London Luton Airport Operations Limited (LLAOL)

Climate Change Adaptation Report (CCAR)

November 2021

Executive summary

Purpose of this report

This report has been produced for the purpose of providing an assessment of climate change risks to London Luton Airport (LLA)'s assets, operations and strategic functions. This report has been prepared as part of Defra's Third Round of Adaptation Reporting to inform the UK Government's Third Climate Change Risk Assessment (CCRA3). This report provides an update on LLA's approach to adaptation and the key climate change risks since the previous adaptation report which was published in 2011[1]. As part of the development of this report Wood has consulted with internal stakeholders within LLA including the sustainability, operations, commercial and technical services teams.

LLA's recognise the potential impacts of climate change and have an increased ambition to mitigate and adapt for the potential impacts of climate change. Adaptation to climate change is essential since historic GHG emissions have already committed us to some degree of climate change which will manifest as physical risk to organisations and infrastructure assets. This report assesses the risks and opportunities relating to:

- **Physical risks**: these result from events (acute) or longer-term shifts (chronic) in climate patterns. They may cause direct damage to assets and indirect impacts from supply chain disruption.
- **Transition risks**: 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. These transitions may vary in speed and may have financial (revenue or expenditure costs) or reputational risks to organisations.
- **Opportunities**: efforts to mitigate and adapt to climate change also produce opportunities for organisations, for example, through resource efficiency and cost savings, the adoption of low-emission energy sources, the development of new products and services, access to new markets, and building resilience in operations.

Approach to considering risks and opportunities

The CCAR assessment considers three time periods:

- **Baseline –** UK climate projections for the period 1981 – 2000 to represent baseline conditions.
- **Short-term** – the period 2021-2040 (2030s) is used to understand short term risks in the physical risk assessment (in line with LLA's concession agreement).
- **Longer-term** – the period 2061-2080 (2070s) is used to assess long term risks in the physical risk assessment, which covered the anticipated design life of assets at the airport.

Risks and opportunities have been identified and assessed using a standardised risk assessment framework which considers **thresholds for impact**, the **likelihood of events** and the **severity of impacts**. The framework has additionally been expanded to include a high-level assessment of transition risks at LLA to reflect current best practice and TCFD guidance. It should be noted that this does not represent full scenario analysis and is not aligned to TCFD reporting requirements. This work is just an initial step toward the wider

[1] The previous report was submitted by LLAO as part of CCRA1. LLAO did not submit a report during the second reporting round (CCRA2).

suite of climate change assessment work which will include further scenario analysis, horizon scanning and implementation of TCFD recommendations.

A summary of the key risks and opportunities is in the next table.

Risk	Baseline	2030s	2070s
Physical	The key risks are **around heavy rainfall and flooding of drainage infrastructure** followed by **increased temperatures** leading to impacts to working conditions, colder conditions increasing de-icing requirements and **low ceiling heights** impacting airport operations.	**Risks from increased temperatures** become more prominent and also include impacts on take-off weights, other temperature (hot and cold) risks are also high, and rainfall related flooding remains a potential issue though improvements to the onsite drainage system are anticipated to reduce risks. **Higher risks** also start to appear associated with the **wider aviation sector.**	The risk profile is similar to the medium term, though with **higher temperatures pushing more associated risks to fore**, including potential infrastructure damage and passenger wellbeing impacts.
Transition	The key risks are around meeting policy requirements (including **credible net zero strategies**) and **implementation of TCFD recommendations** as week as **technological change** triggering substantial investment and/or disruption.	The **baseline risks remain high**, but market risks around **decreases in demand or capacity limits** also come to the fore. **Reputational risk** linked to perceptions also become more important.	**Risk profile is similar to the 2030s**, though **reputational risks continue to increase**.
Opportunities	The **transition to a lower carbon economy** offers the potential for LLA to **take a leading role** in guiding change and development in the aviation sector. There may also be opportunities around a **longer summer season**.	**Options around the low-carbon transition continue to increase** and the **decrease in frequency** (though possibly not severity) of **fog and low temperature** events may also present opportunities.	**Further growth in low carbon economy opportunities**, with the greatest potential around supporting new technologies / operational measures / better infrastructure for the aviation sector.

Recommendations and summary

LLA recognises the need to identify and embed climate change adaptation and mitigation within LLA's strategic business planning. The physical impacts of climate change and the transition to a lower carbon economy represent both risks and opportunities to the airport that need to be assessed through integration into existing LLA risk governance processes and adapted to/mitigated against where required.

- Adaptation will include investment in upgraded physical infrastructure (such as the upgrade of the surface water drainage system) and further scenario analysis, horizon scanning to understand the actions associated with TCFD requirements.
- Mitigation will require development of net zero strategy which LLA have committed to develop in 2022.

The Sustainability Team at LLA will have overall responsibility for reporting, monitoring and review of the climate change adaptation risks and actions. However, in line with internal LLA processes, identification of risks, compliance with risk control measures and reporting to department leads, Directors and the Board will be the responsibility of specific teams and departments within LLA. This integration as part of standard business activities at LLA will allow consideration of climate change risk and opportunities to become part of LLA's strategic business planning.

Contents

1.	**Introduction**	**5**
1.1	Climate change overview	5
1.2	Approach to climate change at London Luton Airport	6
	1.2.1 Climate change mitigation	6
	1.2.2 Climate change adaptation	7
1.3	Purpose of the report	7
1.4	Progress since previous report	8
2.	**Profile of London Luton Airport**	**10**
2.1	Organisation context	10
2.2	Internal change governance	10
2.3	Climate change objectives	10
2.4	Risk management approach at LLA	11
3.	**The climate change adaptation process**	**12**
4.	**Physical risks**	**14**
4.1	Understanding the risk and setting thresholds	14
4.2	Quantifying the risk	15
	4.2.1 Summary	15
	4.2.2 Quantifying all physical risks	17
5.	**Transition Risks**	**20**
5.1	Understanding the risk	20
5.2	Quantifying the risk	20
6.	**Opportunities**	**23**
6.1	Understanding the opportunities	23
6.2	Quantifying the opportunities	25
7.	**Adaptation actions**	**26**
8.	**Monitoring and reporting**	**30**
9.	**Summary**	**31**

Appendix A	Progress against AP1 Actions
Appendix B	Approach to quantifying and managing risk
Appendix C	Impacts at LLA in a 2°C and 4°C world
Appendix D	Direct and indirect physical risks identified and included in the assessment

1. Introduction

1.1 Climate change overview

Climate change is regarded as one of the most significant threats of our times and increasing focus is being paid to mitigate and adapt for the future. The 2014 Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[2] concluded that observed warming of the climate system is unequivocal, and impacts are recognised at regional and local scales. The Sixth Assessment Report is anticipated to be published in 2021-2022, with the first report providing an updated physical understanding of the climate system and climate change expected in August 2021. Progress in planning and delivering adaption measures in the UK is not keeping pace with increased risk and there is an urgent need for adaptation action to increase in the UK[3].

The extent of future climate change is linked with the effectiveness of efforts to limit GHG emissions. In November 2016, the Paris Agreement[4] came into force in which the majority of countries agreed to work together to limit global temperature rise to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. It was acknowledged within the Paris Agreement and the subsequent Special Report[5] by the IPCC that the lower temperature limit would significantly reduce the risks and impacts of climate change. The Paris Agreement calls for global emissions to peak as early as possible and then fall to net zero later this century. It also acknowledges the role of adaptation to the adverse impacts of climate change, calling for an increased ability to foster climate resilience.

The UK Government has set a clear priority for taking action on climate change. In July 2019, the UK became the first major global economy to pass legislation to achieve 'net zero' greenhouse gas (GHG) emissions by 2050[6]. In December 2020, the UK communicated its new Nationally Determined Contribution (NDC) under the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC). The NDC[7] commits the UK to reducing economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels. This commitment was also strengthened in the setting of the UK's sixth carbon budget which requires a reduction in GHG emissions by at least 78% by 2035 relative to 1990 levels, including emissions from international aviation and shipping[8].

