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Climate Resilient Airports

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Climate Resilient Airports

Contents

Introduction

A climate resilient airport is one that has taken steps to prepare for the challenges that climate change and severe weather bring. Airport planning is conducted for many reasons, and they increasingly include consideration of the risks and impacts associated with climate changes and plans for future climate conditions.

The ninth UN Sustainable Development Goal (SDG 9), 'Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation'[1], measures the progress made in developing, maintaining, and upgrading resilient infrastructure, including that of airports.

Airports face numerous climate challenges which may impact their operations, infrastructure, and business continuity. This paper provides a high-level overview of the issues climate change may bring for airports, as well as some strategies on how to anticipate and prepare for contingencies. This paper is not intended to capture every single aspect regarding climate change and aviation, but will instead stay focused on airport resilience.[2] Considering relevant work on adaptation[3] currently underway by ICAO and international organizations such as Airports Council International (ACI), additional references may be added to the paper at a later stage.

Aviation Climate Impacts[4]

The ICAO Airport Planning Manual, Part II, and Climate Change Synthesis[5] documents identified nine primary climate impacts, which may include, but are not limited to:

- **Sea level rise:** elevated flood risk; seawater damage or inundation of airport infrastructure; risk of permanent inundation in some locations; rising ground water tables damaging infrastructure; risk of inundation of ground transport links; greater risk of storm surge inundation due to sea level rise.
- **Storm surge**: damage to airport infrastructure and airport buildings; disruption of operations or temporary airport closure; reduced airport accessibility for ground and air transport; increases in contamination risk.[6]
- **Increased intensity of storms**: damage to airport infrastructure and airport buildings; accelerated ageing of the airport facilities and infrastructure, such as runways; destruction

[1] See UN SDG's and Indicators at: https://unstats.un.org/sdgs/indicators/database/

[2] The definition of resilience used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC**
Resilience = the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation. Available at: **https://www.ipcc.ch/sr15/chapter/glossary/**

[3] The definition of adaptation used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC**
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. Available at: **https://www.ipcc.ch/sr15/chapter/glossary/**

[4] The definition of impacts used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC** Impacts (consequences, outcomes) = the consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure, and vulnerability. Impacts generally refer to effects on lives; livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial. Available at: **https://www.ipcc.ch/sr15/chapter/glossary/**

[5] See ICAO Climate Change Adaptation Synthesis at: https://www.icao.int/environmental-protection/Pages/Climate-Adaptation.aspx

[6] Any flooding, including by storm surge, can bring in toxic and hazardous materials from off-airport including sewage, hydrocarbons, and other chemicals. Additionally flooding of airport infrastructure such as storage buildings, hangars and fueling facilities raise risk of contamination from materials common to the airport setting, such as oils, fuels, firefighting foams, anti-icing and de-icing chemicals and water collecting/treatment facilities. Following a storm, the area impacted by storm surge may need to be decontaminated before any other recovery action is taken.

of or damage to mobile or fragile equipment; increased flight delays and cancellations; temporary airport closure.

- **Changes in average and extreme temperatures**: exceedance of design standards leading to heat damage on airport surfaces; take-off weight restrictions, possibly requiring longer runways or schedule changes; changes in heating and cooling requirements increasing energy consumption and associated environmental and financial costs; overheating of equipment or degradation of performance; impact on the amount, location and temporal distribution of traffic demand; permafrost thawing may lead to ground instability causing damage both to aircraft movement areas (holes and buckling), and to infrastructure integrity and stability; impact on fuel handling and storage, due to maximum temperature restrictions.
- **Changing precipitation (intensity and type):** abnormal precipitation quantities or location; need for increased airport surface drainage capacity (runway, taxiway, ramp and apron); risk of flash flooding or inundation of infrastructure; potential risks to ground transport links; increase of existing, or emergence of new, drought regions, leading to restricted access to water supply; impacts on operations due to increasing precipitation.
- **Changing icing conditions:** increased use of pavement deicers; reduced airport capacity; increased use of aircraft de-icing and anti-icing.
- **Changing wind:** increased risk to aircraft operations due to high and varying winds conditions; changes to prevailing wind direction; potential risk of ground equipment being lifted and disrupting aircraft movements on ground; limitations to aircraft loading and unloading due to high winds; in extreme high wind conditions, reduced airport capacity due to air traffic control tower closures.
- **Desertification:** increased risk of soil erosion around runways, taxiways, and aprons; water shortages; disruptive sand storms; risk of encroachment of sand dunes on airport facilities; effects of sand on aircraft operations; effects of sand damage on airframes and engines.
- **Changes in biodiversity (wildlife and ecosystems):** changes in wildlife migration patterns; changes to the local biodiversity; increase in wildlife hazard.

