadly and openly about potential measures, rather than placing boundaries on what could or should be included or excluded for consideration. Once an initial long list of adaptation measures is identified, there can be further refinement to select adaptation measures based on feasibility, cost and resourcing, or other criteria.

To identify these adaptation measures, it is highly recommended to **engage with a broad group of internal stakeholders**, including those who may already be managing some aspect or activity associated with the priority climate-related risks identified. Airport operators may opt to hold a large workshop for initial brainstorming of ideas, followed by subsequent small group discussions to refine and select adaptation measures.

The **Climate Risk Assessment Tool** offers a list of potential adaptation measures to get airport operators started in this Step. Adaptation measures can be identified for potential implementation in the short-, medium- or long-term, based on the inherent risk rating and how profile of the risk changes over time, as well as the anticipated capacity of the airport to implement certain measures. For example, major upgrades may not be undertaken in the short-term if financing is not available, so this may be selected as a medium-term measure. The timing of actions should coincide with the timeframes of the assessment – for example, if a risk becomes High in 2050 (mid term), appropriate actions should be identified in the early or mid term to reduce the risk to a tolerable level.

Some example adaptation measures are listed below in Table 1.

Table 1 Categories and examples of climate adaptation measures

Category	Description	Example
Infrastructure and buildings	Design changes and modifications to infrastructure and built environment that aim to increase the robustness or redundancy of key assets, infrastructure networks and equipment.	• Preliminary assessments to provide base case for subsequent infrastructure modifications e.g. drainage and hydrological assessments, wind shear studies • Raising minimum floor levels to reduce exposure to flooding/overland flow • Using impermeable pavements for stormwater management • Introducing passive or mechanical cooling systems to reduce heat-related impacts • Raising design standards to account for increased wind or fire ratings
Operational changes	Updates to policies and procedures that aim to minimise exposure or impact associated with climate-related events	• Hazard warning systems and triggers for storms, rainfall and high wind events to instigate alternative operational responses and flight planning • Increased inspection and maintenance of runways and taxiways to monitor for degradation

Category	Description	Example
		• Water conservation practices to manage during drought periods
Nature-based solutions and environmental adaptations	Measures which use and enhance the natural environment to provide hazard protection and other ecosystem services	• Installation or restoration of coastal ecosystems (e.g. mangroves and seagrass) to mitigate flooding and erosion impacts • Installation of green spaces and increasing tree canopy to reduce urban heat island effect
Energy and utility resilience	Developing options to protect and diversify how energy and other utilities are supplied and used on site	• Installation of renewable energy sources and battery storage • Rainwater capture and storage to minimise use of potable water
Insurance, finance and risk management	Measures that boost the resilience of financial mechanisms and investments on site	• Incorporate consideration of climate risk as part of business case for future investment • Communicate adaptation efforts with insurers to reduce premiums
People and safety	Measures that monitor and protect personnel wellbeing and health, and built capability	• Training exercises to prepare for extreme weather events • Adjustment of work schedules to avoid periods of the day with high exposure to adverse weather
Technology and research	Research, development and investment in new technologies to enhance adaptation efforts and minimise risk	• Improved wind assessment technology • Access to satellite data to improve accuracy of incoming weather systems to prepare for potential impacts
Community and stakeholder engagement	Efforts to collaborate and communicate with airport partners and community to improve overall resilience and share in the adaptation effort	• Develop communities of practice to share insights and findings with airport partners • Establish or reinforce partnerships with emergency responders and local authorities to coordinate disaster management efforts

Adaptation measures must be identified for all priority climate-related risks, though the triggers for selecting and implementing each measure are likely to differ across organisations. For airports, it is useful to consider:

- Short and long-term adaptation needs, including how adaptation actions influence master planning and anticipated site layouts.
- Design thresholds of assets and where adaptation measures can extend these thresholds, or where their effectiveness will reach a limit based on these thresholds.
- The expectations of key airport customers and any existing agreements or terms which guide the adoption of adaptation measures.
- Avoidance of locking in maladaptive practices.
- Short and long-term cost effectiveness of the actions.
- How adaptation actions can help to reduce vulnerability across specific assets or areas of the airport site, by building adaptive capacity or reducing exposure.
- How adaptation actions can render co-benefits, such as operational cost reduction, improved ecosystem services, improved health and wellbeing or broader community resilience.

Box 6 presents a Case Study of Taoyuan International Airport which demonstrates how adaptation measures were selected to reduce vulnerability across specific areas of the airport's site and operations.

Box 6 Case Study - Taoyuan International Airport

Taoyuan International Airport – Storms and lightning	
Hazard:	Extreme rainfall and storms
Outcome:	Airport inundation and dangerous working conditions
Impact:	Passenger delays, missed flights, health and safety concerns

Taoyuan International Airport, located in Taoyuan City, serves as the primary international gateway for northern Chinese Taipei, including the capital city Taipei. Thunderstorms pose significant challenges to airport operations, including flight delays, cancellations, and safety risks for aircraft during take-off and landing. Taoyuan International Airport (TPE) does experience thunderstorms, particularly during the summer monsoon season, when the region is affected by the East Asian monsoon. However, the probability of thunderstorms can vary depending on the specific weather patterns at any given time.

The airport conducted a vulnerability assessment which highlighted three key areas at risk during thunderstorms: flight operations, ground operations and infrastructure.

Taoyuan International Airport has introduced a Lightning Warning System (ALWS) to enhance staff safety during thunderstorms. The system includes two alert levels: Amber (lightning within 8 km) and Red (within 3 km). Amber alerts allow non-essential outdoor activities to continue based on airline and ground operations discretion, while red alerts require immediate suspension of all outdoor work. Visual signals and audible alarms accompany both alerts as part of the airport's formal storm warning procedures.

In response to increasing rainfall intensity, TPE's third runway development includes a dedicated drainage strategy for both core operational zones (runways, taxiways, terminals) and buffer areas near Nankan and Puxin Creeks. The design accounts for 200-year storm events, with elevated runway and taxiway surfaces to reduce flood risk. Critical building entry points are positioned above projected water levels. In the buffer zones, flood ways and detention ponds have been added to manage stormwater surges and protect infrastructure during extreme weather.

