ADVISORY CIRCULAR

Subject	Issuance Date	AC Number	Version
Guidance Material on Climate Change Risk Assessment and Adaptation	1-September-2024	156-09	1.0

Note: This Advisory Circular is published to provide additional information and recommended actions that further elaborate on provisions or concepts prescribed in the GACAR Part -156

1. Introduction

1.1 Purpose

The purpose of this advisory circular is to prescribe:

- Climate change assessment stages,
- Climate change adaptation planning stages.

1.2 Applicability

This advisory circular is applicable to all aerodrome operators, air operators and air navigation service providers

1.3 Cancellation

This is the first official version of this advisory circular, and it cancels no other advisory circular on the subject matter.

1.4 Related regulatory references

a) GACAR Part - 156

1.5 Related reading materials and references

a) ICAO, Climate Risk Assessment, Adaptation and Resilience, available at: https://icao.int/environmental-protection/Pages/Climate-Change-Climate-Risk-Assessment,-Adaptation-and-Resilience.aspx

b) National Center for Meteorology, available at: https://ncm.gov.sa/ar/Pages/default.aspx. Email: cr@ncm.gov.sa

Approval

This advisory circular has been approved for publication by the Executive Vice President for Safety and Environmental Sustainability of the General Authority of Civil Aviation.

2. Introduction

The purpose of this document is to provide guidance on how to conduct a climate change risk assessment and how to develop and implement an adaptation plan. The document consists of two parts: climate change risk assessment and climate change adaptation.

3. Climate change risk assessment

Climate change poses significant risks to the aviation industry, necessitating a proactive approach to assess and adapt to these challenges. Climate change risk assessment involves analyzing the potential impacts of climate change, such as extreme weather events, rising sea levels, and changing precipitation patterns, on airport infrastructure, operations, and safety. This assessment helps identify vulnerabilities and develop strategies for climate change adaptation.

The climate change risk assessment process involves six stages. These stages are assessment planning, assessment scope, data collection, climate stressors and scenarios identification, climate change impacts assessment, assessment findings communication and periodic monitoring and review. This section will discuss each of these stages and their associated actions.

3.1 Assessment planning and preparation

The purpose of this stage is to prepare for the assessment itself and to develop the framework for the assessment process. It involves 6 actions as follows:

1) **Obtain senior leadership commitment:** a commitment from senior leadership is required before the assessment can begin**.** It legitimizes the risk assessment and facilitates procuring required human and financial resources. It is necessary to identify the objective(s) of the risk assessment, its expected goals, and the target audience for any recommendations.

   Organizations should also coordinate with external stakeholders at this stage of the process, for example, an airport operator should consult with the main aircraft operators operating at an airport, or an Air Navigation Service Providers (ANSPs) should consult with the main aircraft operators that operate in its airspace.

2) **Assess the organization's existing climate change governance:** check if the organization has an existing framework, leadership structure, methodology, or decision-making process (e.g., a risk management masterplan). A key starting point could be the organization’s safety management system as the processes for assessing safety risks are similar to those for assessing climate change risks. If something does exist, then the organization should evaluate it for usability.

3) **Identify internal expertise and external partners as needed:** determine who needs to be involved in the assessment, internally and externally. This may include the Saudi National Center for Meteorology and Regional Center for Climate Change which can be contacted through several contact information provided on their official website or this email cr@ncm.gov.sa

   Also, it may include subject-matter experts (internal and external), safety experts and operational personnel. It is also recommended to identify a champion for the project: somebody who is committed to the work and will drive it forward. While the initial stages of the risk assessment may have an internal scope, it may also be necessary to engage external stakeholders for input. For example, it may be important to coordinate with national or local transport providers to identify risks when ground transport access routes are vulnerable to a climate impact, such as flooding or sea level rise.

4) **Identify resources and assign roles and responsibilities:** the climate adaptation risk assessment and planning process should be multi-disciplinary and, therefore, it is important to encourage all those with key asset and operational knowledge and who have decision-making responsibilities to take ownership of the work and be engaged. Once a team is identified, the organization should assign roles and tasks within the project.