These climate factors will impact airport infrastructure and operations, and the impacts to one airport may be extended to others due to the interdependencies of aviation networks. To build resilience, airports must identify the potential climate risks they face and take actions to minimize the impacts. Airport operators may also wish to consider how the effects of climate impacts could propagate through the local, national and wider aviation networks.

Risk[7] Exposure[8]

To identify the potential risks and improvement opportunities regarding climate change, airports may carry out climate change risk assessments.[9] The risks of climate change are often depicted graphically on a risk matrix as shown in Figure 1 below, and they can be expressed as a function of the probability of the event occurring and the severity of the consequence of the impacts. The outcome is often referred to as *risk exposure* and is a measure of the risk that the airport faces in relation to the climate impact. Considering that risks and exposure are generally based on a defined timeframe, risks may increase if a longer timeframe is applied.

SAFETY RISK		Severity				
Probability		Catastrophic	Hazardous	Major	Minor	Negligible
		A	B	C	D	E
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E

Figure 1. ICAO Risk Matrix DOC 9859 - 4th Edition[10]

Industry Recommendations

ACI's resolution[11] and policy brief on resilience and adaptation to climate change[12] recommends airports take four primary actions with respect to their adaptation planning:

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[7] The definition of risk used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC**
Risk = the potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain. In the context of the assessment of climate impacts, the term risk is often used to refer to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence.
Available at: **https://www.ipcc.ch/sr15/chapter/glossary/**

[8] The definition of exposure used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC**
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. Available at: https://www.ipcc.ch/sr15/chapter/glossary/

[9] The definition of risk assessment used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC**
Risk assessment = the qualitative and/or quantitative scientific estimation of risks. Available at: **https://www.ipcc.ch/sr15/chapter/glossary/**

[10] The Safety Management Manual (SMM), 4th Edition.
https://www.icao.int/safety/SafetyManagement/Pages/Access%20to%20ICAO%20%20Annexes%20and%20Guidance%20Material.aspx

1) Consider the potential impact of climate change when developing Master Plans;
2) Conduct risk assessments of aircraft operations and infrastructure based on potential climate impacts;
3) Develop and incorporate actions at an early stage according to the risk assessment, in line with the overall business plans and emergency plans; and
4) Develop effective communication channels with all airport stakeholders and local emergency management officials.

Resilience Planning

Airports want to be prepared for potential risks, and Master Plans are one of the ways climate impacts can be considered and aligned with overall airport planning for future development. Alternatively, a climate change risk assessment and adaptation plan may be developed as a 'stand-alone' corporate approach. Airports already use numerous planning processes including asset management plans, irregular operations plans, or enterprise risk management systems, and all of these can be useful to an airport in adapting to climate impacts.[13]

The process for developing an Airport Master Plan is described in ICAO document 9184, *Airport Planning Manual (Part I and II)*. Many States have developed their own planning guidance based on this. A master plan is a guide for development of future airport facilities, and the Airport Master Plan is an effective place to integrate climate considerations and work towards resilience. The master plan should make resilience and adaptation to climate impacts one of the primary goals of the planning process. The master plan process will usually discuss current services and operational activity to identify issues and needs for future growth. Resilience would then be considered in the assessment of needs along with other factors. As the planning process looks at future aviation forecasts and the facility requirements that will be needed, resilience will feature in the development and evaluation of alternatives for future airport growth. The master plan process usually culminates in a discussion of the importance and priority of certain elements identified in the plans, as well as the financial feasibility of these actions. While resilience measures may add costs to future development, consideration of these measures within the master planning process should balance the overall assessment of costs and benefits to highlight measures the airport can implement to meet their goals.