Historic GHG emissions have already committed us to some degree of climate change, which is having a global effect today, manifesting as physical risks to organisations. For the UK, future climate projections show that climate change is projected to lead to increasing temperatures, changing rainfall patterns, increasing flood risk and more extreme weather events. The UK Government is required, under the Climate Change Act 2008 to publish a climate risk assessment every five years. Currently, the process is ongoing to develop the third report (CCRA3) which will be based on independent technical advice provided by the Climate Change Committee (CCC) and reports produced by organisations including strategic airport operators, road and rail providers, energy generators, water companies, electricity transmission companies etc[9]. The recently

[2] IPCC (2014), AR5 Synthesis Report: Climate Change 2014, [online]. Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf
[3] CCC (2021). Progress in adapting to climate change 2021, [online]. Available at: https://www.theccc.org.uk/wp-content/uploads/2021/06/Progress-in-adapting-to-climate-change-2021-Report-to-Parliament.pdf
[4] UNFCCC (2015), The Paris Agreement, [online]. Available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[5] IPCC (2018). Special Report: Global Warming of 1.5°C, [online]. Available at: https://www.ipcc.ch/sr15/
[6] UK Government (2019). The Climate Change Act 2008 (as amended), [online]. Available at: https://www.legislation.gov.uk/ukpga/2008/27/contents
[7] UK Government (2020), The UK's Nationally Determined Contribution communication to the UNFCCC, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943618/uk-2030-ndc.pdf
[8] UK Government (2021), The Carbon Budget Order 2021, [online]. Available at: https://www.legislation.gov.uk/uksi/2021/750/contents/made
[9] Defra, (2018), List of organisations reporting under adaptation reporting power: third round, [online]. Available at: https://www.gov.uk/government/publications/climate-change-adaptation-reporting-third-round/list-of-organisations-reporting-under-adaptation-reporting-power-third-round

published technical report on UK Climate Risk[10] states that the gap between the level of risk the UK faces and the level of adaptation underway has widened. The principals for good adaptation endorsed by the CCC includes understanding threshold effects, assessing risks for a future climate warming scenario equivalent to ~4°C of global warming by the end of the 21st century (a "4°C scenario"), considering opportunities and integrating adaptation. These principles are part of this report.

The UK's climate change risk assessment[11] suggests that these impacts are likely to result in disruption and damage to infrastructure and loss of essential services. Hence, it is necessary to explore how resilient the services, assets and infrastructure upon which society relies are to the impacts of climate change, as well as continuing to reduce emissions. This report examines the resiliency of assets and operations at London Luton Airport (LLA) to inform the UK's updated risk assessment.

1.2 Approach to climate change at London Luton Airport

LLA have acknowledged the need to consider carbon emissions and climate change adaptation within the Responsible Business Strategy 2020-2025[12] developed by the airport operator London Luton Airport Operations Ltd. (LLA). Within this strategy six focus areas were highlighted. One of the six focus areas is to ensure environmental responsibility and efficiency with the aim to minimise the environmental impacts from the airport. Within this focus area, carbon emissions and climate change were identified as targets that address the key issues.

The weather and climate are a daily consideration for aviation operators and airlines as it plays a critical role in safety procedures. Past experiences of poor weather have led to learning opportunities and helped to inform operational and emergency procedures including further investments in winter operation procedures and equipment with upgrade works ongoing.

1.2.1 Climate change mitigation

Awareness of the need to protect our environment has never been higher and the requirement for aviation to decarbonise quicker, never clearer. LLA have committed to playing a key role in ensuring the UK Government net zero target is achieved, including developing infrastructure to help airlines to reduce their GHG emissions. LLA have also committed to achieving net zero emissions for Scope 1 and 2 sources, by 2040. LLA have also set targets to reduce emissions from the emission sources they directly or indirectly control including sourcing all electricity from renewable sources, generating at least a quarter of the electricity demand from on-site renewables and reducing energy demand per passenger. Further details of the actions LLA are taking to mitigate climate change, and how these are related to the outstanding planning application, can be found in their outline Carbon Reduction Plan[13].

London Luton Airport is actively involved in climate change mitigation, particularly through the aviation sector group, Sustainable Aviation, a coalition of UK airlines, airports, aerospace manufacturers and air navigation service providers. The coalition is working collaboratively to address the future sustainability of the aviation sector. Airport signatories are committed to a sustainable future through addressing local air quality issues; reducing their carbon footprint by implementing energy saving measures; engaging with local communities and other key stakeholders; and sharing environmental management best practice between airports.

[10] CCC (2021), Independent Assessment of UK Climate Risk Advice to Government for CCRA3, [online]. Available at: https://www.theccc.org.uk/wp-content/uploads/2021/07/Independent-Assessment-of-UK-Climate-Risk-Advice-to-Govt-for-CCRA3-CCC.pdf.
[11] UK Government (2017), UK Climate Change Risk Assessment 2017, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584281/uk-climate-change-risk-assess-2017.pdf
[12] London Luton Airport (2019), Our Responsible Business Strategy 2020 – 2025, [online]. Available at: https://www.london-luton.co.uk/LondonLuton/files/eb/eb79ca97-d37c-4803-9f89-c4965a466814.pdf
[13] LLAOL (2021) Outline Carbon Reduction Plan, [online]. Available at: https://planning.luton.gov.uk/online-applications/files/B04F31C56B95C4F7248C376CBD2A17AB/pdf/21_00031_VARCON-CARBON_REDUCTION_PLAN-934819.pdf.

1.2.2 Climate change adaptation

LLA have previously assessed and reported on adaptation to climate change in the first round of UK adaptation reporting in 2011[14]. Within the Responsible Business Strategy[12], a key target is focused on building climate adaptation measures at the airport. LLA made a commitment to identify climate change risks and develop a resilience plan and integrate it into business risk assessment process by the end of 2022. This adaptation report represents the first step in the process.

The 2011 Climate Change Adaptation Report (CCAR)[14] highlighted the top 10 climate-risks that were prioritised for adaptation action. These risks include impacts to airfield operations, surface access (roads and car parks), airport terminal operations, and airport cargo from climate hazards including increasing frequency of extreme weather events; milder, wetter winters; warmer, drier summers; and prolonged hot days and nights. This report will provide an updated and more comprehensive assessment of the climate-related risks and the adaptation measures required to increase resilience to them.

It is acknowledged that climate change presents both risks and opportunities to organisations. The Task Force on Climate-related Financial Disclosures (TCFD) has divided climate-related risks into two major categories – physical and transition risks. Over the past decade, since the 2011 report, adaptation efforts at LLA have primarily focused on physical risks. This report represents increased ambition to prepare for the impacts of climate change and will consider physical risks, transition risks and climate-related opportunities:

- **Physical risks**: these result from events (acute risks) or longer-term shifts (chronic risks) in climate patterns. They may cause direct damage to assets and indirect impacts due to supply chain disruptions.
- **Transition risks**: 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. These transitions may vary in speed and may have financial or reputational risks to organisations.
- **Opportunities**: Efforts to mitigate and adapt to climate change also produce opportunities for organisations, for example, through enhanced resource efficiency and cost savings, the adoption of low-emission energy sources, the development of new products and services, access to new markets, and building resilience in operations.

1.3 Purpose of the report

Section 62 of the Climate Change Act 2008[6] sets out the Adaptation Reporting Power (ARP) which gives the Secretary of State the power to direct reporting authorities to provide details of the impact of current and projected climate change and to report on progress implementing adaptation actions. Completed reports will be analysed by the Government and used to help to map climate change risks across the UK and levels of preparedness across key sectors. This will help the Government to better understand the risks facing the UK and to address any problems that are raised.

LLA reported to Defra under the first round of the Adaptation Reporting Power (ARP) and is again reporting in the third round. LLA's most recent Climate Change Adaptation Report was published in 2011[14]. This Climate Change Risk Assessment report represents LLA's response to the third round of UK adaptation reporting. It provides an updated climate risk assessment, assesses LLA's resilience to current and future predicted effects of climate change and includes proposals for adapting to climate change. It has been prepared in accordance with Statutory Guidance from the Secretary of State and sector guidance from the Airport Operators Authority (AOA). As part of the development of this report Wood has consulted with

[14] London Luton Airport (2011), Climate Change Adaptation Report, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/184758/Archive_2.zip

internal stakeholders within LLA including the sustainability, operation, commercial and technical services teams.

The objectives of this report are therefore to provide:

- Information on progress against previously identified actions in adapting to climate change since the 2011 previous report;
- An updated risk assessment based on UKCP18 for physical risks;
- Increase the scope of the risk assessment to address transition risks and climate-related opportunities;
- Updated risk register and actions.