Airports with high levels of climate maturity may consider the use of multi-criteria analysis (MCA) to evaluate adaptation measures. MCA is a flexible and effective approach used by organisations to undertake an initial short listing or ranking of options as part of a high-level assessment. The MCA process involves defining a set of criteria and a supporting, scoring and weighting system. Each option is then given a score against each criterion, which is then totalled to enable a ranking to guide decision-making. When assessing options, it is important to take a wider view of the outcomes of an option to identify potential unintended consequences of an action, which may lock in potential maladaptation (i.e. consider the implications to connected systems). Use a structured method to assess each adaptation option based on a range of practical and strategic factors, such as:

- Implementation timeframe (short-, medium-, or long-term)
- Which risks are addressed, and whether the option addresses multiple risks (co-benefits)
- Impact on reducing likelihood and/or consequence of risk
- Technical, operational, and financial feasibility (using simple scales such as low/medium/high or easy/moderate/difficult)
- Broader co-benefits (e.g. environmental, social, economic)
- Whether the measure can be delivered internally or requires coordination with external stakeholders
- Opportunities to leverage existing or planned actions or investments

Core task

3.2 Assess residual risk based on planned implementation of adaptation measures

Once adaptation measures are identified and selected, it is important to go back the risk assessment and determine how the likelihood and consequence would change, based on the planned implementation of adaptation measures associated with each priority risk. Likelihood and consequence can be re-assessed to give a residual risk rating. It is recommended that this residual rating should now fall within the risk appetite for the airport operator, otherwise further investigation and discussion is required to improve the adaptation measure(s) associated with that risk.

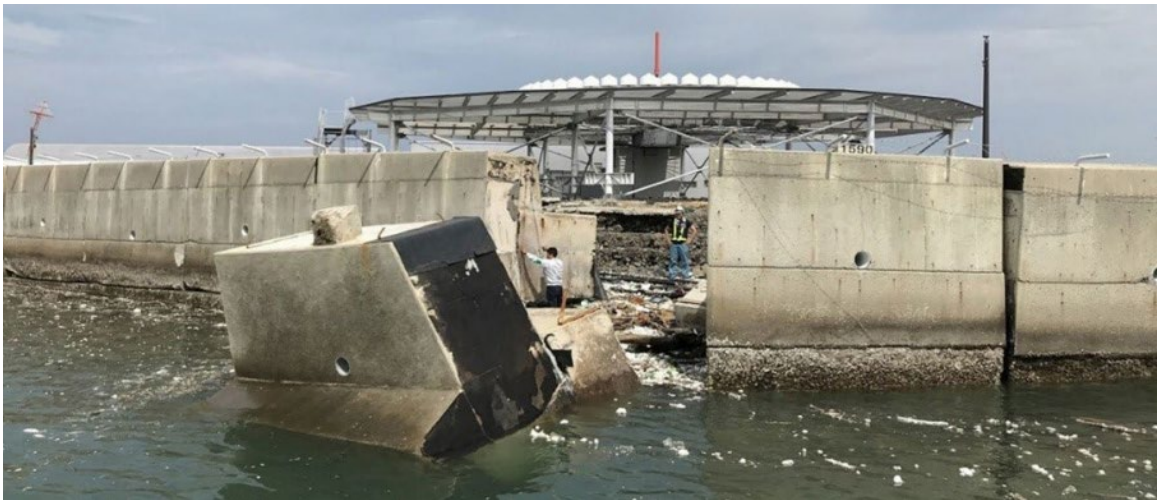
The **Climate Risk Assessment Tool** provides a place to conduct the residual risk assessment, within the ‘Adaptation Measures’ tab of the Tool. The residual assessment adopts the same risk descriptors and risk matrix as the inherent risk rating for consistency.

Box 7 presents a Case Study for Kansai International Airport that demonstrates the implementation of an adaptation measure that helped reduce the impact of a climate-related risk.

Box 7 Case Study - Kansai International Airport

Kansai International Airport – Asset damage from storm surge	
Hazard:	Tropical storms and storm surge
Outcome:	Infrastructure damage
Impact:	Airport closure, expensive repairs, and insurance claims

Kansai International Airport is a major aviation hub in Japan, ranking as the third busiest airport in the country. Situated on reclaimed, low-lying land, Kansai Airport is vulnerable to flooding. On September 4, 2018, the airport was inundated by the Category 2 Typhoon Jebi's storm surge. The most severe typhoon in 25 years, Jebi damaged infrastructure and forced airport closure for 17 days. Damage to the airport included the airport sea wall and revetment (refer to image below).



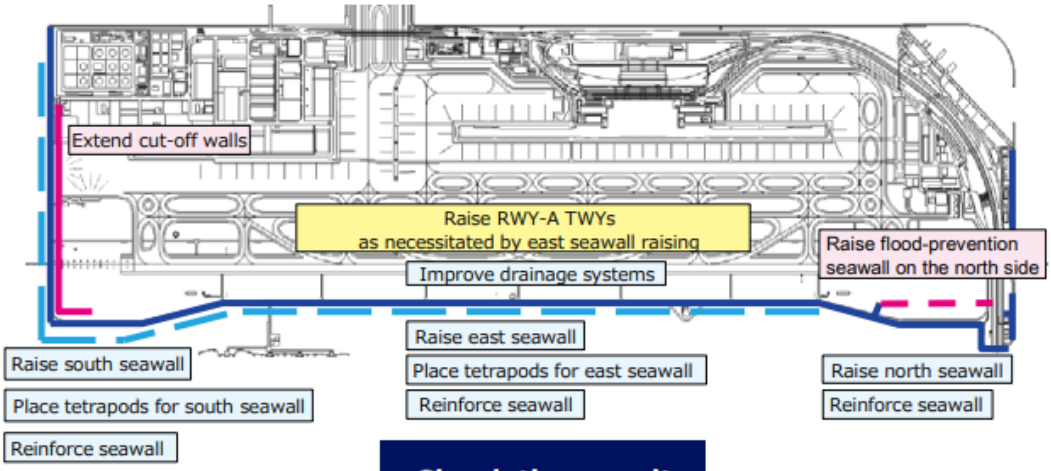
The airport began its efforts by identifying and prioritizing critical infrastructure assets as well as analysing the cascading effects of asset failure and sensitivity to climate event exposure. A Flood Simulation Tool was employed to recreate the flooding of 2018 and its impact on the terminal, airside and landside assets. From this basis, various mitigation measures were created and selected based on effectiveness, cost and implementation timeline. Investment estimates were created for two final solutions – both of which promised to reduce airport downtime from the two weeks experienced in 2018, to two days. The project team's in-depth modelling and scientific expertise provided Kansai Airport with a clear vision on what assets were at risk, how that risk could be mitigated or avoided, and the investment and solutions required to do so.

The figure below provides a snapshot of one of the main initiatives outlined in Kansai Airport's Business Continuity Plan (BCP). This initiative involved implementing seawall raising, tetrapod placement and other measures to prevent overtopping waves as modelled from the flood simulation tool.

