The main scientific document this synthesis consulted is the IPCC Fifth Assessment Report (AR5), published in 2014. AR5 is recognized by the international scientific community as the most current and comprehensive publication pertaining to climate change science. In 2018 the IPCC published a special report on keeping to 1.5° C of global warming. It looked at if and how we can achieve 1.5 °C and the difference in impacts between 1.5 and 2 °C. However, it did not update the full set of scientific information from the Firth Assessment Report: that will be update in the Sixth Assessment Report, for which the Summary for Policy makers is scheduled for publication in 2021.

Climate Adaptation Synthesis

By Ms. Rachel Burbidge (EUROCONTROL) and Ms. Andrea Freeburg (US FAA)

According to the 2014 UN Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, there is scientific consensus the climate is changing, and will continue to change for the foreseeable future. Climate change will have impacts across society, including the aviation sector. While aviation currently operates safely and efficiently in a variety of climates, climate change is likely to pose a number of risks for the sector in the future, including increased frequency and intensity of disruptive weather events in some areas of the world, potentially beyond the current capacity for resilience of the aviation system. Despite increasing global climate change mitigation efforts, some degree of climate change is unavoidable. Therefore, action is needed to adapt and build resilience to rising sea levels, higher temperatures, stronger storms, and other potential impacts. For this reason, and in response to a call from concerned Member States, ICAO has been working to provide information on climate change adaptation and resilience to the global aviation sector beginning with the 2013 update of the ICAO Airport Planning Manuel. In February 2016, the triennial ICAO Committee on Aviation Environmental Protection (CAEP) Plenary meeting approved a new task to develop a Climate Adaptation Synthesis report that was subsequently adopted in 2019.

DEVELOPING THE SYNTHESIS

The objective of the Climate Adaptation Synthesis task was to gather existing information on the range of projected climate impacts for the aviation sector so as to better understand the potential risks to planning, infrastructure, and operations. The working group considered impacts at local, regional, and global levels. It also gathered examples of related adaptation and resiliency efforts and actions that may reduce the risk associated with the impacts of climate change, some of which have already been implemented by Member States, local authorities, and aviation sector organizations.

As part of this substantial piece of work, a survey to gather input from States and organizations was developed. Responses were received from States, airports, airlines, ANSPs, and a global organization. At least one response was received from every ICAO Region.

The survey asked respondents the following questions:

- Whether they expect to be impacted by climate change?
- Whether they are already experiencing impacts?
- Which climate change impacts respondents expected to be impacted by?

- Whether they were taking any measures to adapt to the impacts of climate change, such as a climate change risk assessment, or adaptation measures?
- How prepared they think the global aviation sector is for the impacts of climate change, and what further action might be considered?

The key findings from the survey are presented later in this article.

In parallel to analyzing the survey results, a literature review of current scientific and policy documents containing relevant material on the potential impacts of climate change for aviation and possible adaptation and resilience measures was carried out. Some of the documents were global in context, while others were regionally or more locally specific. Each document was analyzed separately and the relevant information on climate impacts, effects on the aviation sector, and adaptation and resilience measures was combined to provide a high-level synthesis of the best available current information.

CLIMATE ADAPTATION SYNTHESIS CONTENT

The Synthesis provides a detailed overview of climate change risk and resilience for the global aviation sector. It contains information on nine physical impacts of climate change:

- sea level rise
- storm surge
- increased intensity of storms
- changing in average and extreme temperatures
- changing precipitation
- changing icing conditions
- changing wind
- desertification
- biodiversity (wildlife and ecosystems)

For each of these impacts, the synthesis describes:

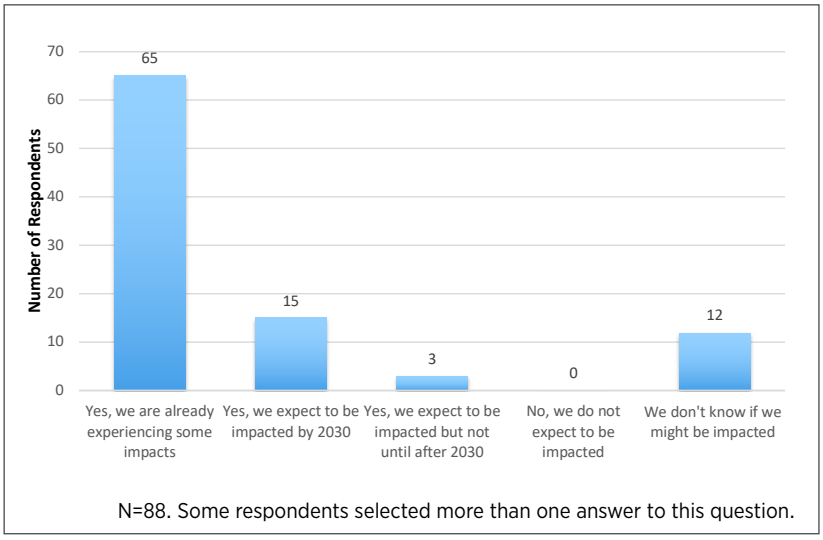
1. What the impact is.
2. Expected timescales for the impacts.
3. Potential effects for the aviation sector.
4. Potential adaptation and resilience measures to address the impact.

The synthesis also identifies business risks for the sector such as changes to revenue. Additionally, the synthesis provides a summary of high-level information on carrying out a climate change risk assessment and developing an adaptation plan based on material gathered during the literature review. Finally, the synthesis provides a qualitative analysis of survey responses regarding the preparedness of the global aviation sector to deal with the impacts of climate change.

CLIMATE IMPACTS FOR THE GLOBAL AVIATION SECTOR

As listed above, nine potential climate change impacts for the global aviation sector were identified. This was done according to the recently updated ICAO Airport Planning Manual Part 2 Land Use and Environmental Management (ICAO Doc 9184), and confirmed by the review of scientific literature. Information for each of these nine impact categories was synthesized separately and included in a regional analysis, so as to provide a comprehensive global picture as to the varying risks to the aviation sector from climate change.

FIGURE 1: Q1 - Do you expect to be impacted by climate change now or in the future?



N=88. Some respondents selected more than one answer to this question.

One of the key findings of the synthesis was that 65% of survey respondents are already experiencing climate change, and no respondents indicated that they did not expect to be affected (Figure 1). This suggests that climate change impacts are a tangible risk for most of the survey respondents.

Of the nine impact categories included in the survey, the three that survey respondents expect to be most impacted by are:

- **Higher Average and Extreme Temperatures:** 91% of respondents stated that they are affected today, or expect to be affected in the future, by higher average and extreme temperatures. Both average global mean temperatures and extreme high-heat days are expected to increase. The impacts to aviation from higher temperatures are wide-reaching. For example, high heat days can stress cooling systems or damage the airfield surface, if temperatures exceed design standards. Higher temperatures can also reduce air density, which can affect aircraft take-off requirements. Additionally, higher temperatures may cause permafrost to thaw in northern regions, destabilizing infrastructure and contributing to erosion.
- **Changing Precipitation:** 89% of respondents stated that they are affected today, or expect to be affected in the future, by changes in precipitation. Changes in precipitation type (e.g., rain, snow, hail), as well as precipitation frequency, potentially leading to extreme rainfall or prolonged drought are expected. There is considerable variation in precipitation forecasts globally, but the International Panel on Climate Change fifth Assessment Report (IPCC AR5) WGI (the physical science basis) states that climate change is likely to bring a change, and potential exacerbation of these conditions to all regions. Extreme rainfall may cause flooding of airport surfaces and infrastructure, while drought may lead to reduced water availability.
- **Increased Intensity of Storms:** 86% of respondents stated that they are affected today, or expect to be affected in the future, by increased intensity of storms. IPCC AR5 Synthesis illustrates how, as temperatures increase, the risk of extreme weather events, such as extreme storminess, will also increase. Increased intensity of storms may cause damage to aviation infrastructure and cause delays or cancelations to commercial air service.