1.4 Progress since previous report

LLA provided a submission[14] to the Department for the Environment, Food and Rural Affairs (Defra) under the first round of the Adaptation Reporting Power (ARP) of the UK Climate Change Act 2008. The 2011 report identified key risks and opportunities from climate change, and established what the consequences would be for London Luton Airport and interdependent stakeholders. These risks were quantified using a qualitative framework. The impacts of climate change risks in 2020 and 2050 were considered within the report. A longer-term timescale of 2080 was not included given the site concession agreement for LLA ended in 2028 at the time of the report writing. Thresholds at which performance of London Luton Airport's assets are affected by extreme climate weather events were not considered.

Where current controls were deemed insufficient a series of prioritised adaptation actions were identified with actions assigned to 1 year to 15-year timescales. Progress on the individual actions is shown in **Appendix A**. Since 2011, LLA have enhanced their action on sustainability specifically with regards to climate adaptation and mitigation. Key actions and progress that LLA have made include:

- Improvements to winter operating procedures enhancing de-icing processes to increase efficiency whilst not compromising operations;
- Increasing de-icing capacity with the opening of new facilities to facilitate efficient winter operating procedures;
- Upgrades to air conditioning capacity in areas of the terminal building where this has been required;
- Review of current operating procedures in light of climate change events including incorporation of best practices from lived experience of extreme weather events including in the Winter Operations Plans and Staff Resourcing Plans;
- Investigation and ongoing re-design of the drainage system to increase capacity and ensure that this is fit for the future; and
- Publications of the Responsible Business Strategy[12] in 2019 which includes specific targets and actions on climate change adaptation and mitigation to ensure continued improvement over the period 2020-2025.

In the decade since LLA's first adaptation report, scientific understanding and governmental action on climate change have also progressed. In 2014 the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5)[2] was released providing robust evidence that "*human influence on the climate system is clear*". In 2018, the IPCC released a special report on the climate change impacts of a temperature increase of 1.5°C above pre-industrial levels[5] which is likely to be reached "*between 2030 and 2052 if [the trend] continues to increase at the current rate. (high confidence)*". This special report strengthened the global

response to the threat of climate change, including from the UK Government. The Climate Change Act 2008 was updated to commit the net UK carbon account for the year 2050 to be at least 100% lower than the 1990 baseline ('the UK carbon target')[6]. The UK carbon target is now often referred to as 'net zero'.

This increased ambition is mirrored by LLA who are committed to playing their part in ensuring this UK target is achieved. This report under the third round of ARP incorporates the increased scientific understanding of the last decade including new UK climate projections published in 2018 and increased understanding of potential variations in climate variables. With the increased ambition for climate change mitigation and the net zero target, it is clear that rapid decarbonisation is needed across the UK economy to transition to a low-carbon future compatible with net zero. LLA recognise that this transition could bring about both risks and opportunities to the business and have thus included consideration for transition risks within their adaptation report for the first time.

2. Profile of London Luton Airport

This report is prepared by LLA to cover all airport operations at London Luton Airport, Luton, UK. It is anticipated to inform a sectorial report provided by the trade association representing the interests of UK airports.

2.1 Organisation context

London Luton Airport (LLA) is owned by Luton Borough Council (LBC) through the company London Luton Airport Ltd (LLAL). The airport is operated, managed and developed by London Luton Airport Operations Ltd (LLA), until 31 March 2031. Aena (51%) and AMP Capital (49%) are the shareholders in LLA. LLA pays LBC (via LLAL) a concession fee based on passenger volumes.

LLA recognise their responsibility to support the local community and to mitigate any impact of their operations on the community and the environment and they therefore have responsibilities and duties within plans such as the Responsible Business Strategy and the Noise Action Plan.

2.2 Internal change governance

Risk management at LLA is built around a clearly defined governance structure. This provides a suitable framework to manage and ensure effective implementation of Health, Safety and Environment (HSE) policies, Safety Management Systems (SMS) and Environmental / Energy Management Systems (EMS / ENMS).

Climate change is a daily consideration for aviation operations, and past experience of poor weather at London Luton Airport has informed operational and emergency procedures. Managing the potential impacts of the weather is supported by meteorological information provided by the Met Office (TBC) and onsite monitoring equipment. Many of the operational risks associated with climate change are addressed within existing business risk management and operational procedures and generally focus on short to medium term impacts.

2.3 Climate change objectives

LLA's Responsible Business Strategy 2020-2025 sets out a long-term commitment to be a responsible and sustainable business. The strategy is in its early phases and is anticipated to develop over time in terms of the ambition and the actions within it. Within the RBS is the aim to minimise the environmental impacts of the airport including addressing carbon emissions and climate change. LLA are committed to playing our part to achieve the UK Government net zero target by 2050 and have committed to assess climate change risks for the airport and incorporating these into the business resilience plans. This CCAR acts as the first step in this process.

Climate change will not only affect the LLA business directly, but also poses risks for the airport through our supply chain. The RBS includes a commitment to identify the climate change risk for our strategic suppliers and develop a climate change resilience plan. LLA is actively involved in climate change mitigation, particularly through the Sustainable Aviation coalition of UK airlines, airports, aerospace manufacturers and air navigation service providers.

2.4 Risk management approach at LLA

LLA take a proactive approach to manage, assess, review and record business risk ensuring safe and responsible running of London Luton Airport. The process provides assurance that the risks to the Airport are, wherever possible, eliminated or reduced, and at all other times properly controlled or mitigated. The risk management process transcends all aspects of the business from senior managers in individual departments to AENA/AMP Capital Board of Directors.

All risks are assessed using the approved LLA risk assessment matrix to ensure consistency with corporate procedures. This method utilises a risk matrix that defines the level of risk (as a value between 1 and 25) by considering the severity of a risk against the likelihood of it occurring. This approach has been used in the CCAR development[15].

LLA have previously assessed and reported on the physical risks of climate change, including in the first round of adaptation reporting in 2011[14]. Here, for the first time, transition climate risks have also been considered to recognise LLA's increasing ambition with regards to responding to climate change issues. Due to the preliminary nature of the transition risk assessment, the detail is at a higher level at this stage and will need to be developed further in future years. Consideration of both physical and transition risks is in line with recommendations from the TCFD[16] and best-practice climate reporting.

Projections of climate change vary over time with potential hazards increasing or decreasing in magnitude and/or frequency over time. The risk associated with potential climate change hazards is therefore not static in time and must be considered evolving.

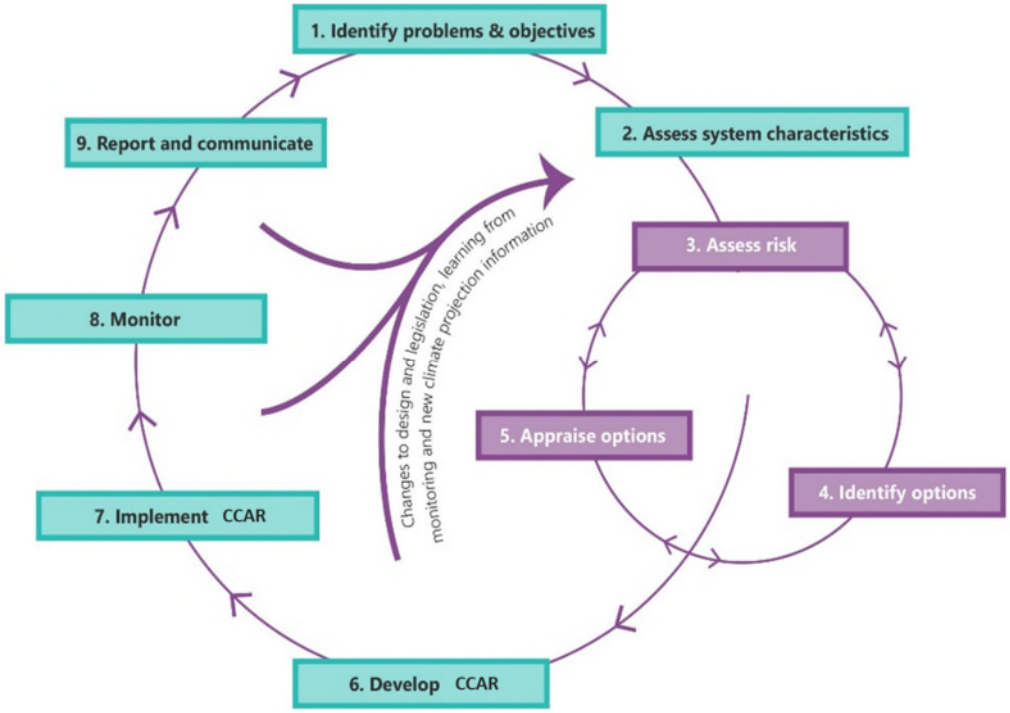
[15] Where required, the LLAOL risk assessment matrix has been aligned to the AOA template for the purposes of aviation sector-wide reporting conducted under AOA. While the methodology is consistent, the terminology used is different. In general, AOA take a slightly more conservative approach to categorising risk levels.