● Infrastructure preparedness

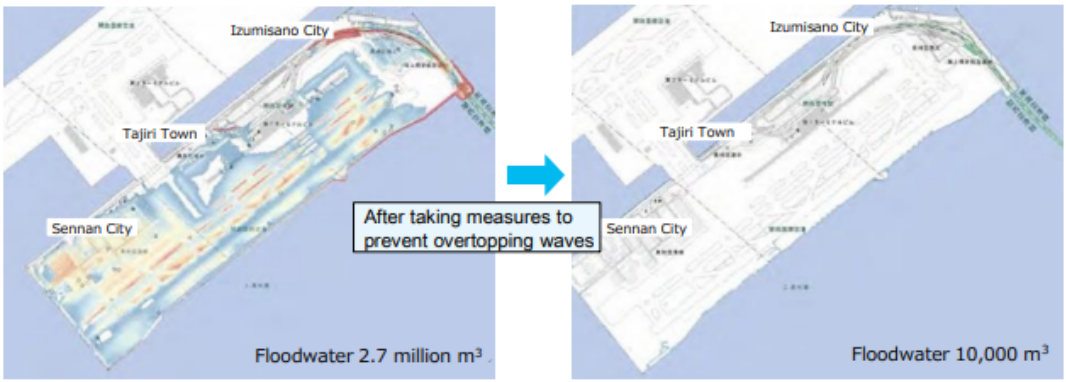
Measures to prevent overtopping waves

■ Seawall raising, tetrapod placement and other measures



Simulation result

The volume of floodwater will be reduced significantly if a flood of the same scale as Typhoon Jebi occurs



[Before] When Typhoon Jebi hit KIX in 2018 [After] 2020 (plan)

- The simulation assumes that a flood of the same scale as Typhoon Jebi (same height of waves/tides) hits KIX from the east and south
- Floodwater of 10,000 m³, which is expected to flow into KIX in the simulation, can be pumped up by the existing drainage pumps (installed in 10 locations on Phase I Island; pumping capacity of about 200K m³/hour)

Additionally, insight and expertise, paired with strong stakeholder involvement, gave all the client and stakeholders an understanding of the airport assets in relation to climate resilience, helping them make improvements that will reduce their downtime during future climate events.

Core task

3.3 Develop a climate adaptation plan

A climate adaptation plan provides a transparent approach to addressing climate-related risks over time. It is the document that collates your climate change risk assessment's key findings and proposed a direction and set of actions for responding to priority risks. A climate adaptation plan should include at a minimum:

- The process undertaken and rationale for the adaptation measures selected and the residual risk
- Steps for implementing the plan over time, including any key milestones
- Indications of required budget and resources, including opportunities to leverage existing or secure new funding
- A process for monitoring and evaluation of implementation of the adaptation measures
- For each adaptation measure:
  - The expected outcome of the measure
  - Description of the key actions to take
  - Which priority risks the measure is connected to
  - Designation of risk owner(s), accountabilities and responsibilities
  - Expected timeframe for implementation
  - Potential triggers or thresholds for the measure to take place, enabling flexible management over time

Grouping actions into themes may help to identify common threads across the adaptation measures or can help consolidate measures into responsible divisions or groups. Themes may be based on climate hazards, separation into airport planning and operational cycles, or separate measures by internal and external engagement requirements. Enhancing governance (or building internal capacity/ leadership) around climate risk management may also be a fundamental theme to support effective adaptation. Redesigning governance systems to be more collaborative, flexible, integrated and able to deal with redundancies and complexity is essential to build resilience.

Core task

3.4 Gain endorsement of the climate adaptation plan

Following development of the climate adaptation plan, gaining endorsement is a critical step to ensure commitment and resources are established for implementation. Airport operators will have an established process for taking key policies or procedures up to senior management for approval, so the climate adaptation plan should follow this existing process. This may involve the development of a high-level paper summarising the purpose and outputs of the climate adaptation plan or preparing a short and compelling presentation. In any case, some key messages which could encourage commitment and endorsement of the plan include:

- Reinforcing the collaborative nature of the risk assessment, and how the adaptation plan is backed by widespread knowledge and experience of a diverse set of internal stakeholders.
- Expressing the need for airports to support the aviation industry's efforts to adapt to climate change, with the climate adaptation plan being a central document that formalises the airport operator's key actions.

- Demonstrating how climate adaptation can improve resilience, which in turn can reduce capital and operational expenditures and operational downtime, while improving reputation, revenue generation and safety.
- Communicating the rising expectation, and in some jurisdictions, the mandatory requirement to report on climate-related risks and opportunities, as well as efforts made to respond to those risks and opportunities.

It is also recommended to engage with relevant board committee/s responsible for the oversight of climate-related risks, to keep those committees informed of proposed actions, seek their approval to initiate action with appropriate resourcing, and maintain connection between implementation and oversight bodies across the airport organisation.

Core task

3.5 Begin implementation of the adaptation action plan

Once the climate adaptation plan has been endorsed, it is time to begin implementation. Adaptation measures should be sequenced to support a staged implementation, so that internal stakeholders are not overwhelmed with the number of measures to implement at the same time.

It is also useful to establish a working group that will monitor the implementation and performance of the climate adaptation plan and adaptation measures. This group is likely to involve internal stakeholders from across the airport, including those who were involved in the climate change risk assessment process. Adaptation measure owners should either form part of this group or be regularly engaged to provide feedback on the progress of implementing adaptation measures, as well as monitoring effectiveness of the measures. This is also further discussed in Step 4 of the climate change risk assessment process.

At the end of Step 3 you will have:

- ✓ A list of adaptation measures to address each priority risk
- ✓ Determined residual risk ratings for each priority risk
- ✓ Developed, documented and endorsed a climate adaptation plan
- ✓ Begun implementation of the climate adaptation plan

Step 4: Monitor, review and report

Purpose of this Step

To track the effectiveness of adaptation actions over time, ensure climate risks remain appropriately assessed, and inform decision-making through regular review, communication and reporting. This step supports continuous improvement, strengthens accountability, and enables the organisation to respond to new information, changing conditions, or unforeseen events.

Expected outcome

The assessment findings and adaptation measures are monitored for performance and effectiveness and are continually reviewed and updated. Communication of progress ensures transparency and supports strategic decision-making.

Task summary

	Task	Output
4.1	Develop a Monitoring and Evaluation Plan	• A plan to track adaptation implementation, and monitor climate risks
4.2	Communicate findings of the climate change risk assessment and climate adaptation plan	• The findings of the assessment are communicated throughout the organisation and all staff are aware of their roles and responsibilities for managing climate-related risk
4.3	Periodically review and reassess physical climate risks	• Risks are reviewed upon release of new information or at minimum every five years

Core task

4.1 Develop a monitoring and evaluation plan

Monitoring and evaluating climate change adaptation and risk management practices is necessary to support a flexible response and reduce the risk of inefficient use of resources. This is particularly true for adaptation, giving the inherent uncertainty of responding to climate change, and the complex and long-term nature of managing climate risks. Monitoring and evaluation can help achieve different objectives, depending on the scale of climate change risk assessment conducted and the objectives of the organisation.