5) **Identify drivers for the assessment:** identify the main drivers driving the organization into conducting this risk assessment. This could be financial disclosure requirements or previous climate change related events that caused damage and costs to the organization.

6) **Develop a timeline for the assessment and identify milestones:** identify a timeline for performing the assessment and consider key internal participants' availability and external stakeholders' constraints. For example, airports and ANSPs may want to avoid scheduling consultations with airlines during peak travel season.

3.2 Define the scope of the assessment

This stage establishes the parameters of the assessment (i.e., what is and what is not included) through two key actions:

1) **Define the geographical scope and organizational boundaries of the assessment:** Setting the assessment's boundaries includes defining organizational boundaries. For example, different parts of an airport may be under the control of different entities, or some infrastructure may be owned by the

Best Practices/lessons learned for scope decisions

When undertaking a climate change risk assessment, one of the key challenges can be defining the assessment's scope: the scope of a risk assessment can range from an entire multi-site organization down to an individual asset or operational procedure. While it may be clear that a risk assessment should cover key operations and infrastructure, it should also cover climate impacts to personnel, passengers and general equipment.

In some cases, the scope of the risk assessment may be limited to elements that are essential for service provision, such as airport runways and terminal buildings, or where vulnerabilities due to climate change are already evident—for example, raised sea levels encroaching on runways at coastal airports, or damage to infrastructure from stronger storms. These elements are often prioritized as they are already visible or having a tangible impact. These are clearly essential elements to include in the assessment, and certainly provide a good starting point. However, if the assessment is limited to these more obvious components there is a risk of overlooking equally important elements that may be less obvious initially. For example, ground access to an airport or air navigation facility, health and wellbeing impacts on passengers and personnel due to extreme heat, or underground utilities that could be impacted by flooding and result in disruption to airport operations.

Therefore, depending on the geographical scope and specifics of an individual organization, scope definition for a climate risk assessment should aim to identify any components of assets or operations, which are weather-sensitive and thus could be impacted by a climate induced change in conditions. This could include electrical systems in locations, which may be vulnerable to flooding, heating, ventilation, and air conditioning (HVAC) systems which risk being overloaded in extreme temperatures, or risks to ground staff from extreme heat.

organization, whilst other infrastructure may be rented. In such cases, it is important to define which entity has responsibility for the assessment.

2) **Define the scope of assessment at a high level:** An assessment can focus on an entire system or be scoped to focus on specific vulnerabilities to specific aspects. In order to avoid missing key issues in one area that can have spill-over effects for another area, it is recommended to assess the whole system or organization, also taking into account access points or key suppliers. If the assessment focuses only on a specific aspect of a system, it should clarify that scope clearly in the documentation and ensure that there are no unexpected consequences such as missing key issues or impacts that may have knock-on effects to other components of the organization or system that were not assessed. For the most comprehensive assessments, this guideline recommends taking a system approach when possible. For example, assess the whole airport from an infrastructure and operations point of view, supply chain needs and surface transportation rather than assessing only a part of the airport, such as the terminal infrastructure.

3.3 Collect climate data and identify climate stressors and scenarios

This step recommends gathering climate data before selecting the climate scenarios to be assessed. There are four actions in this stage:

1) **Collect historical and baseline climate data, including reports of previous incidents and impacts:** the organization can contact MEWA and the National Center for Meteorology (NCM) for historical climate data. The organization may also have data on previous weather-related incidents and impacts, and which may be exacerbated by climate change.

2) **Gather local or regional climate change projections at an appropriate scale:** As with the historical climate data, it is recommended that an organization should contact MEWA and the National Center for Meteorology (NCM) which may already have the required forecasts, and/or climate projections. It is recommended to target a ten-year timeframe to understand more immediate impacts.

3) **Identify climate stressor confidence levels and the scale of change expected in terms of available thresholds and timeframes:** The ICAO Climate Adaptation Synthesis contains information on potential climate stressors to aviation and may be a starting point to identify impacts to consider and their potential effects. Identify climate stressors that may affect the organization and the scale of change for each stressor that could cause possible impacts. This is an iterative process as climate projections are not static and the climate may change in a different way or at a different speed than originally projected. It is also necessary to establish confidence levels. These are the required levels of certainty of the results of the risk assessment.