[16] TCFD (2017), Recommendations of the Task Force on Climate-related Financial Disclosures, [online]. Available at: https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf

3. The climate change adaptation process

The overall approach to delivering and maintaining an appropriate climate change adaptation process at LLA is shown in Figure 3.1. It enables the continual re-evaluation of the climate resilience of the airport using a 'plan, do, check, act' approach. The process will be updated whenever there is a need due to a legislative requirement (e.g. under the Climate Change Act 2008), improvements in data, at regular time intervals or due to learning from monitoring.

Figure 3.1 Overall approach to delivering and maintaining an appropriate climate change adaptation process at LLA. Source: Wood, 2019



The stages of the approach are characterised below:

1. **Identify the problem and objectives** – This includes setting out the context and rationale for carrying out the CCAR and defining the objectives that it sets out to achieve (see Section 1.2).
2. **Assess system characteristics** - The scope and boundaries of the system to be considered in the risk assessment is described in Section 1. Climate change impacts on the degradation of the service that the system provides (in this case passenger throughput, air transport movements (ATMs) etc.) will be considered.
3. **Assess risks** which could impact future operations – Where possible, critical thresholds (i.e. a point beyond which the performance of an asset or a system suffers an intolerable shift, such as a safety temperature limit at which a materials or infrastructure assets become unsafe due to vulnerabilities to damage) will be used to screen climate risks. However, where these are not available or easily defined, expert judgement will be used in combination with secondary evidence (see Sections **Error! Reference source not found.** to 6).
4. **Identify options** to mitigate climate risks and exploit opportunities – Adaptation options and solutions to enhance asset performance and overall system resilience will be identified (see Section

7). These could include hard engineering solutions, operational policies, investment strategies, behavioural change policies and nature-based solution.

5. **Appraise options** to mitigate climate risks and exploit opportunities – actions will be prioritised to increase resilience to the most prominent risks identified and will include consideration of no-regret options (see Section 7). These measures will include approaches for ensuring the overall resilience of the airport to risks related to direct physical climate change impacts, transition climate risks and interdependencies.

   Stages 3-5 will be iterative in the future, with assessment, option development and option appraisal revised to ensure that the options taken forward are optimal. In the future, a range of decision-making tools may be incorporated to aid this process.

6. **Develop CCAR** – The adaptation measures to be implemented will be set out in order of priority. The timescales and responsibilities for each will be documented within this report.

7. **Implement CCAR** and actions – The adaptation plan will be implemented ensuring there is accountability for implementation by management and reporting on actions to ensure those identified are delivered. This process will consider the policies, processes and operational activities that climate change adaptation will be embedded into.

8. **Monitor** the adaptation measures – The progress of the measures within the CCAR will be monitored and used to inform and influence updates to the risk assessment. Dedicated personnel within LLA are responsible for reporting, monitoring and review of actions within the CCAR with progress on actions published publicly, where relevant, within the Annual Monitoring Report. The Government adaption reporting cycle is five-years and as part of this process monitoring of progress in previous CCRAs should be conducted.

9. **Report and communicate** – Progress against the CCAR will be reported at regular intervals and to respond to all legislative reporting requirements (for instance, future rounds of reporting under the Climate Change Act 2008).

This report forms the CCAR described in Stage 6 and reports on the processes within Stages 1 to 5 of the above progress. Stages 7-9 will be implemented by LLA in the future and will be informed by the actions and recommendations contained within this report.

4. Physical risks

4.1 Understanding the risk and setting thresholds

Physical risks at LLA have been split into two broad categories:

- **Direct risks** which have an immediate effect to LLA (i.e., damages result from direct contact with the hazard) such as infrastructure damage at the site or delay/cancellations to take off and landing procedures. The direct risks considered in this assessment include:
  - Increases to maximum temperature (including daily temperature and seasonal variations);
  - Extreme winds (including mean wind speeds and wind gusts);
  - Rainfall / surface water flooding;
  - Snowfall;
  - Extreme cold;
  - Fog;
  - Low ceiling height;
  - Lightning / thunderstorms;
  - Blizzard conditions;
  - Extreme weather events; and
  - Sea level rise.
- **Indirect risks** where the effects occur within the wider aviation network or interdependencies but will have implications for LLA. (i.e., damages result from the hazard event, but not its direct impact). The indirect risks considered in this assessment include:
  - Indirect risks of increased temperatures;
  - Interdependency risk from electrical and power supply, water supply and the supply chain;
  - Risks to the wider aviation sector and especially to LLA's destination / origin airports.

Twenty direct risks have been identified to LLA. These risks have been established at a high-level based on a combination of LLA's previous climate adaptation report, results from the UK Climate Risk Assessment, UKCP18 projections, sector specific risk assessments and professional judgement. The risks and thresholds used to determine impacts are described in Appendix D, Table D.1. Also shown are current control measures in place to manage these risks. These control measures represent current practice and have been embedded into the risk assessment.

A further nine indirect risks have also been identified and assessed for LLA. As described in Appendix B, indirect risks are assessed on a qualitative basis only. These risks and control measures are described in Appendix D, Table D.2.

4.2 Quantifying the risk

4.2.1 Summary

Table 4.2 provides a risk register of all identified risks at LLA. The top five[17] headline risks to LLA that require an adaptation response from LLA are described in Table 4.1 for each of the time periods studied.

Key risks to London Luton Airport in the baseline scenario include extreme cold causing de-icing requirements, precipitation leading to flooding risk, and high temperature causing infrastructure damage or impacting operations. Over time climate change and the influence of planned actions to increase resilience will result in a change in the likelihood and severity, respectively, of key risks. Over the 2030s and 2070s, the key risks identified to LLA include increased average temperatures and extreme heat periods impacting operations (including take off procedures, thermal comfort in buildings, and work schedules) and infrastructure damage to airfield structures and fire risk. Other risks highlighted in the assessment include the risk from flooding and strong winds. Extreme cold and snow risk is a priority risk in the baseline scenario but decreases in priority in the long-term future scenario due to the likelihood of the events occurring decreasing.

It should be noted that *PR23 (Increased Temperature): Increased risk of communicable disease and epidemics* comes out highly ranked in all three time horizons, this is because (as has been seen through the COVID-19 pandemic) the severity of impact is Catastrophic. However, the cause of this risk is more complex than climatic changes and it is captured elsewhere in the LLA risk assessments, duplicating it here is viewed not appropriate as solutions will not be generated through climate change adaptation and response. Therefore it has been excluded from the information in Table 4.1.

[17] Note that in the baseline and 2070s time horizons more than 5 risks are listed due to equal scoring of multiple risks

Table 4.1 Top five[18] risks identified in the assessment for the various timescales

Rank	Baseline	Rank	2030s	Rank	2070s
1=	**PR8 (Rainfall):** Exceedance of drainage infrastructure capacity associated with minor surface (pluvial) flooding events	1=	**PR2 (Maximum Temperature):** Impacts on maximum take-off weight (MTOW)	1=	**PR2 (Maximum Temperature:** Impacts on maximum take-off weight (MTOW)
2=	**PR3 (Maximum Temperature):** Delays to construction, maintenance and operational work	1=	**PR3 (Maximum Temperature):** Delays to construction, maintenance and operational work.	2=	**PR3(Maximum Temperature):** Delays to construction, maintenance and operational works.
2=	**PR10 (Snowfall):** Increased snow hazard and de-icing requirements due to a minor snowfall event.	1=	**PR12 (Extreme cold):** Low temperatures causing reduced friction and increased de-icing requirements. (Additionally to snowfall impacts that would be expected at this temperature).	2=	**PR1 (Maximum temperature):** Infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac
2=	**PR12 (Extreme cold):** Low temperatures causing reduced friction and increased de-icing requirements. (Additionally to snowfall impacts that would be expected at this temperature).	2=	**PR8 (Rainfall):** Exceedance of drainage infrastructure capacity associated with minor surface (pluvial) flooding events	3=	**PR4 (Maximum temperature):** Impacts thermal comfort of staff and passengers in terminal buildings and aircraft on stands
2=	**PR15 (Low Ceiling Height):** Risks associated with reduced visibility, increasing risk of accidents and collisions	2=	**PR27 (Aviation sector risks):** Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a short term period (i.e. hours to days).	3=	**PR5 (Maximum temperature):** Impacts on the surface integrity of surface access routes leading to and around the airport
2=	**PR 22 (Increased Temperatures):** Increased fire risk of combustible materials			3=	**PR22 (Increased temperature):** Increased fire risk of combustible materials
				3=	**PR8 (Rainfall):** Exceedance of drainage infrastructure capacity associated with minor surface (pluvial) flooding events
				3=	**PR27: Interdependencies / cascade risk** due to the wider aviation sector where disruptions occur over a short term period (i.e. hours to days).