A monitoring and evaluation plan should consider the following components at a minimum:

- **monitoring objectives/scope** – specify the aspects of climate risk and adaptation planning to be monitored and evaluated. Define the geographical scope and anticipated outcomes of the monitoring efforts. The scope may include a combination of monitoring risk related factors as well as the implementation of actions.
- **time period** – an agreed period for ongoing monitoring and timeframe for completion of monitoring objectives e.g. every six months or once a year.
- **performance** – indicators and management triggers – identify specific indicators to measure progress towards adaptation goals and objectives. Indicators may include status of implementation of actions in the plan, performance of assets or operations in extreme weather events, triggers that support the implementation of adaptation pathways.
- **responsibility** – for data collection, reviews and reports – identify and engage the stakeholders who are needed to undertake and support the monitoring process.
- clear articulation of long-term and intermediate **outcomes or targets** that will demonstrate success.
- **metrics** – agreed measures that will indicate change, and baselines where appropriate. Metrics may include existing operational indicators such as time lost during weather events, cost of loss or damage to airport site, facilities or supply chain, insurance costs or trend analysis of insurance premiums, changes to asset valuation and media sentiment.

Adaptation pathways may be a useful way to represent when adaptation steps are required to occur. Adaptation pathways present a staggered approach to adaptation, where one action precedes another and enables the subsequent pathway to be achieved, building resiliency over time. These pathways may form the basis of a monitoring and evaluation plan to monitor progress and identify when management triggers have been reached.

For more mature organisations, **embedding Key Performance Indicators (KPIs) into business processes** can support stronger governance and ensure adaptation is continuously improved over time.

What's involved:

- Define meaningful KPIs aligned to adaptation goals (e.g. risk reduction, implementation progress).
- Set measurable targets or thresholds (e.g. % of critical risks with action plans).
- Integrate KPIs into existing systems, such as:
  - Enterprise risk monitoring,
  - Asset management and maintenance tracking,
  - Operational performance dashboards,
  - Capital planning and procurement processes,
  - Executive performance and remuneration frameworks.

Examples of potential KPIs:

- % of assets or business activities vulnerable to climate-related physical risks
- % of identified high-priority risks with adaptation actions underway or completed
- % of adaptation actions completed on schedule relative to planned timelines
- % reduction in climate-related operational disruptions year-on-year
- Number of climate-related incidents avoided or mitigated due to implemented measures
- % of capital investment projects screened for climate risk and adaptation opportunity
- % of capital projects incorporating climate risk assessment in planning and design stages
- Number of climate adaptation measures integrated into existing maintenance or renewal schedules
- Amount of capital expenditure, financing or investment deployed towards climate-related risks and opportunities

Core task

4.2 Communicate findings of the climate change risk assessment and climate adaptation plan

Effectively communicating the outcomes of the climate change risk assessment (CCRA) and associated adaptation actions is essential to ensure organisation-wide awareness, support, and integration. This step involves presenting findings to senior leadership, incorporating relevant insights into enterprise risk reports, and delivering briefings to operational teams and key stakeholders.

Airports are likely to already have established communication and endorsement processes—such as those used for safety or operational procedures—which can be leveraged to share the results of the CCRA. Communication should include a summary of the assessment approach, key climate hazards identified, and potential impacts, particularly on critical or vulnerable asset classes. Presenting findings in a format familiar to internal audiences helps reinforce the legitimacy and importance of the work, while supporting alignment across departments for future climate resilience actions.

Airports with high levels of climate maturity may consider developing **external reporting** to provide a formal record of an airport's climate change risk assessment (CCRA), adaptation actions, and progress over time. While internal reporting—such as the CCRA, adaptation plan, and ongoing monitoring—is often the starting point, developing external reports helps demonstrate transparency, accountability, and alignment with stakeholder expectations.

Airport operators may begin with an internally focused report, expanding on communication efforts outlined in core task 4.2. As climate risk governance matures, this reporting can evolve into externally facing disclosures, such as content within a sustainability report, annual report, or dedicated climate-related disclosure.

External reporting should document the processes, findings, and key learnings from the assessment and adaptation journey. For some airports, climate-related disclosure may also be a regulatory requirement, under frameworks such as IFRS S2, AASB S2, New Zealand's XRB, HKEX's Climate Disclosure Requirements, the standards issued by the Sustainability Standards Board of Japan (SSBJ) and the Korean Sustainability Disclosure Standards (KSDS). Operators should review and align with any applicable standards to ensure reporting meets industry and jurisdictional expectations. Operators may also consider voluntarily aligning to international climate disclosure standards to promote transparent communication of climate risks and response measures, which can bring reputational benefit and improved investor confidence and access to finance.

Core task

4.3 Periodically review and reassess physical climate risks

To ensure climate risk management remains effective and up to date, the Climate Change Risk Assessment (CCRA) and associated adaptation plan should be periodically reviewed. A formal review should be conducted at least every five years, particularly for strategic risks, while more operational climate risks may warrant annual reassessment.

Reviews should include an evaluation of confidence ratings for priority risks and assess the relevance and effectiveness of current adaptation measures. Reassessment may also be triggered by specific internal or external events, such as:

- **Internal triggers:** changes to airport infrastructure, systems, or operations; updates to asset management plans; or existing internal review cycles.
- **External triggers:** new or updated climate data, evolving regulatory or disclosure requirements, or significant climate-related events or near misses.

To support continuous improvement, the review process should be embedded in organisational systems, with clearly defined triggers, timelines, and responsibilities. This ensures risks are actively monitored, findings are documented and shared, and adaptive action remains aligned with evolving climate and operational contexts.

At the end of Step 4 you will have:

- ✓ Developed a Monitoring and Evaluation Plan to track adaptation implementation and monitor climate risks
- ✓ Communicated findings of the Climate Change Risk Assessment and Climate Adaptation Plan throughout the organisation

Additional Resources

This section of the Guideline introduces additional reference materials to support airports in delivering their climate change risk assessments.

Glossary of key terms

Key terminology used in this Guideline and commonly observed across climate change risk assessments are defined below:

- **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 (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **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 (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Cascading impact:** Cascading impacts from extreme weather/climate events occur when an extreme hazard generates a sequence of secondary events in natural and human systems that result in physical, natural, social or economic disruption, whereby the resulting impact is significantly larger than the initial impact. Cascading impacts are complex and multi-dimensional, and are associated more with the magnitude of vulnerability than with that of the hazard (Intergovernmental Panel on Climate Change (IPCC), n.d.)
- **Climate:** In a narrow sense, climate is usually defined as the average weather, or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization (WMO). The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the *climate system* (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Climate change:** 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 (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Climate change risk assessment:** A systematic process of identifying, analysing, and evaluating the potential impacts of climate change on a specific organisation, system or community.
- **Climate risk:** The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of *climate change*, risks can arise from potential *impacts* of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, *livelihoods*, health and *well-being*, economic, social and cultural assets and investments, infrastructure, services (including *ecosystem services*), *ecosystems* and species (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Climate variable:** A physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth's climate (World Meteorological Organization (WMO), 2025).
- **Climate projection:** Simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases (GHGs) and aerosols and changes in land use, generally derived using climate models (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Compounding impact:** Compounding impacts arise from the interaction of hazards, which can be characterised by single extreme events or multiple coincident or sequential events that interact with exposed systems or sectors (Intergovernmental Panel on Climate Change (IPCC), n.d.).