Of course, planning for resilience does not have to be limited to an airport master plan. Some airports have developed separate resilience management plans. There are a number of key steps suggested when developing a framework to address climate change impacts. The process usually begins by identifying climate risks to operations and infrastructure. Once risks are identified and prioritized, corresponding actions which would mitigate those risks can be defined. The next step is to develop an action plan to implement those actions.

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[11] ACI Resolution 3/2018, https://aci.aero/news/2018/06/22/28th-aci-world-annual-general-assembly-passes-six-resolutions-to-support-world-airports-priorities-and-interests/

[12] ACI Policy Brief, *Airports' Resilience and Adaptation to a Changing Climate*. September 2018.

[13] *Using Existing Airport Management Systems to Manage Climate Risk*. (2018). ACRP Research Report 188, Available at - http://www.trb.org/Main/Blurbs/178312.aspx

Potential steps in the process might include the following:[14]

1. Develop a project team and identify stakeholders that may include airlines, tenants, community members, and others. External partners such as local utilities and transportation agencies may also play critical roles in airport resilience.
2. Research climate projections for the location and understand the risks they pose to airport assets and operations.
3. Prioritize those risks based on the comparison of risk and exposure (described above).
4. Consider short and long term adaptation strategies that can minimize risk and exposure.
5. Develop a climate adaptation plan to mitigate the expected effects on operations and infrastructure at the airport. This may include integrating actions into airport planning documents and procedures to enhance resilience.
6. Measure and track actions as they are implemented in order to report on their success. Some may be easy to assess with metrics, others may be qualitative in nature.

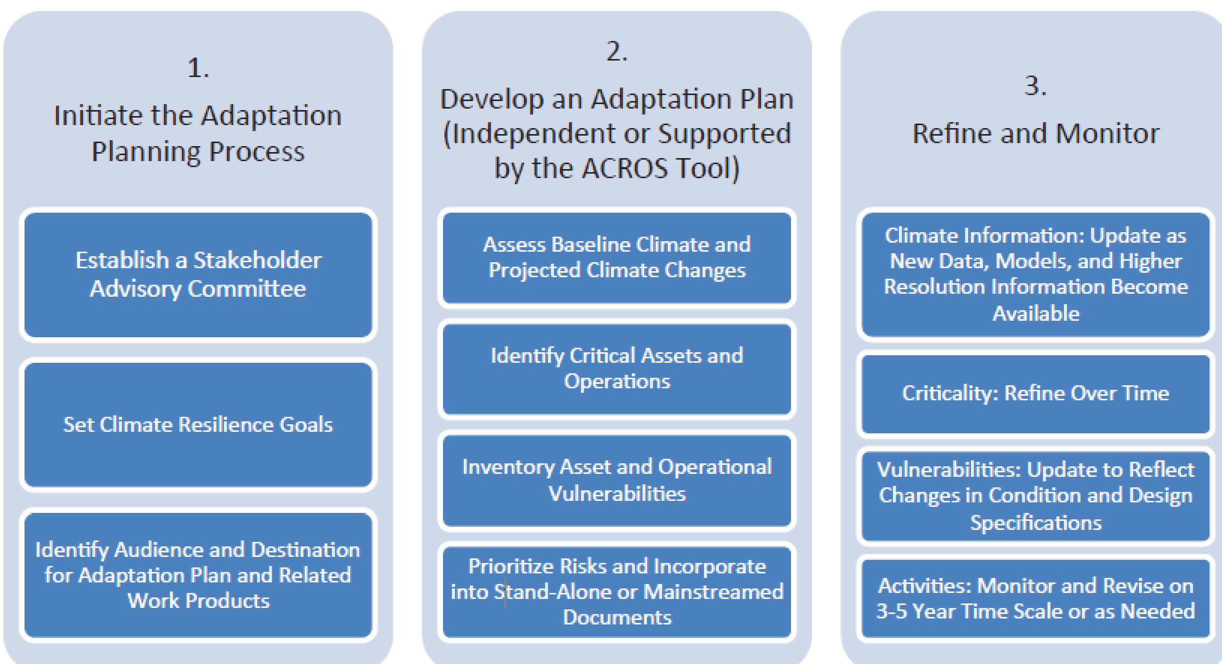

Figure 2. Components of the climate change adaptation planning process[15]