Note that the relative scores of individual risks varies.

[18] Note that in the baseline and 2070s time horizons more than 5 risks are listed due to equal scoring of multiple risks

4.2.2 Quantifying all physical risks

The headline risks for a baseline scenario (including consideration of current control measures), anticipated risk in the 2030s under RCP8.5 scenario and anticipated risk in the 2070s under RCP8.5 scenario are shown in Table 4.2.

Table 4.2 Quantifying the physical risks to LLA

Risk Code	Climate Variable	Risk	Baseline				2030s				2070s			
			Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence
PR1	Maximum temperature	Infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac	3	4	**8**	High	3	4	**8**	High	3	5	**10**	High
PR2	Maximum temperature	Impacts on maximum take-off weight (MTOW)	4	3	**8**	High	4	4	**12**	Low	4	5	**20**	Low
PR3	Maximum temperature	Delays to construction and maintenance works	3	3	**9**	High	3	4	**12**	Medium	3	5	**15**	High
PR4	Maximum temperature	Impacts thermal comfort of staff and passengers in terminal buildings and aircraft on stands	3	4	**8**	High	3	4	**8**	High	3	5	**10**	High
PR5	Maximum temperature	Impacts on the surface integrity of surface access routes leading to and around the airport	2	4	**8**	High	2	4	**8**	High	2	5	**10**	High
PR6	Extreme winds	High wind speeds or gusts impacting take off procedures	1	5	**5**	High	1	5	**5**	Medium	1	5	**5**	Medium
PR7	Extreme winds	High wind speeds or gusts causing damage to high structures	2	1	**2**	Medium	2	1	**2**	Medium	2	1	**2**	Medium
PR8	Rainfall / surface water flooding	Exceedance of drainage infrastructure capacity associated with minor surface (pluvial) flooding events	4	4	**16**	High	2	5	**10**	High	2	5	**10**	High

Risk Code	Climate Variable	Risk	Baseline				2030s				2070s			
			Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence
PR9	Rainfall / surface water flooding	Exceedance of drainage infrastructure capacity associated with moderate flooding events	5	2	**8**	High	3	2	**4**	High	3	3	**6**	High
PR10	Snowfall	Increased snow hazard and de-icing requirements due to a minor snowfall event.	4	3	**9**	High	4	2	**6**	High	4	2	**6**	High
PR11	Snowfall	Substantial snow hazard and de-icing requirements due to a major snowfall event.	4	2	**8**	High	4	2	**8**	High	4	2	**8**	High
PR12	Extreme cold	Low temperatures causing reduced friction and increased de-icing requirements. (Additional to snowfall impacts that would be expected at this temperature).	3	5	**9**	High	3	4	**12**	Medium	3	3	**9**	Medium
PR13	Extreme cold	Low temperatures causing reduced friction and increased de-icing requirements. (Additional to snowfall impacts that would be expected at this temperature).	4	2	**8**	High	4	2	**8**	High	4	2	**8**	High
PR14	Fog	Risks associated with reduced visibility, increasing risk of accidents and collisions	2	3	**6**	High	2	3	**6**	Low	2	3	**6**	Low
PR15	Low ceiling height	Risks associated with reduced visibility, increasing risk of accidents and collisions	3	3	**9**	High	3	3	**9**	Low	3	3	**9**	Low
PR16	Lightning / Thunderstorms	Lightning strikes and associated fire risk	3	2	**6**	High	3	3	**9**	Low	3	3	**9**	Low
PR17	Blizzard	Blizzard risk (combined impact of snowfall, wind and low temperatures)	3	2	**6**	High	3	2	**6**	Medium	3	1	**3**	Medium
PR18	Extreme weather events	Risk of passenger flight disruption due to the cumulative impact of extreme weather events (e.g. extreme snowfall during a period of low temperatures) or impacts greater than current projections suggest.	4	1	**4**	High	4	2	**8**	Low	4	2	**8**	Low

Risk Code	Climate Variable	Risk	Baseline				2030s				2070s			
			Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence
PR19	Extreme weather events	Risk of delays and loss of capacity in cargo facilities due to the cumulative impact of extreme weather events (e.g. extreme snowfall during a period of low temperatures) or impacts greater than current projections suggest.	4	1	**4**	High	4	2	**8**	Low	4	2	**8**	Low
PR20	Sea level rise	Risk of inundation of airport due to sea level rise.	0	1	**0**	Low	0	1	**0**	Medium	0	2	**0**	Medium
PR21	Increased temperatures	Local ecosystem changes	3	2	**6**	High	3	3	**9**	Low	3	3	**9**	Low
PR22	Increased temperatures	Increased fire risk of combustible materials	3	3	**9**	High	3	4	**9**	Low	3	5	**15**	Low
PR23	Increased temperatures	Increased risk of communicable disease and epidemics	5	2	**10**	High	5	2	**10**	Low	5	2	**10**	Low
PR24	Interdependency risk	Interdependencies / cascade risk due to disruptions in the electrical and power supply	3	2	**6**	High	3	2	**6**	Low	3	3	**9**	Low
PR25	Interdependency risk	Interdependencies / cascade risk due to disruptions in water supply	2	1	**2**	Medium	2	2	**4**	Low	2	2	**4**	Low
PR26	Interdependency risk	Interdependencies / cascade risk due to disruptions to services provided by site concessions and delivery partners.	4	1	**4**	Low	4	2	**8**	Low	4	2	**8**	Low
PR27	Aviation sector risks	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a short-term period (i.e. hours to days).	2	4	**8**	Low	2	5	**10**	Low	2	5	**10**	Low
PR28	Aviation sector risks	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a medium-term period (i.e. weeks to months).	2	2	**4**	Low	2	3	**6**	Low	2	3	**6**	Low
PR29	Aviation sector risks	Interdependencies / cascade risk from origin/destination airports being inundated due to sea level rise causing long term closures.	4	0	**0**	Medium	4	1	**4**	Medium	4	2	**8**	Medium

5. Transition Risks

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. LLA have recognised that these transition risks may have an impact on their operation and have therefore included them in this CCRA. As described above, the assessment of transition risks is at a preliminary stage and risks are assessed on a qualitative basis only.

Further analysis will be required to bring the understanding of the transition risks faced by LLA to full maturity including quantitative analysis and scenario development. To aid future work on transition risks, the risks have been grouped in this report in line with the recommendations by the TCFD**Error! Bookmark not defined.** for policy and legal risks, technology risks, market risks and reputation risks.

5.1 Understanding the risk

Transition Risks can be categorised as summarised in Table 5.1 and further elaborated upon in Appendix E.

Table 5.1 Categories of Transition Risk

Risk	Description
Policy Risk	Policy action around climate change continues to evolve with objectives tending to fall into two categories: policy actions to constrain or mitigate actions that contribute to the adverse effects of climate change and policies that seek to promote adaptation to climate change. Both types of policy actions are of relevant to LLA and could present a risk or opportunity in the future. The risk itself is dependent on the nature and timing of the policy change
Technology Risk	Technological improvements or innovations that support the transition to a lower-carbon economy have the potential to have a significant impact on LLA. For example, in the aviation sector, the development and use of sustainable biofuels, hybrid and electric aircraft will affect the competitiveness of UK airports and ultimately the demand for their services from end users.
Market Risks	While future growth and increased passenger demand for aviation could enable expansion and new routes to open at LLA, there are risks associated with the transition to a low carbon economy that could impact demand. Key transition risks to LLA with regards to market risks and aviation demand have been identified as: • Changes in demand (passenger driven or regulated) • Changes in market segments • Competition from lower carbon travel options
Reputational Risk	Climate change has been identified as a potential source of reputational risk tied to changing customer or community perceptions of an organisation's contribution to, or detraction from, the transition to a lower-carbon economy

5.2 Quantifying the risk

The Transition Risks have been quantified in Table 5.2. LLA recognises the need to identify and embed climate change adaptation and mitigation within LLA's strategic business planning. The physical impacts of climate change and the transition to a lower carbon economy represent both risks and opportunities to the airport that need to be assessed through integration into existing LLA risk governance processes and adapted to/mitigated against where required.