   Not all stressors may have quantifiable data to compare to a threshold. Thus, in some cases, only a qualitative assessment or a site-specific scenario-based assessment is possible. In cases where there is no data available to quantify stressors, it is advised to take a conservative approach and add a "safety factor" to the assessment to account for variability

4) **Determine relevant climate scenarios to be assessed (e.g., based on the IPCC's RCPs), as well as initial climate impacts to be considered:** Identify the climate scenario(s) to be considered. This should take into account the organization's level of risk tolerance. For example, tolerance for long

periods of operational disruptions may differ based on the type of operation or service offered. A major hub airport with many connections and feeder flights may have very low tolerance for major and prolonged disruptions, while an airport with low traffic volumes may have higher tolerance. Given uncertainties in the future impacts of climate change, more than one RCP scenario may be considered. Cumulative impacts of multiple stressors should also be considered. For example, a rise in sea level and an increase in wind speed can interact with each other to intensify the total impact.

3.4 Assess climate change impacts

The stage outlines how climate change impacts might affect the organization and provides recommendations for developing a risk matrix and prioritizing risks. There are 14 actions under this stage:

1) **Determine the impacts of climate change in the selected scenario:** Identify the climate impacts, and the projected extent of impacts, that are expected under each scenario. All assumptions and data gaps should be recorded.

> **Best Practices/lessons learned on climate impact assessment**
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> When carrying out a climate risk assessment, climate impacts may need to be assessed though expert judgement. Engaging the organization's personnel is essential, such as asset operators, operational staff and facility managers who have hands-on experience to assess expected impacts. Such personnel are the primary knowledge holders and will be able to identify both impacts to infrastructure and operations that the changing climate may already be causing, and any potential future impacts based on climate projections. While this input is essential to the success of the risk assessment, asset owners and decisionmakers may also require quantitative information to take adaptation action. For example, if an assessment is only based on qualitative assessment, the accuracy and utility of the assessment results may depend on which personnel are available and willing to engage in the process, and the overall results could be challenged. Therefore, comprehensive documentation and data tracking is advised to ensure that no key information is overlooked if the knowledge holders are unavailable or have limited ability to participate.

2) **Select an impact assessment methodology:** impact assessment methodology selection will be based on expected climate change impacts. One of the most common methodologies is considering probability and the impact of the climate stressor (likelihood x Consequence = Risk). More resources are provided at the reading material section.

3) **Select the assets and components of the system to be assessed:** Identify the assets and components of the system to be assessed. This should include infrastructure, operations and any other critical elements that fall within the scope of the assessment. In some cases, assets can also encompass personnel. For assets and infrastructure, it is important to consider its lifespan or lifecycle and if its absence affects any other assets. With assets that have a short lifecycle, the organization should assess the feasibility of expanding or adapting the assets to accommodate future needs.

   In addition to collecting climate data, collecting asset data can be important for assessing impact (e.g. asset condition, technical specifications, and life cycle information, for example, when the asset might be due for replacement, or a major rehabilitation is a factor to be considered). Additionally,

"cascading effects" should be accounted for. For example, the impact on one component of the system due to a failure or reduction in performance of another component. Secondary impacts may include supply chain failures or ripple effects in the aviation system due to disruptions elsewhere.

4) **Set a timeframe for the risk assessment:** The timeframe will be informed by the climate data and the asset(s) and operations being assessed. As noted under the previous step, asset lifecycle and investment cycles will be important to consider. There may be value in looking at more than one timeframe to capture shorter-term and longer-term impacts. For example, when considering future runway length and elevation, consider long-term planning needs. While a runway pavement's estimated lifecycle may only be twenty years, the grading, drainage, fill and orientation may exceed the lifespan of the pavement or have longer-term implications.

5) **Identify current design or operational thresholds:** For each asset, identify design and operational thresholds. As an example, wind loads should be considered for buildings and high temperature extremes for pavement. Any planned capital projects such as renovations or new construction should incorporate these considerations.