[14] Similar steps were described in ACRP Report 147, Climate Change Adaptation Planning: Risk Assessment for Airports. (2015), U. S. National Academy of Sciences. Available at - https://crp.trb.org/acrp0267/acrp-report-147-climate-change-adaptation-planning-risk-assessment-for-airports/

[15] ACRP Report 147, Climate Change Adaptation Planning: Risk Assessment for Airports. (2015), U. S. National Academy of Sciences.

Furthermore, airports may wish to re-evaluate the climate projection data every five to ten years to ensure the plan and its priorities remain in line with projected future climate conditions and airport goals.

Reporting and Communications

Communicating airport adaptation efforts helps the aviation community and stakeholders understand the issues involved in resilience planning and appreciate efforts taken by the airport to overcome those issues. Airports with robust climate adaptation plans can achieve this by reporting on their efforts. One good example is Heathrow Airport (LHR), which publishes reports of adaptation progress online.[16] Such communication also helps share ideas and best practices with other airports.

Airports have emergency communication systems that often include an Emergency Operations Center (EOC) that is used during crisis events. Not only are these communication systems tied to the airlines but they often extend to tenants and other relevant parties. Maintaining an accurate and updated contact list is vital to ensuring effective communication. The EOC should have existing emergency plans and standard operating procedures to address potential events such as storm surge, flooding and other storm related events. Prompt and accurate information can help the airport population respond in advance of potential events. Hong Kong Airport has an excellent communication plan in place which was triggered successfully in August 2017 during the Typhoon Hato. The plan was activated alerting the public using digital displays in the terminals, public announcements through the local media, airport website, mobile application and media briefings.[17]

Stakeholder Engagement[18]

Preparing to handle more severe weather events, and in greater frequency, requires coordination with several stakeholders from inside and outside the aviation sector. For instance, receiving information in advance from meteorological agencies, and working in collaboration with the municipality and other aviation stakeholders to promote business continuity and proper handling of constrained passengers is essential before, during and after an event. Several airports work in close cooperation with relevant stakeholders in order to improve efficiency of action. For instance, critical utilities necessary for airport operation could be discussed with service providers.[19]

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[16] https://climate-adapt.eea.europa.eu/metadata/case-studies/assessing-adaptation-challenges-and-increasing-resilience-at-heathrow-airport

[17] ACI World Resilience and Adaptation to a Changing Climate Policy Brief. Available at: https://store.aci.aero/wp-content/uploads/2018/10/Policy_brief_airports_adaption_climate_change_V6_WEB.pdf

[18] The definition of Stakeholder Engagement used in this publication is adapted from the UNGP Reporting Framework (United Nations Guiding Principles).

Stakeholder engagement = an ongoing process of interaction and dialogue between an organisation and its stakeholders that enables the organisation to hear, understand and respond to their interests and concerns, including through collaborative approaches. Available at: https://www.ungpreporting.org/resources/glossary/

[19] Please also refer to ICAO Circular 351, Community Engagement for. Aviation Environmental Management.

Additional considerations:

Airports as Relief and Shelter

When major disruptive events such as hurricanes or tsunamis occur, airports want to recover and resume operations as soon as possible, but they often assume additional roles in the immediate aftermath of events beyond the usual activities, such as humanitarian relief for emergencies. In fact, airports may become the centralized hub for emergency response with incoming supplies and personnel flying into the airport while emergency/medical evacuation occurs on the other side. In addition to food and shelter for stranded passengers, refugees from storms and floods often go to the airport where they expect to find access to drinking water and other amenities.