- Adaptation will include investment in upgraded physical infrastructure (such as the upgrade of the surface water drainage system) and further scenario analysis, horizon scanning to understand the actions associated with TCFD requirements.
- Mitigation will require development of net zero strategy which LLA have committed to develop in 2022.

The greatest transition risk for LLA over the next 30 years is anticipated to be UK policy changes associated with the commitment to net zero by 2050. This commitment will also require technological developments within the aviation sector to support such a goal which present both risks and opportunities to LLA. Consideration of transition risks is a key recommendation made by the Task Force on Climate-related Financial Disclosures (TCFD) and reporting against these recommendations will become mandatory for most organisations in the UK by 2025.

The Sustainability Team at LLA will have overall responsibility for reporting, monitoring and review of the climate change adaptation risks and actions. However, in line with internal LLA processes, identification of risks, compliance with risk control measures and reporting to department leads, Directors and the Board will be the responsibility of specific teams and departments within LLA. This integration as part of standard business activities at LLA will allow consideration of climate change risk and opportunities to become part of LLA's strategic business planning.

Table 5.2 Quantifying the transition risks to LLA

Risk Code	Risk	Baseline				2030s				2050s			
		Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence	Severity	Likelihood	Risk Score	Confidence
TR1	Policy risk - risk of decarbonisation and net-zero policies that constrain or mitigate activities contributing to climate change and increase the need for adaptation and mitigation.	4	4	**16**	Low	4	4	**16**	Low	4	5	**20**	Low
TR2	Technology risk - risk of development and deployment of new technologies that requirement investment at the airport to allow for uptake and/or cause a disruption to current operating procedures.	3	3	**16**	Low	4	4	**16**	Low	4	4	**16**	Low
TR3	Market risk - risk of decrease in passenger demand due to policy regulations restricting capacity/growth or passenger behaviour choices.	4	2	**8**	Low	4	4	**16**	Low	4	4	**16**	Low
TR4	Market risk - changes in market segment with particular consideration given to reduced demand for business travel.	3	4	**9**	Low	3	4	**12**	Low	3	4	**12**	Low
TR5	Market risk - competition from lower-carbon travel options.	2	2	**4**	Low	2	3	**6**	Low	2	3	**6**	Low
TR6	Reputation risk - linked to changing customer perceptions	2	2	**6**	Low	2	3	**9**	Low	2	4	**12**	Low

6. Opportunities

6.1 Understanding the opportunities

Opportunities at LLA are related to both physical and transition changes anticipated as a result of climate change, with three key opportunities identified in each category. For physical climate change impacts the greatest opportunities relate to:

- **Increases in temperatures leading to an extended summer seasons and increased demand**: Physical climate impacts including increased dry period and warmer temperatures across many of LLA's destinations, particularly those in Europe, are anticipated. This may increase the demand for certain routes, extend the period over which greater summer demand exists for, or create new destination options that LLA can capitalise on.
- **Reduction in fog occurrences and frequencies**: Although climate projections are uncertain, and therefore confidence is low, a potential reduction in fog frequency is anticipated in the future. This could lead to a reduction in weather-related disruption at LLA and a decreased requirement to implement the Low Visibility Procedures in the future. A reduction in fog occurrence would therefore likely lead to fewer weather-related delays and maintenance of more efficient take-off and landing procedures. Although an opportunity, it would be safety critical for LLA to maintain existing control measures to ensure the airport is able to respond to these events when they do occur.
- **Reduction in snow and low temperature event frequency:** A potential reduction in snow event frequency is anticipated in the future which could lead to a reduction in weather-related disruption at LLA. Control measures including de-icing facilities would still need to be maintained to ensure the airport is able to respond to these events when they do occur.

The transition to a lower carbon economy will support global decarbonisation and mitigation efforts therefore reducing the magnitude of potential changes in physical climate indices. This in itself is an opportunity for LLA since it will reduce the need for adaptation in the future. Other opportunities associated with the transition to a low carbon economy include:

- **Opportunities to support new technologies and infrastructure to drive aviation sectoral improvements and developments**: Changes in the aviation sector are anticipated as part of the drive to a lower carbon economy. In particular, technology developments expected include roll out of sustainable aviation fuel, next generation planes with increased fuel efficiency and new electric, hydrogen or hybrid planes. LLA have the opportunity to support these technological changes driving forward shifts in the aviation sector and capitalising on efficiencies and improvements they provide.
- **Capture market share from competitors**: Over time it is likely that the market share held by different airports will change due to climate-related impacts and other shifts in the market, leading to concentrations and contractions at different airports. Noting the CCC's recommendation to the UK Government to place constraints on new airport capacity, Government preference for future expansions could be given to airports with lower-carbon intensities (Scope 1-3), greater infrastructure for new technologies (e.g. SAF and electric flights) and wider local economic and social benefits.
- **Market shifts and consumer choices**: It is anticipated that shifts in consumer behaviours will occur with the transition to a lower carbon economy. Passengers may make more conscious travel choices and the growth of sustainable tourism could represent an opportunity for LLA to

position itself as a sustainable option, in line with the owner's declaration to be the UK's "most sustainable airport over the next 20 years".

6.2 Quantifying the opportunities

Table 6.1 Quantifying the climate related opportunities available to LLA

Opp. Code	Climate Variable	Opportunity	Baseline				2030s				2070s			
			Severity	Likelihood	Opp. Score	Confidence	Severity	Likelihood	Opp. Score	Confidence	Severity	Likelihood	Opp. Score	Confidence
O1	High temperatures	Increase in summer season	4	3	12	Low	4	4	16	Low	4	5	20	Low
O2	Fog	Reduction in fog frequency	2	0	0	Low	2	3	6	Low	2	3	6	Low
O3	Snow	Reduction in snow and low temperature event frequency	2	0	0	Low	2	3	6	Low	2	3	6	Low
O4	Transition to low-carbon economy	Opportunities to support new technologies / operational measures / better infrastructure for the aviation sector	5	1	5	Low	5	2	10	Low	5	3	15	Low
O5	Transition to low-carbon economy	Opportunity to capture market share from competitors	5	0	0	Low	5	1	5	Low	5	2	10	Low
O6	Transition to low-carbon economy	Market shifts and consumer choice	5	0	0	Low	5	1	5	Low	5	2	10	Low

Note: for opportunities high scores represent the greatest opportunities to LLA and are therefore potential for benefits.

7. Adaptation actions

As part of the risk assessment, LLA have identified actions required to adapt to the potential physical and transition risks of climate change. Actions have also been identified to support the realisation of opportunities. Actions have been formulated using the SMART principals (Specific, Measurable, Attainable, Relevant and Time-based).

Recommendations are focused on adapting and reducing physical risk (Table 7.1), developing greater understanding of the implications of transition risks using scenario development (Table 7.2), and taking actions to enable opportunities to be realised (Table 7.3). A full list of recommendations is provided in in Appendix F.

The recommendations for reducing and adapting to risks and realising opportunities at London Luton Airport have been allotted according to short-, medium- and longer-term timescales, covering the period up to 2050. These categories are defined by milestones previously reported:

- **Short Term:** These recommendations align with the time period of the Responsible Business Strategy.
- **Medium Term:** These recommendations cover the period of LLA's concession agreement for the management, operation and development of the airport with the local authority. Measures may require increased expenditure, further modelling or may be conditional on the results of feasibility studies.
- **Longer Term:** These measures recognise uncertainty in the longer term and the need for monitoring of climate change implications.