6) **Identify the stressors for assets and operations identified in step 3:** For each group of assets or operations, identify the climate stressors that could impact it and the potential effects of those stressors. The overview of Key Climate Change Vulnerabilities for Aviation Organizations referred to in section 1.5, provides additional examples

7) **Determine the probability (likelihood) of occurrence of each impact:** Different impacts will have different probabilities of occurrence and may use different metrics. It is important for an organization to have not only the most up-to-date projections but to review them periodically and update their risk assessment as necessary. For example, major flood events may be projected to occur once in 100-years whereas for extreme temperature days the key information may be the number of expected annual occurrences when the daily temperature hits a threshold temperature (e.g. number of days).

   MEWA, NCM or external climate experts can provide probabilities of future weather events.

8) **Identify the consequences of each impact at the identified level of probability:** Identify the expected effects on each group of assets or operations. As an example, for a 100- year flood, the organization should review what measures are in place and how such an event may impact the assets and operation.

9) **Create a risk matrix:** a risk matrix is used to assess risk by considering the likelihood or probability of occurrence of an event happening, and weighs that against its corresponding impact. When completing a risk matrix, assign each potential impact a risk rating according to how likely it is to happen and what the consequences (severity) would be if it did happen.

10) **Evaluate existing adaptive capacity:** adaptive capacity is "The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences." (IPCC 2018, p. 542). For an organization to evaluate its existing adaptive capacity, it should assess how prepared it already is by systematically reviewing each climate stressor and considering what capabilities it has to address it.

    For example, depending on the organisation, some elements to consider while evaluating existing adaptive capacity include:

- Does the organisation's heating, ventilation, and air conditioning (HVAC) system have the ability to accommodate projected changes in temperature over a lifespan of 10 to 15 years? If not, isthe physicalspace to increase cooling capacity available?
- If an airport's automated people mover (APM) system for travel between terminals is not functioning due to a disruptive weather event, is there an alternative mode of transport available?
- Is there more than one access road to the airport? If not, can provisions be made for additional access?
- Do existing sea-level defences have the capacity to increase height in the case of higher projected sea level rise?

Such consideration will help identify where adaptive capacity is available. However, the amount of adaptive capacity may be limited. For example, an airport may only be able to raise its sea defenses by an additional two feet while projections may indicate three feet is necessary. As a result, while some adaptive capacity is available, some vulnerabilities may remain. Therefore, where there is insufficient adaptive capacity in place, the organization has some vulnerabilities to acknowledge and address.

11) **Identify remaining vulnerabilities:** assess remaining vulnerabilities and decide whether and how they should be addressed after identifying existing adaptive capacity.

12) **Rank and prioritize vulnerabilities:** There may not be resources to address all identified vulnerabilities. It is also not possible to prepare for every possible event. Therefore, focus on the most critical based on priorities as determined by goals, operation type, business, and risk tolerance. This kind of prioritization emphasizes the importance of leadership buy-in.

13) **Consider the cumulative impacts of multiple stressors:** Based on the understanding of each individual impact, consider how cumulative or cascading impacts can increase risks. For example, consider how a combination of a rise in sea level and an increase in wind speed affect storm surge impacts, or the combination of storm surge, sea level rise, and a king tide occurring simultaneously with an intense precipitation event affect flooding impact.

3.5 Finalize assessment

After risks and vulnerabilities are clearly identified and prioritized, consolidate and finalize the assessment, in preparation for adaptation planning. There are three actions to this step:

1) **Prepare the assessment report:** A report of the assessment should provide the main findings for example, climate stressors, expected risks and the associated confidence levels, current adaptive capacity and vulnerabilities. At this stage, adaptation measures should not be proposed.

2) **Report to senior leadership:** Senior leadership will need to decide on the final risk acceptance level and minimum service levels to be maintained in the adaptation planning.

3) **Communicate with stakeholders the results of the risk assessment:** Developing a plan to communicate the outcomes of the risk assessment is key to ensure the outcomes of the assessment are effectively communicated to internal and external stakeholders given the importance of damages, disruptions and costs from potential climate impacts.