Large airports may be equipped with resources to act as EOCs with emergency power sources, available conference rooms, multiple phone lines, security staff and food and water stores. Smaller airports that do not have these resources may nonetheless be called to act as EOC sites, due to their proximity to the disruptive event and their ability to conduct relief operations. When a disaster event prevents operations at a location, airports in close neighboring areas to such events may provide support too. ICAO is currently working with the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), ACI, International Air Transport Association (IATA) and the Civil Air Navigation Services Organization (CANSO) to develop guidance on airport preparedness for disaster relief.

The United States' Federal Emergency Management Agency (FEMA) provides an assessment checklist for evaluating an EOC.[20] The checklist covers the following six areas: facility features, survivability, security, sustainability, interoperability and flexibility. A good resilience plan should take into account such consideration. Many of these elements may be already covered within the airport's emergency operations plan.

Combining Mitigation[21] with Adaptation

Resilience and adaptation considerations can be incorporated into different projects, including those focused on reducing CO_2 emissions. In fact, airports planning CO_2 mitigation projects should include resilience and adaptation assessments at design stages of these initiatives, combining efforts to both reduce contributions to climate change and to become more resilient to its potential impacts. This is the case when, for example, investment is made into a solar farm at the airport site: it makes sense to adapt the project to be more resistant to more adverse weather events expected at that particular location and also benefit from the energy independence of the system. An example is Honolulu International Airport, where they are installing solar panels at the airport's Terminal 2 parking garage. This initiative is expected to reduce energy consumption, provide covered parking, and generate cleaner forms of energy for the airport's operation. By doing so, the airport is expected to become more energy independent, and thus more resilient to adverse weather impacts.

[20] See: https://www.fema.gov/emergency-operations-center-assessment-checklist

[21] The definition of Mitigation of climate change used in this publication is from the IPCC **2018 Special Report: Global Warming of 1.5 ºC**.
Mitigation (of climate change) = a human intervention to reduce emissions or enhance the sinks of greenhouse gases. Available at: **https://www.ipcc.ch/sr15/chapter/glossary/**

The Task Force on Climate-related Financial Disclosures

Climate risks are also associated with potential economic impacts. Understanding those has become an important element among stakeholders around the globe. Investors and other stakeholders have become more interested in having access to this type of information. A useful related initiative is the Task Force on Climate-related Financial Disclosures. It was created to support voluntary climate-related financial disclosures with the objective to provide a transparent decision-useful information to lenders, insurers, and investors. It can be a useful tool for airports and other stakeholders working through a resilience framework. [22]

Aircraft operational considerations

As airports are designed to facilitate aircraft operations, attention must be placed on the effects of mitigation and adaptation measures on aircraft operations. As an example: caution should be taken that glare from solar panels does not hinder pilot visibility during takeoff and landing; a sea wall must be designed so that it does not induce adverse wind , wake or turbulence effects for aircraft landing or taking-off.

Some Available Resources

Some States have developed guidance to assist airports in preparing for climate changes. Transport Canada and Natural Resources Canada released a foundational knowledge synthesis in 2017 entitled *Climate Risks and Adaptation Practices for the Canadian Transportation Sector 2016*.[23] The report presents regional chapters which include observed climate impacts, future risks, opportunities and adaptation approaches for road, rail, air and marine transportation in Canada. In the United States, FEMA developed a website with resources to help manage and prepare for climate change providing different tools and data, as well as strategies, policy and publications.[24] EUROCONTROL has fact sheets available online: https://www.eurocontrol.int/update/adapting-aviation-changing-climate . ICAO has developed a series of Fact Sheets describing potential impacts to aviation from climate change, available at: https://www.icao.int/environmental-protection/Pages/Climate-Adaptation.aspx .

Examples of Action

Many airports have taken steps to strengthen their facilities against potential impacts of future climate. Actions are based on individual airports risk assessments and there is no 'one fits all' solution. It depends on the type of potential climate impacts each airport is faced with in the timeframe they've decided to consider and the consequent level of risk they are willing/able to take combining with their ability to implement adaptation measures from an economic perspective too. Some of the examples were highlighted in aforementioned ACI policy brief, presenting cases from Asia, Europe, and North America. Several studies from US Transport Research Board (TRB) Airport Cooperative Research Program (ACRP), and Transport Canada[25] also provide examples of the sort.[26] Additional cases are available below.