Table 7.1 Adaptation actions for Physical Risks

Milestone	Actions
Short Term	• **Review Capital Project Programme** to ensure it indicates which capital projects will mitigate/adapt to the impacts of climatic change and ensure it provides an indication of the extent of mitigation/adaptation. Consider development of TCFD scoping report in advance of mandatory requirements to assess financial materiality of potential impacts. • **Updated review of the High Temperature Plan** accounting for the potential impacts of climate change (last reviewed in 2015). Ensure the Plan provides adequate monitoring and inspections of critical infrastructure features including the runway, apron and surface access routes. • **Assess current Building Management System and heating, ventilation and air conditioning (HVAC) set up** to establish whether current system will be able to cope with longer term temperature change and variability. • **Thermal modelling should be conducted around the terminal and buildings** to understand this issue of thermal comfort further and identify where additional measures need to be implemented (e.g. installation of new air conditioning equipment). • **Conduct further research to understand the impact (if any) that climatic change may have on London Luton Airport's buildings** including detailed flood risk modelling of the area proximal to the terminal buildings. Consider co-funding research projects with local universities to assess potential impacts at the airport. • **Re-visit the existing processes and check tolerances of the buildings** to cope with periods of prolonged increased temperatures, including anticipated increased in internal temperatures and HVAC facilities. • Update of the Wildlife Strike Hazard Reduction Plan accounting for the potential impacts of climate change on the key species and natural environment (e.g. vegetation management trends, migratory birds, changes in summer season length etc). • **Conduct quantitative modelling and assessment of surface water drainage provisions** and future precipitation scenarios. • **Assess the potential areas where flooding could occur** against projections over asset lifetime timescale and amend the capital project programme if required. • **Review the potential of extreme precipitation events** to cause an increased likelihood/severity of slips/trips and falls at the levels indicated in the long term. • **Completion of engineering programme to upgrade drainage facilities** at LLA including updating the scope of the upgrade works to include consideration for climate change and flood risk. Recommended upper end uplifts should be included in design from the start to reduce future costs. • **Ensure consideration for climate change and use of appropriate materials** (considering their climate sensitivity) **is included as standard** in all repair, maintenance and replacement procedures. • **Generation of on-site renewable combined with energy demand reductions** to meet at least 25% of the energy demand by the end of 2026. By the end of 2023, LLA will reduce operational electricity demand to less than 2.0 kWh/pax. • **Regular maintenance of snow, de-icing and anti-icing equipment**. Follow snow plan, monitor the use of equipment to ensure adequate for use during periods of ice and snow. • **Implementation of planned procedures to upgrade de-icing equipment**. • Conduct further research to **improve understanding of how cloud ceiling and fog could change** due to climate change and the impacts on low visibility procedures at UK airports. • Include **measures to reduce water usage** including within future Environmental Action Plans, in line with requirements within Luton's Responsible Business Strategy published in 2019. Other examples could include grey water capture and use retro-fitting of water saving devices during routine maintenance activities or end-of-life upgrades, including dual flush WCs and low-flow taps and showers. • Consideration for **potential impacts of climate change leading to disruptions to other modes of transport used for accessing the airport** including rail services should be considered in airport planning and risk management processes.

Milestone	Actions
Medium term	• Conduct **further research into MTOW restrictions** and how these could impact commercial arrangements at LLA. Give due consideration to transitional technology changes including a trend towards larger planes and improvements in aircraft lift in new generation aircraft. Facilitate discussions with airlines to ensure this is understood and mitigated for. • **Review capital projects in relation to airfield re-surfacing to check existing levels of tolerance to climate change**. Make sure all future airfield resurfacing works consider the impacts of increasing temperatures, to protect the project / asset throughout its lifetime. • **Monitor IT server performance during periods of increased temperatures**. Upgrade equipment as necessary. • Conduct **further research into the potential impact of sustained or compounded extreme weather events upon terminal and airport performance**, and identify key areas of risk and improvement.
Long term	• **Monitor vegetation management requirement (e.g. frequency) against temperature trends**. • **Research into the potential impacts of wind speed changes** given anticipated future aircraft technology i.e. transition to larger aircraft.

Table 7.2 Adaptation actions for Transition Risks

Milestone	Actions
Short Term	• **Consideration for the financial materiality of risks** in terms of costs and revenues **in line with TCFD recommendations for disclosure**. • Detailed **research into the transition risks** that may affect LLA including developing full scenario analysis. • Participation in **expert working groups, industry sector initiatives** and **airport operator forums** to capture best practice learning and drive change. • **Engage with policy makers and decision makers** to guide and influence change. • **Continued monitoring of national and international policies** including plans and strategies.
Medium term	• **Support for low carbon technology improvements** including provision of infrastructure, where appropriate, at LLA. • **Diversify the supply chain** where possible to reduce risk exposure within the supply chain.
Long term	• Consideration for **mechanisms that could allow diversification in airport operations** (e.g. diversification into increased long-haul flights which are less exposed to risk due to other lower-carbon alternative travel options such as rail/electric flights).

Table 7.3 Adaptation actions to realise Opportunities

Milestone	Actions
Short Term	• Take action to **position LLA as a low-carbon relative to competitors** through the use of lower-carbon intensive practices and carbon reductions for Scope 1 and 2 emissions. • **Investment in water efficiency measures** which have co-benefits of reducing water usage and increase resilience. • **Monitor frequency of implementation of low visibility procedures and Winter Operations Plan** to review need with changing climate. Review procedures as required to ensure safety standards are maintained and procedures are appropriate for less frequent but potentially more severe events. • **Investment in energy efficiency measures** which have co-benefits in terms of climate mitigation and adaptation. • **Install electric vehicle charging points** as required by demand to increase use of sustainable transport solutions thereby increasing resilience.
Medium term	• Maintain dialogue with airlines and the wider aviation sector to **encourage the use of newest, greenest fleet**. • **Engage with airlines** to share knowledge, establish best practice and influence an increased focus on adaptation.
Long term	• Analysis to **identify passenger demands and under-served or unserved routes** to identify possible future routes to new destination airports. • Investigate opportunities and conduct feasibility studies into implementing **infrastructure needs to support new technologies within the aviation sector**.

8. Monitoring and reporting

The Sustainability Team at LLA will have overall responsibility for reporting, monitoring and review of the climate change adaptation risks and actions. However, in line with internal LLA processes, identification of risks and compliance with risk control measures will be applicable to all teams and departments within LLA.

Monitoring of the implementation of actions, completion and progress made to date will be conducted on a regular basis and reported on an internal and external basis to relevant parties. Internal reporting on actions and KPIs, as set out in this report, will be conducted on an annual basis. Roles and responsibilities for each action will be assigned internally within six months of the publication of this report to ensure governance arrangements are in place. Upon completion, each action and supporting evidence will be reviewed and signed off by a competent authority, acknowledging any assumptions or limitations.

Climate related risks and opportunities will be integrated in the internal risk management process at LLA with reporting as standard to departmental leads and the board. This is part of standard business activities of LLA and as such will allow consideration of climate change risk and opportunities to become part of LLA's strategic business planning.

Unrepentant reporting will also be conducted externally through the UK adaptation cycle reporting powers and LLA's Annual Monitoring Report. Climate change risks will be reviewed every five years, in line with the UK Government review of the carbon budgets and the UK adaptation cycle. An updated risk assessment and action plan will be published publicly as part of this process. New iterations of the CCAR will include analysis of the latest UK climate projections, updates to climate-related thresholds specific to LLA, and will set out the performance on adaptation actions against the KPIs identified in this report.

The annual monitoring cycle and five-yearly review and update cycle do not prevent ad-hoc updates to the climate change adaptation plan being made. Material changes in local or national policies, progress in best practice within the aviation sector, or experience from future near-term events could all provide rationale for updating the adaptation action plan outside of the anticipated review cycles.

9. Summary

London Luton Airport (LLA) recognised the need to identify and embed climate change adaptation within the Responsible Business Strategy 2020-2025. The physical impacts of climate change and the transition to a lower carbon economy represent both risks and opportunities to the airport that need to be assessed and mitigated against where required.

This assessment has assessed risks which could impact future operations at LLA. For consistency a standardised risk assessment framework has been used which is based on guidance by Defra, AOA and industry best-practice. Where possible, critical thresholds specific to operations at LLA (i.e. a point beyond which the performance of an asset or a system suffers an intolerable shift) has been used to screen climate risks. Key risks include:

- Extreme cold and snow hazards having an impact in the short-term on winter operations.
- Variability in precipitation patterns and the potential for surface water flooding to the airport due to insufficient drainage capacity.
- Temperature increasing which have the potential to cause damage to airfield structures including airfield tarmac and surface access routes, restrictions on maximum take-off weight, and reductions in thermal comfort impacting passengers and staff inside airport buildings.
- Implementation of policy changes required to achieve the UK net zero 2050 target which may affect the UK economy or the aviation sector specifically.

Adaptation options and solutions to enhance asset performance and overall system resilience have been identified where required. Actions have been prioritised to increase resilience to the most prominent risks identified on short-term timescales. Recommendations include measures that will ensuring the overall resilience of the airport to risks related to direct and indirect physical climate change impacts, transition climate risks and interdependencies. It is critical that climate resilience is embedded into the practices, policies and decision-making process at LLA.