- **Exposure:** The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **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 (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Physical risk:** Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for organisations, such as direct damage to assets and indirect impacts from supply chain disruption (Task Force on Climate-related Financial Disclosures (TCFD), 2017).
- **Scenario:** A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Sensitivity:** The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Transition risk:** Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organisations (Task Force on Climate-related Financial Disclosures (TCFD), 2017).
- **Trigger:** An internal or external event, change, or condition that initiates or prompts a reassessment of priority risks and adaptation measures. Examples of internal triggers include changes to airport infrastructure, systems, or operations; updates to asset management plans; or existing internal review cycles. Examples of external triggers include new or updated climate data, evolving regulatory or disclosure requirements, or significant climate-related events or near misses.
- **Resilience:** The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure (Intergovernmental Panel on Climate Change (IPCC), n.d.).
- **Risk appetite:** The amount and type of risk that an organisation is willing to take in order to meet their strategic objectives. (Institute of Risk Management, n.d.)
- **Vulnerability:** The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (Intergovernmental Panel on Climate Change (IPCC), n.d.).

Additional components and interactions of climate-related risk

Defining direct and indirect risks

Climate-related risk can be direct or indirect. **Direct risks** are those that have direct impacts on the airport, such as damage or disruption to assets, health impacts to community and/or staff. **Indirect risks** are those that occur outside of the airport's operations but have secondary consequences to the airport, for example closure of public transport or roads leading to access or egress issues for staff and passengers.

Identifying compounding, cascading and aggregate impacts

Compounding impacts arise from the interaction of hazards, which can be characterized by single extreme events or multiple coincident or sequential events that interact with exposed systems or sectors. An example of compounding risk is provided below in Figure 10.

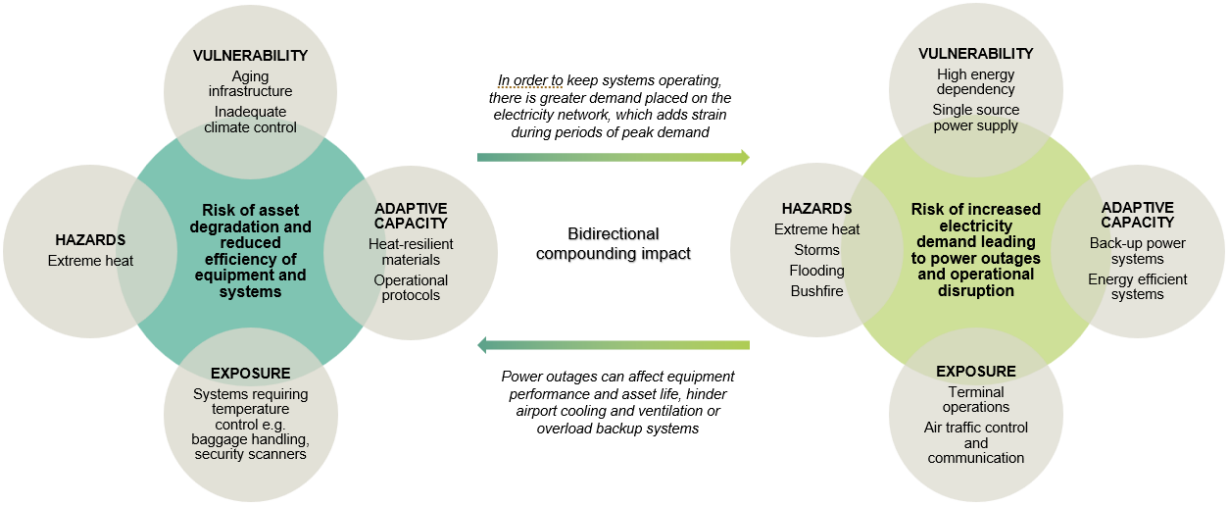


Figure 10 Example of compounding climate risks.

Cascading impacts occur when one event or trend triggers another. Interactions can be one way (e.g. domino effects) but can also have feedbacks. Cascading risk is often associated with the vulnerability component of risk, such as critical infrastructure. An example of cascading risk is provided in Figure 11 below.

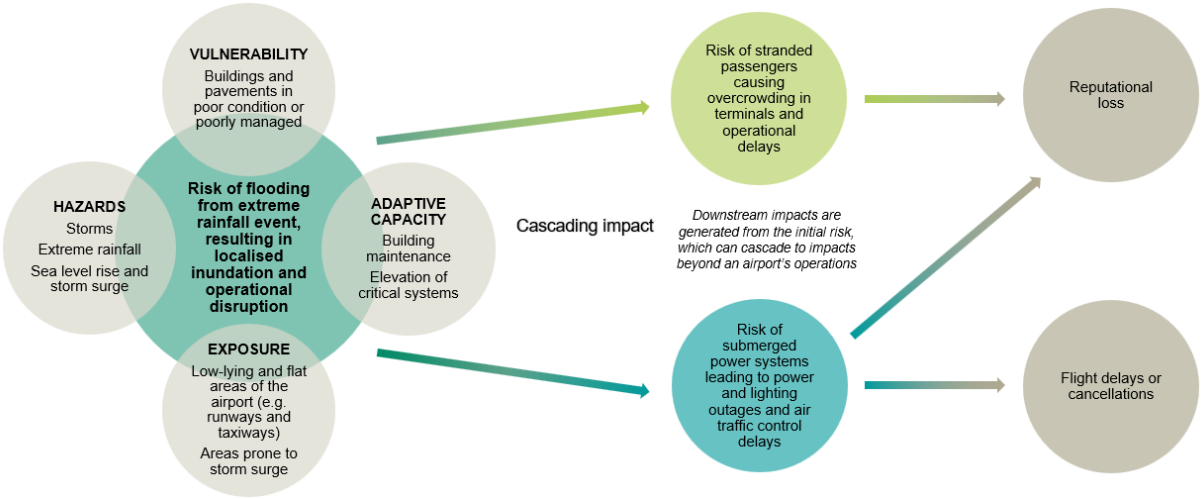


Figure 11 Example of cascading climate risks

Aggregate risks involve multiple unrelated risks occurring simultaneously or in quick succession that have potential to produce a more significant overall risk than the sum of their individual parts. An example of aggregate risk is provided in Figure 12 below.