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[22] Based on information available at the TCFD website: https://www.fsb-tcfd.org/about/#

[23] Palko, K. and Lemmen, D.S. (Eds.). (2017). *Climate Risks and Adaptation Practices for the Canadian Transportation Sector 2016*. Ottawa, ON: Government of Canada.

[24] See: https://www.fema.gov/climate-change

[25] See: https://www.nrcan.gc.ca/environment/impacts-adaptation/10029

Toronto Lester B. Pearson International Airport (Canada)[27, 28]

From January 5 to 9, 2014, a combination of rain, snow, snow squalls, and wind chills/extreme cold in Eastern Ontario and other parts of Canada (reaching -39ºC with windchill) severely disrupted passenger travel at many airports in Canada, including Toronto Pearson International Airport. Extreme cold and ice build-up slowed ground crews and caused some equipment (e.g., fueling) to fail or operate intermittently. The temperature drop also caused snow and slush on taxiways, apron, and gate areas to freeze. Temperatures were too cold for chemical treatments to effectively melt the ice and snow. These operational impacts along with other factors (such as the airport receiving high numbers of diverted flights from other airports), created delays and disruptions in passenger travel throughout Canada. In response to this event, the Greater Toronto Airports Authority (GTAA) developed recommendations for future improvements, such as:

- Improving communication protocols with airlines and other airport service providers, by developing a clear, consistent and accurate flow of information among service providers;
- Creating a passenger-facing app, enhancing joint protocols, developing the necessary processes and other tools for irregular operations communications to passengers, media and Toronto Pearson employees to enable timely and effective communication; and
- Establishing an 'Airport Updates' web page that becomes the GTAA website's dominant web page during a service disruption.

Amsterdam Airport Schiphol (Netherlands)

At Amsterdam Schiphol Airport a Water Sensitive Airport Framework is in place.[29] In 2010, Schiphol unveiled its Water Management Plan 2015. The plan reflects a number of priorities: water quality (clean water), water quantity, airport planning, maximizing the potential for sustainability and innovation in water use, and how to limit impacts of incidents and accidents on water bodies.

Since then, Schiphol has commissioned a study to explore more ambitious and sustainable objectives as part of its Water Vision Schiphol 2030 strategy. The vision emphasizes coping with climate change, airport planning, and water management activities to 2030 and beyond, to ensure sustainable use of water across all airport activities.

Water Vision Schiphol 2030 goes beyond flood protection to encompass dealing with other extreme weather conditions: achieving a healthy ecosystem; climate-proof airport planning; and 'greening' airport operations. In October 2014 the UN Framework Convention on Climate Change (UNFCCC)

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[26] ACRP Synthesis 33, *Airport Climate Adaptation and Resilience* (2012); Report 147 *Climate Change Adaptation Planning: Risk Assessment for Airports* (2015); Report 188, *Using Existing Airport Management Systems to Manage Climate Risk* (2018).

[27] Woudsma, C., and Towns, W. (2017). Ontario. In K. Palko and D.S. Lemmen (Eds.), Climate risks and adaptation practices for the Canadian transportation sector 2016 (pp. 139-179). Ottawa, ON: Government of Canada.

[28] https://www.torontopearson.com/en/community/get-involved/community-conversations/winter-operations-disruption-2014

[29] Creating water sensitive airports in times of climate change (2016). International Water Week at Singapore, Volume: 2016. Available at - https://www.researchgate.net/publication/305477965_Creating_water_sensitive_airports_in_times_of_climate_change

included the Water Vision Schiphol 2030 in the Private Sector Initiative database of actions adapting to climate change.

New Mexico City International Airport (Mexico)[30]

For a greenfield project such as the new Mexico City International Airport, the opportunity exists to incorporate water management and flood resilience into the design process from the earliest stages. The problem is that Mexico City is a fast-growing metropolis that faces serious water challenges in terms of subsidence, soft soil conditions, droughts, earthquakes, flash flooding, water supply, and sanitation.