3.6 Periodic monitoring and review

Review the assessment periodically, as both climate projections and the organization's operations and assets, and the condition of those assets, may change. There are two actions in this step:

1) **Set periodic review timeframe and review any changes to assets or operations due to climate stressors.**

2) **Compile data on impacts and damages that occur, including types, intensity, and costs:** Collect data on impacts and damages that occur on an ongoing basis. Such information will inform any review of criticality, prioritization and resource allocation. It will also serve to monitor how impacts and costs evolve over time

4. Climate change adaptation planning

Climate change adaptation planning for aviation organizations should be done in four stages (as shown in figure 1). This section will discuss each of these stages and their associated actions.

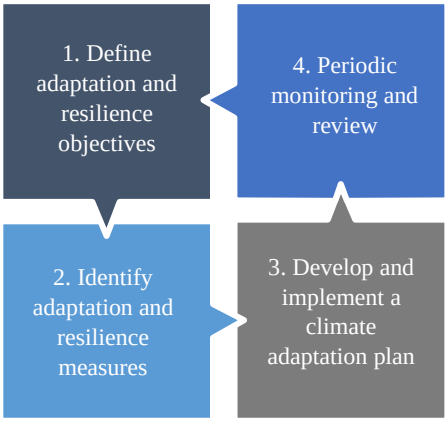

Figure 1: Climate change adaptation panning four stages

4.1 Define adaptation and resilience objectives

The fifth action in section 5.1 of this document identifies organizational drivers that should be considered when defining adaptation objectives. The climate change adaptation plan should reference and adhere to them. This stage consists of four actions:

1) **Prioritize the criticality of assets and operations:** determine the most critical vulnerabilities to address to ensure reliable and safe operation of those critical elements.

2) **Identify high-level potential adaptation and resilience measures:** The goal of implementing an adaptation or resilience measure is to reduce the risk of a climate impact to an acceptable level of risk. Before identifying a risk acceptance level, it is necessary to have a broad idea of the types of adaptation and resilience measures available for various risk levels. A preliminary high-level set of potential adaptation and resilience measures can be identified from the ICAO Menu of Adaptation Options referenced in section 1.5

3) **Determine risk tolerance:** Identifying an acceptable risk level, or risk tolerance, is an iterative process to identify the needed adaptation and resilience measures. There are many factors that come into play when determining an appropriate and achievable level of adaptation and resilience; for example, useful life of an asset, cost-benefit of the adaptation measures, and uncertainty in the assessment.

   Different systems (assets and operations) may have different requirements and risk acceptance levels. The more critical the asset or operation then the lower the risk acceptance level would normally be. When deciding on risk acceptance level, a decision needs to be taken in terms of which timeframe to plan for (e.g., for ten years, fifty years). This may vary according to the asset and/or its operations.

Defining risk acceptance levels is an iterative process. For example, an organization may initially decide on a low-risk acceptance level (e.g. for a 1 in 500-year event). However, to achieve that level of resilience may require major investments, for example a sea-wall or structural elevation, at the expense of other projects from which the organization could benefit (i.e. lost opportunities). Therefore, there may be a need to balance higher risk acceptance (e.g. only preparing for a 1 in 50-year event) with cost and operational implications.

4) **Identify potential opportunities:** Changes in climate may also result in opportunities. Risk Assessment step 4.14 already identified some potential practical examples (e.g., to operational procedures). There may also be an opportunity to reallocate scarce resources for other purposes. For example, although some organizations will need to expand assets or operations to handle increased impacts (e.g., stormwater retention facilities in areas where rainfall is expected to increase), other organizations may see a reduction in demand for such facilities (e.g., areas where rainfall is expected to decrease).

4.2 Identify adaptation and resilience measures to address prioritized vulnerabilities

High-level potential measures were identified in the previous stage. As part of this stage, more detailed adaptation and resilience measures will be identified according to the risk tolerance. This stage has three main actions:

1) **Develop detailed adaptation and resilience options:** Using the high-level set of adaptation and resilience options identified in the previous stage as a starting point, and taking account of the risk acceptance level identified for each vulnerability and the available budget, draw up a short-list of potential measures. Potential adaptation and resilience measures can be identified from the ICAO Menu of Adaptation Options referenced in section 1.5.