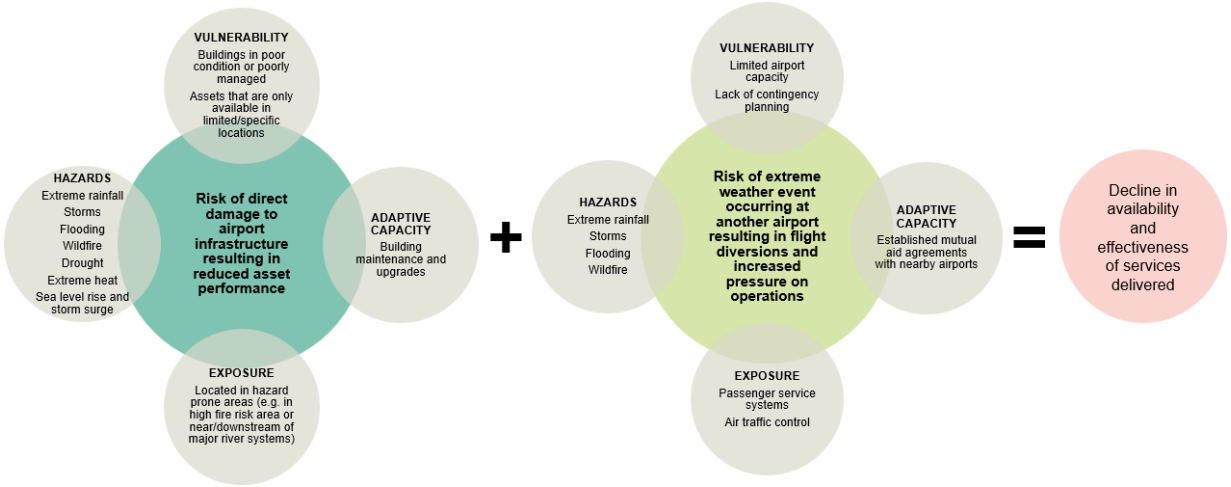


Figure 12 Example of aggregate climate risk

Airport operators are encouraged to revisit these definitions and examples when using the **Climate Risk Assessment Tool**, to help identify a broad array of potential climate-related physical risks.

Understanding climate scenarios and projections

Climate change projections help us to understand potential changes in climate variables such as average annual rainfall or number of days of extreme heat and are modelled under different scenarios or plausible futures. The Intergovernmental Panel on Climate Change (IPCC) has been central in delivering publicly available global projection data, which in turn inform climate change risk assessments. These projections are generated through global climate models coordinated under the Coupled Model Intercomparison Project Phase 6 (CMIP6), which provides a consistent framework for comparing climate outcomes across a range of scenarios. Each scenario reflects a different concentration of global greenhouse gas emissions reached by 2100, based on assumptions of different combinations of possible future, economic, technological, demographic, policy, institutional trajectories, energy supply and demand and land-use changes.

Climate scenarios have evolved over time, from Representative Concentration Pathways (RCPs) to Shared Socioeconomic Pathways (SSPs). Table 2 below provides a description of RCPs and SSPs that are closely correlated in terms of projected greenhouse gas concentrations. RCPs are now considered alongside SSPs in climate projection data outputs to derive emissions and concentration scenarios that consider the socioeconomic assumptions underlying the SSPs as well as the adaptation and mitigation action underlying the RCPs.

The number in the title of each RCP corresponds to the extra energy, or radiative forcing levels, (in W/m^2) reaching the earth by 2100. For example, RCP4.5 represents a scenario in which 4.5 W/m^2 reach the earth by 2100.

This Guideline and the accompanying **Climate Risk Assessment Tool** have adopted SSP2 and SSP5 and the associated climate projection data under those scenarios.

Table 2 Description of RCP and SSP scenarios

	Representative concentration pathways (RCPs)	Shared socio-economic pathways (SSPs)
IPCC Report	**Developed for IPCC Fifth Assessment report (AR5)**	**Developed for IPCC Sixth Assessment report (AR6)**
Description	**Describe different levels of greenhouse gas emissions that may occur in future.**	**Describe socio-economic trends that may shape the future.**
Scenarios	**RCP8.5**: A future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100.	**SSP5**: a 'Fossil-fuelled development' narrative under which emissions rise rapidly to roughly double present levels by 2050, a rate now considered to be unrealistically high. This is consistent with warming of 3.3 to 5.7 °C at 2100 relative to pre-industrial times.
	RCP6.0: Lower emissions, achieved by application of some mitigation strategies and technologies. CO2 concentration rising less rapidly (than RCP8.5), but still reaching 660 ppm by 2100.	**SSP4:** an 'Inequality' narrative under which emissions follow a highly uneven trajectory. High-income countries and regions make significant technological advances and reduce emissions, while low-income regions remain heavily reliant on fossil fuels due to limited access to clean technologies and weak institutions. This leads to a growing divide in both economic development and climate vulnerability. Global emissions remain high overall, consistent with 3.0 to 4.1 °C of global warming at 2100 relative to pre-industrial times.
	No equivalent RCP	**SSP3:** a 'Regional Rivalry' narrative under which emissions continue to rise, to roughly double present levels by 2100. This is consistent with 2.8 to 4.6 °C of global warming at 2100 relative to pre-industrial times. It is often used as a 'high emissions' scenario

	Representative concentration pathways (RCPs)	Shared socio-economic pathways (SSPs)
		since SSP5-8.5 is widely considered to have unrealistically high emissions.
	RCP4.5: CO_2 concentrations are slightly above those of RCP6.0 until after mid-century, but emissions peak earlier (around 2040), and the CO_2 concentration reaches 540 ppm by 2100.	**SSP2**: a 'Middle of the Road' narrative under which emissions start to fall in the middle of the century. This is most similar to current global emissions reductions policies and pledges (assuming that they are met), leading to around 2.1 to 3.5 °C of global warming at 2100 relative to pre-industrial times.
	RCP2.6: The most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining. The CO_2 concentration reaches 440 ppm by 2040 then slowly declines to 420 ppm by 2100).	**SSP1**: a 'Sustainability' narrative under which there is an immediate reduction in emissions and a rapid transition to 'net zero'. This SSP is likely to keep global warming to below 2 °C relative to pre-industrial time (the main goal of the Paris Agreement).

Figure 13 shows the emissions over time under baseline scenarios and under different mitigation targets, where radiative forcings in 2100 are limited to 6.0, 4.5, 3.4, 2.6 and 1.9 watts per m2 (the coloured lines). The average amount of warning associated with the range of baselines and each of the targets is also shown on the right. This figure helps to show when climate scenarios diverge over time, with more significant divergence occurring around the middle of the century.