Other key impacts and their potential effects include sea-level rise inundating infrastructure, changes in icing conditions leading to changes to de-icing requirements, changes to wind patterns including changes to the Jetstream which could affect flight times, and an increase in en-route turbulence. Other impacts may include: an increase in desertification and a resulting increase in sandstorms disrupting operations, an increase in wildlife hazards due to changes to biodiversity, and business and economic impacts such as increased costs from delayed and cancelled flights, or changes to tourism demand patterns.

CLIMATE CHANGE ADAPTATION AND RESILIENCE

The synthesis also looked at what States and organizations can do to reduce the risks from climate change impacts. It found that the most common approach is to carry out a climate change risk assessment and then develop a climate adaptation plan. This process involves determining how the climate might change in a given area, and what risks this change may have for aviation, specifically. The next step is to identify appropriate climate adaptation and resilience measures to reduce the risk from the climate change impacts identified, and develop an action strategy in a climate adaption plan that sets out and prioritizes how those measures will be implemented. For example, adaption and resilience measures could include such measures as: increasing surface drainage to accommodate an increase in heavy precipitation, implementing defenses against sea-level rise, relocating infrastructure on higher terrain, increasing terminal cooling capacity, and reinforcing infrastructure to deal with stronger and more frequent storms. Of course, any decision on what measures to implement, and to what extent, are at the discretion of an individual State or organization. Given that climate may change differently or more quickly than current projections, it is important to review adaptation plans and measures at regular intervals to ensure the information is current.

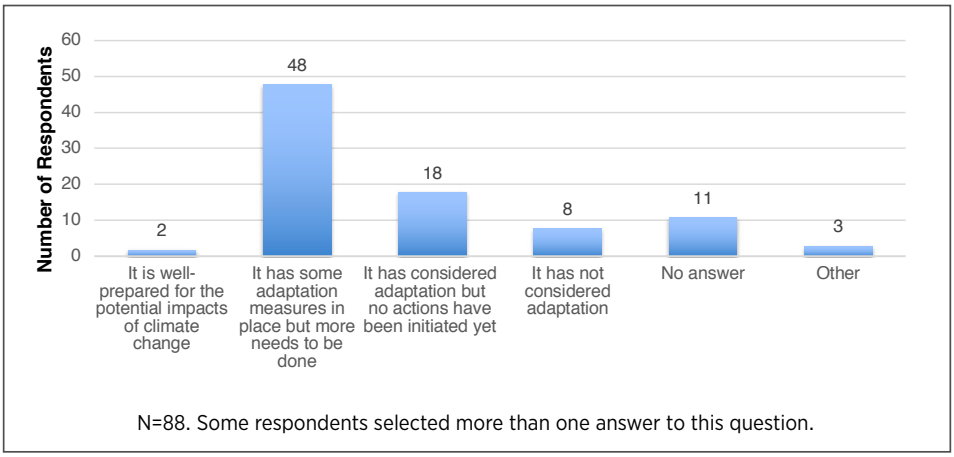
HOW PREPARED ARE WE?

The final section of the Synthesis collates information from survey respondents on how prepared they think the global aviation sector is to deal with the potential impacts of climate change. For example, 55% of respondents said that they think the sector has some measures in place but that more needs to be done (Figure 2) and 20% of respondents indicated that that they thought the global sector has considered adaptation but has not yet initiated any actions. These results indicate most respondents believe that the aviation sector has started to take action to adapt to climate change, but that more may need to be done.

NEXT STEPS

Climate change is a growing global issue. ICAO will continue to work on climate adaptation and resilience in the next CAEP cycle, which runs from 2019 to 2022. Of particular note, future work will focus on making information from the Synthesis available more widely, to support the global aviation sector in taking measures to adapt and build resilience to the impacts of climate change. States and organizations will be able to use this information to support the identification of climate change impacts, the potential effects these impacts may have on their aviation sectors and organizations, and to identify potential adaption and resilience measures to implement to reduce their vulnerability to climate change impacts.

FIGURE 2: Extent to which respondents think the global aviation sector is prepared for the impacts of climate change.



N=88. Some respondents selected more than one answer to this question.