2) **Analyze adaptation options:** Assess the suitability of the potential options to address each vulnerability and categorize the options according to feasibility. Such an evaluation should consider different elements, such as: low- or no-regrets, win-win options (e.g., opportunities for adaptation measures that reduce GHG emissions), trade-offs (e.g., would implementing an option have an adverse effect on an existing asset or operation?), phased implementation, synergies with other programs/projects, and the availability of regional initiatives and funding. Cost benefit analyses (CBA) can be used to gauge the feasibility and relative benefits of various options. It can also help put a value on an option. For example, in some cases based on the cost of the action and the impacts of failure, it may be acceptable to allow the asset to fail and then rebuild. For critical assets this would not be an option. It is also recommended to consult with key stakeholders on potential measures.

3) **Select the adaptation option:** Once the previous actions are complete, select which option(s) are most suitable to address each vulnerability. There may be budget or resource constraints that preclude the implementation of some options. Therefore, there could be a need to prioritize the proposed options. Once the final options are selected, senior leadership approval may be required.

4.3 Develop and implement climate adaptation plan

A climate adaptation plan can be developed for the short-term, mid-term, or long-term, or a combination of time frames. However, whatever the timeframes selected it would normally be an iterative process. There are four actions to this stage:

1) **Prioritization of implementation:** Establish an order or prioritization for the implementation of each measure. The prioritization should consider which measure is the most critical to implement and which measures are linked to other actions. For example, if resilience is improved in one part of a system but not in another part, the overall resilience of the system may not be increased.

2) **Implementation timeline:** Develop a timeline for implementation based on both criticality and practicality. This may be across a range of timeframes from months, years or even decades, and may be tied to longer term or wider infrastructure or operational improvements. Several elements should be considered when defining the timeline, such as: the asset lifecycle and existing age of the asset, total costs of improvement and costs of failure. The timeline for implementation may also be dependent on available resources. Flexibility in defining and revising the timeline is key. For example, from a practical perspective, it may not be possible to make infrastructure improvements during peak season. Moreover, during quieter periods reduced operations may make certain upgrades less costly in terms of downtime

3) **Implementation process:** Once the timeline is in place, develop a step-by-step process for the implementation of each measure. A checklist approach may be helpful for tracking this action. To the extent possible, embed adaptation into existing strategies and plans. For example, short term measures can be implemented directly but long-term measures may need to be integrated into master plans or investment plans as actual implementation may be at a later stage.

4) **Develop Communication plan (internal and external):** Once the implementation plan is agreed, communicate the measures to be implemented, the rationale for the measures and the timeline and process for implementation to both employees and external stakeholders. Additional coordination or training may be required, especially when new operational procedures or new equipment are introduced. Develop an approach that captures and leverages knowledge and learning from the implementation experience (e.g., best practices). Organizations that have developed adaptation plans should share their experience, when relevant and appropriate, to help build overall aviation sector resilience.

4.4 Periodic monitoring and review

It is important to regularly review both the Adaptation Plan and Climate Change Risk Assessment to verify that the measures that have been implemented are achieving the required results and, if not, then to be able to take remedial action. Periodical review of the risk assessment can also help identify any new risks, and adaptation and resilience measures for those risks can be developed and implemented in a timely manner. There are two actions to this stage:

1) **Monitor the adaptation plan:** Develop a monitoring plan for the adaptation process. This should cover the implementation schedule and how any implemented measures are functioning. It should monitor the performance of each adaptation measure against the defined risk acceptance level and minimum service levels (defined during the risk assessment phase). In the case of major infrastructure improvements, the timescales for monitoring may be longer. As part of a monitoring plan, it is important to report and communicate successes (e.g., where the measures implemented maintained agreed upon service levels during disruption). This can also include cost savings due to the increased resiliency
2) **Review the adaptation plan:** Periodically review the adaptation plan and update it if new adaptation requirements are identified.

GACA Contact:

For any further information, please contact General Directorate of Environmental Sustainability at envi@gaca.gov.sa.

H.M

EVP, Aviation Safety & Environmental Sustainability
Captain/ Sulaiman Saleh Almuhaimedi