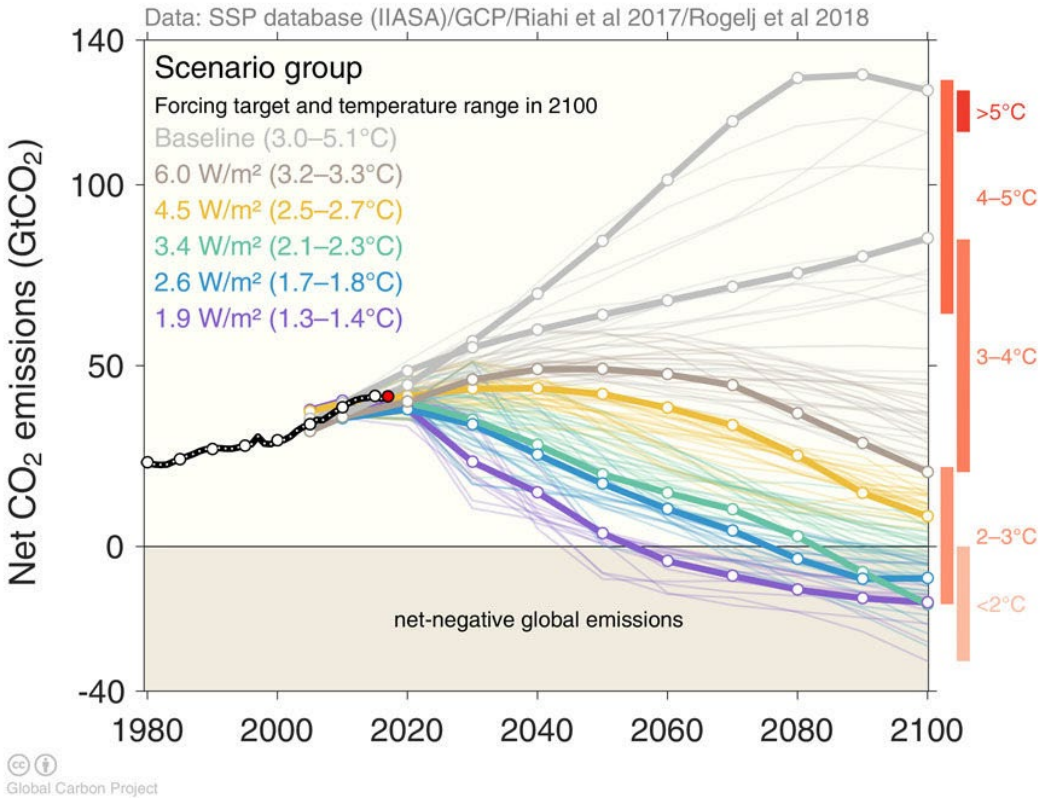


Figure 13 Global CO2 emissions (gigatonnes) for various climate scenarios. Note the radiative forcing (W/m2) corresponds to the numbers in each RCP name ((Peters & Andrews, 2018)

Online resources

Author	Resource title	Description
Climate projection data		
IPCC	WGI Interactive Atlas	Downloadable climate data and visualisation of observed and projected climate change information. This data was used within the **Climate Risk Assessment Tool**.
National Aeronautics and Space Administration (NASA)	IPCC AR6 sea level projection tool	Provides visualisation and download of projected sea level rise relative to 1995-2014 baseline across the globe.
Australian Government National Environmental Science Program	Understanding SSPs factsheet	Factsheet providing a summary of Shared Socioeconomic Pathways (SSPs) described according to projected global warming levels, dominant energy sources and global trends.
World Bank Group	Climate change knowledge portal	Downloadable climate data and country profiles providing global data on historical and future climate, vulnerabilities and impacts.
Climate-related impacts and adaptation measures		
ACI	Policy Brief: Airports' Resilience and Adaptation to a Changing Climate	Provides an overview of how climate change can affect airports, accompanied by recommendations for considering climate-related effects on planning and operations, case studies and example impacts and adaptation measures.
ACI Europe	Adapting Aviation to a Changing Climate Effects and impacts of climate change for aviation	Presents a framework for European aviation stakeholders to integrate climate adaptation into operations, planning, and policy, emphasizing risk assessment, collaboration, and alignment with EU climate goals.
ACI Europe & Eurocontrol	Aviation Preparations for Winter 2023 Adverse Weather	Summary guide outlining potential challenges and response options linked to adverse winter weather conditions in Europe.
ACI Europe & Eurocontrol	Aviation Preparations for Summer Adverse Weather	Summary guide outlining potential challenges and response options linked to summer weather and high temperatures in Europe.
International Civil Aviation Organisation (ICAO)	Key Climate Change Vulnerabilities for Aviation Organisations	Identifies sector-specific vulnerabilities—across airports, ANSPs, and aircraft operators—linked to climate hazards like heat, flooding, sea-level rise, and extreme weather.
ICAO	Menu of Adaptation Options	Offers a categorised list of operational and infrastructure-focused adaptation measures that aviation organisations can implement to address climate-related risks.

Author	Resource title	Description
ICAO	Climate Resilient Airports Eco Airport Toolkit	Outlines practical strategies and case studies to help airports enhance resilience to climate change by integrating risk assessment, infrastructure adaptation, and operational planning into airport development and management.
ICAO	Climate Adaptation Synthesis Report	This report identifies potential impacts of climate change that may affect the global aviation sector, together with concrete adaptation and resiliency measures that may be implemented to tackle them.
Climate change risk assessment approaches		
ACI Latin America and the Caribbean	Adapting Airports in Latin America and the Caribbean to a Changing Climate	Provides guidance for airports in Latin America and the Caribbean to assess climate risks and implement context-specific adaptation measures, with a focus on regional challenges, capacity building, and case-based learning.
ICAO	Key Steps in Aviation Organisation Climate Change Risk Assessment and Adaptation Planning	Guidance for conducting a climate change risk assessment and developing an adaptation plan for airports and ANSPs and aircraft operators, as well as governments and associations engaging with the aviation sector.
International Standards Organisation (ISO)	ISO 14091:2021 – Adaptation to climate change	Standard for assessing the risks related to the potential impacts of climate change. It describes how to understand vulnerability and how to develop and implement a sound risk assessment in the context of climate change. It can be used for assessing both present and future climate change risks.
Osund-Ireland MPP, Powell AJ, Ireland CJ	A global approach to assessing the climate resilience of airports	Paper presented at the 33rd Congress of the International Council of the Aeronautical Sciences, summarising the results of assessing climate resilience of eight representative airports and how ICAO guidance can be applied consistently to better inform airport managers.
Standards Australia	AS 5334:2013 Climate change adaptation for settlements and infrastructure - A risk based approach	AS 5334 is the Australian Standard for climate change adaptation for settlements and infrastructure, providing a risk-based framework to help planners and asset managers identify, assess, and manage climate change impacts on infrastructure and communities to enhance resilience and adaptive capacity.
Climate-related disclosure standards		
International Financial Reporting Standards (IFRS) Foundation – International Sustainability	IFRS S2 climate-related disclosures	The IFRS S2 climate-related disclosure standard requires companies to report on climate-related risks and opportunities, including governance, strategy, risk management, and metrics and targets, with a