The site for the new airport was historically a lakebed, the drained Lake Texcoco, which makes the subsurface conditions very challenging for the engineers and planners. As a solution, the engineers mentioned using a 2-3 m thick layer of tezontle: this volcanic material, common in Mexico, offers a permeable layer, which can provide ground water replenishing in addition to the airport storm water drainage facilities.

The main passenger terminal for New Mexico City International Airport is to obtain LEED v4 Platinum Pre-Certification from the US Green Building Council. A number of large funnel-shaped columns support the roof of the terminal (one of the largest in the world), enabling rainwater to be harvested and fresh air to be admitted. To optimize water usage and support airport sustainability, wastewater will be treated and recycled to supply 80% of non-potable water demand for the whole site, such as landscaping, indoor flush fixtures, and cooling towers.

In essence, creating resilient airports is not just about protecting infrastructure and operational assets from flooding caused by sea, rivers, and storms. It is also about enabling airports to become more sustainable and improve local water, climate, and energy management - something that airports will have to embrace if they want to continue thriving.

Nice Cote d'Azur Airport (France)[31]

At Nice airport, the system of parallel runways, partially built in the sea and at low altitude, will be vulnerable to maritime hazards such as rising sea level and rough seas during storms. Due to climate change, the frequency and intensity of these hazards will increase.

"Aéroports de la Côte d'Azur", the operator of the airport, conducted a maintenance campaign for existing embankments and sea dikes.

The works, costing € 10.40 million and carried out from 2011 to 2013, aimed to strengthen the rip-rap areas that protect the airstrips maritime side of the airport.

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[30] Note that this describes planning for the airport project which has now been moved. The new airport will be built at a site called Santa Lucia: https://en.wikipedia.org/wiki/Mexico_City_Texcoco_Airport https://www.reuters.com/article/us-mexico-airport/new-mexico-city-airport-to-go-in-service-by-mid-2021-official-idUSKCN1S22CU

[31] See the airport website for more information: https://en.nice.aeroport.fr/

Iqaluit Airport (Canada)[32]

Iqaluit International Airport is extremely important to communities in Nunavut given the region's lack of road access. When the airport was constructed in 1942, little was known about the underlying permafrost and its importance to the safety and viability of airport operations. However, many problems related to permafrost – including runway stability issues stemming from thaw settlement of ice-rich soils – have occurred at the airport over its lifespan. Along with the need for expansion and facility replacement, permafrost issues prompted the development of an improvement plan by public and private partners.

In 2013-2014, the *Iqaluit International Airport Improvement Project* was initiated; by then, the importance of understanding the nature, location and influence of permafrost degradation on infrastructure was well-understood. A number of research projects were undertaken, employing a variety of techniques – including ground-penetrating radar, permafrost core analysis, surficial mapping, and remote sensing – to generate site-specific knowledge about permafrost properties and model interactions among permafrost, climate, and airport infrastructure (both existing and proposed). A key finding of this work is that permafrost tends to be subject to greater warming under pavement than embankments (and other "naturalized" surfaces).

The data collected has been used to inform infrastructure decision-making. Maps were produced to identify potentially-problematic locations for existing and proposed infrastructure (e.g., thaw-sensitive soils and/ or difficult terrain for construction); a taxiway was relocated with an insulated barrier to reduce permafrost damage; the importance of removing thick snow cover in key areas was recognized; thermosyphons were installed beneath airport buildings; and drainage was improved to reduce the infiltration of surface water into permafrost. Overall, informed engineering and operational decisions have been made at the airport with respect to the integrity of the underlying permafrost.

— END —

[32] Pendakur, K. (2017). Northern Territories. In K. Palko and D.S. Lemmen (Eds.), *Climate risks and adaptation practices for the Canadian transportation sector 2016* (pp. 27-64). Ottawa, ON: Government of Canada. Case Study 3: Infrastructure Improvements at Iqaluit International Airport, page 53. See: www.tc.gc.ca