Author	Resource title	Description
Standards Board (ISSB)		focus on how climate affects their financial position and performance.
Australian Accounting Standards Board (AASB)	Australian Sustainability Reporting Standard AASB S2 Climate-related disclosures	The ASRS AASB S2 climate disclosure standard requires certain Australian entities to disclose material climate-related risks and opportunities, including their governance, strategy, risk management, and climate-related metrics and targets, aligned with the ISSB's IFRS S2 framework.
The Stock Exchange of Hong Kong (HKEX)	Implementation Guidance for Climate Disclosures under HKEX ESG reporting framework	The document serves as HKEX's Implementation Guidance, explaining how listed issuers should align with its enhanced climate-related disclosure requirements under the ESG Reporting Code—specifically, to adopt new disclosures structured around four core pillars (governance, strategy, risk management, and metrics & targets) and prepare for mandatory implementation in phases from 1 January 2025.
Korean Sustainability Disclosure Standards (KSDS)	Exposure Draft of the Korean Sustainability Disclosure Standards	South Korea's Korea Sustainability Standards Board (KSSB) has released an exposure draft of the Korean Sustainability Disclosure Standards (KSDS), comprising KSSB 1 (general sustainability disclosures) and KSSB 2 (climate-related disclosures) as mandatory requirements, plus KSSB 101 (policy-aligned disclosures) as voluntary, largely aligned with ISSB's IFRS S1/S2. The final standards are expected in late 2024–early 2025, with phased implementation anticipated from 2026.
New Zealand Government External Reporting Board (XRB)	NZ CS 1 Climate-related Disclosures	The Aotearoa New Zealand Climate Standard 1 (NZ CS 1) requires certain New Zealand climate reporting entities to disclose information on climate-related governance, strategy, risk management, and metrics and targets, enabling users to understand the impacts of climate change on the entity's business and resilience.
Sustainability Standards Board of Japan (SSBJ)	The Sustainability Standards Board of Japan (SSBJ) Sustainability Disclosure Standards	Japan's Sustainability Standards Board of Japan (SSBJ) has issued three inaugural sustainability disclosure standards aligned with the ISSB's IFRS S1 and S2: an Application Standard (universal requirements), a General Standard (sustainability-related disclosures), and a Climate Standard (climate-related disclosures). These aim to enhance transparency and comparability in corporate sustainability reporting, with implementation phased in from fiscal years starting April 2025.

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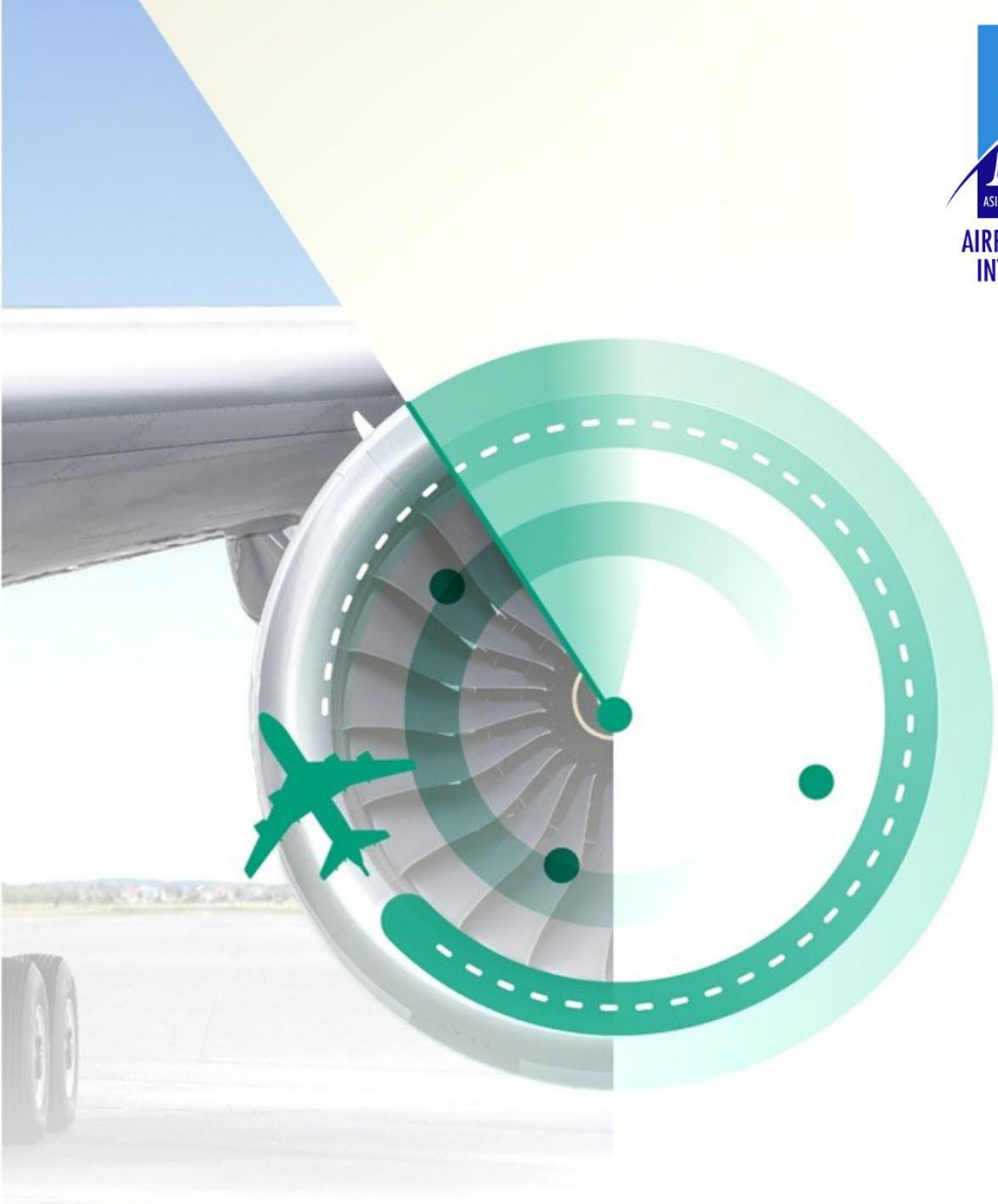

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