LLA will be responsible for implementing the actions that have resulted from the risk assessment, ensuring there is accountability for implementation by management and reporting on actions to ensure those identified are delivered. Monitoring the success and progress of implementation of adaptation measures will be critical for this process and will be required to aid future updates to the risk assessment. In addition to this external report, an internal action tracker has been developed for use by LLA to track, record and where necessary implement corrective actions to ensure appropriate adaptation measures are implemented in advance to mitigate any future physical and transition risks to the airport or operations.

The Sustainability Team at LLA will have overall responsibility for the reporting, monitoring and review of climate change adaptation risks and actions. This will be integrated within internal business risk management processes at LLA and strategic business planning. External reporting on progress will be conducted where applicable within the Annual Monitoring Report and on a five-yearly basis as part of the UK adaptation cycle.

Understanding the risks and potential adaptation options is a critical step in addressing the potential impacts of climate change. This is fundamental for informing the prioritisation of climate action and investment in adaptation and will support LLA to become more resilient to climate change.

Appendix A
Progress against AP1 Actions

Table A.1 Progress on actions identified in AP1 report

Business Function	Action identified in AP1	Timeframe	Progress on action and evidence of completion	Summary of progress
Airport Cargo	To review snow plans to take into account the existing possibilities of prolonged extreme weather incidents	2020 / 2050	LLA Cargo adhere to the current LLA Winter Operations Plan which was last updated for the 2020-2021 season. The snow plans are reviewed annually with consideration of extreme weather events as standard.	Achieved
	Conduct quantitative modelling and assessment of surface water drainage provisions and future precipitation scenarios.	2050	This project is ongoing with analysis and review of the surface water drainage provisions ongoing including detailed design for engineering upgrades. The resiliency of the system should be assessed including the potential impacts of climate change on the quantity of water the drainage system needs to be able to cope with.	Retained, work is currently ongoing
	Site survey of air conditioning in cargo to see if any new equipment needs to be installed which can withstand the constant use this level of temperature increase could create.	2050	Air conditioning is installed in most rooms within the cargo centre and maintained periodically. Staff feedback suggest that all units work well and are sufficient for current use.	Achieved
Airport Terminal	Investigate opportunities for improving air conditioning capacity in parts of terminal building. Assess current Building Management System and heating, ventilation and air conditioning (HVAC) set up. Establish whether current system will be able to cope with longer term temperature projections.	2020 / 2050	Improvements have been made to air conditioning capacity in areas of the terminal buildings where required e.g., walkways. This is based on anecdote evidence of insufficiency supported by spot-checks on temperature. Further work is needed to establish whether the current system is able to cope with longer term temperature projections.	Retained, work has been progressed but further work is required
	Minimise site water demands and consumption where possible. Continue to work upon measures within Environmental Action Plans and achieve internal water reduction targets.	2020	Water reduction targets were included in Luton's Responsible Business Strategy published in 2019. These targets have governance mechanisms to ensure they are achieved and progress is reported within the annual monitoring reports.	Achieved
	Review the Capital Project Programme to make sure it indicates capital projects which will mitigate/adapt to the impacts of climatic change.	2020	Action retained for inclusion in AP3.	Retained, further work required

Business Function	Action identified in AP1	Timeframe	Progress on action and evidence of completion	Summary of progress
	Undertake research to understand the impact (if any) that climatic change may have on London Luton Airport's buildings.	2020	Action retained for inclusion in AP3.	Retained, further work required
	To plan to identify possible future routes which London Luton Airport could offer under these circumstances.	2050	Work is ongoing to inform airlines of passenger demands and where routes are under-served or unserved. This work will continue including consideration for climate change.	Retained, work has been progressed but further work is required
	Include measures in relation to grey water capture and use within future Environmental Action Plans.	2050	Identification of ways to use non-potable water instead of potable water sources is included in Luton's Responsible Business Strategy published in 2019.	Retained, work has been progressed but further work is required
	To scope the potential areas where flooding could occur against projections over this timescale and amend the capital project programme if required.	2050	Flood risk has been identified in the drainage programme works to be completed in upcoming years. The scope of work should be expanded to include consideration of flood risk, including appropriate uplifts for climate change.	Retained, work is currently ongoing
	Re-visit the existing processes and check tolerances of the buildings in accordance of these possible prolonged increases in temperature.	2050	Action retained for inclusion in AP3.	Retained, further work required
	To review the potential of flooding to cause potential of an increase of slips/trips and falls at the levels indicated in the long term.	2050	Action retained for inclusion in AP3.	Retained, work is currently ongoing
	Conduct research to understand the potential for onsite generation / energy-saving measures taking into these projections.	2050	A target of generating 25% of electricity demand from on-site renewable energy has been included in Luton's Responsible Business Strategy published in 2019. This target has governance mechanisms to ensure it is achieved and progress will be reported within the annual monitoring reports. Research into on-site generation is ongoing.	Achieved
	Investigate the potential impact of sustained extreme weather events upon terminal performance, and identify key areas of risk and improvement.	2050	Extreme weather has been considered as a risk within the CCAR for CCRA3 process.	Achieved
Airfield Operations	Review capital projects in relation to airfield re-surfacing to check existing levels of tolerance to climate change. Make sure all future airfield resurfacing works consider the impacts of	2020 / 2050	Work to date has been focused on maintenance and repair cycles rather than upgrades and replacements. Action retained for inclusion in AP3.	Retained, further work required

Business Function	Action identified in AP1	Timeframe	Progress on action and evidence of completion	Summary of progress
	increasing temperatures, to protect the project / asset throughout its lifetime.			
	Regular maintenance of snow, de-icing and anti-icing equipment. Follow snow plan, monitor the use of equipment to ensure adequate for use during periods of ice and snow.	2020	London Luton Airport have taken a collaborative approach to winter operations with partners including The Inland Group of Companies and easyJet. Since 2014 trials and studied have been conducted on de-icing equipment leading to reduced glycol volumes and improved collection and disposal. The Foxtrot taxiway de-icing pad has been introduced with sealed drainage and increased capacity for de-icing requirements. Most of the investment into winter operations equipment will be made by winter 2024/25 with the aim of reducing the runway clearance times by almost 50% compared to today's value (20 minutes)	Retained, work has been progressed and is ongoing
	Assess the impact of surface water run-off on the surrounding drainage and catchment area. Develop a surface water management plan based on increased rainfall projections.	2020	LLA produced a Surface Water drainage Strategy in 2014 followed by London Luton Airport Surface Water Management Feasibility Study report was conducted in July 2018. The scope of the current drainage engineering works should be extended to include consideration for climate change.	Achieved
	Investigate the potential impact that projections could have upon operating procedures. Include risks within LLA's Airfield Operating Procedures and identify steps to mitigate e.g. wildlife migration patterns etc.	2020 / 2050	LLA's AP3 adaptation report acts as this assessment of potential impacts and provides recommendations for adaptation options.	Achieved
	Monitor working conditions to make sure that staff have adequate protective clothing and equipment when working in raised temperatures.	2050	The High Temperature Plan produced in 2015 includes requirements for staff working conditions, clothing and breaks in hot temperatures.	Achieved
	Continue to monitor water use on site to understand quantities of water required to carry out these actions. Ensure adequate quantities of water are available during periods of sustained water shortage.	2050	Water reduction targets were included in Luton's Responsible Business Strategy published in 2019. These targets will support with reducing water requirements during periods of sustained water shortages.	Achieved
	To monitor grass cutting requirement against temperature trends.	2050	The Wildlife Strike Hazard Reduction Plan includes actions on grass cutting and is updated on an annual basis. Action to include climate change is retained in AP3.	Retained, further work required
	Undertake research to establish emerging and alternative approaches to surface management.	2050	Surface inspections are part of the High Temperature Plan produced in 2015.	Achieved

Business Function	Action identified in AP1	Timeframe	Progress on action and evidence of completion	Summary of progress
Offices	Monitor any changes in staff working patterns in relation to increases in temperatures. Update equipment / staff resourcing plans as appropriate.	2050	The High Temperature Plan produced in 2015 includes requirements for staff working conditions, clothing and breaks in hot temperatures.	Achieved
	Monitor IT server performance during periods of increased temperatures. Upgrade equipment as necessary.	2050	Action retained for inclusion in AP3.	Retained, further work required
Surface Access (roads and car parks)	Monitor industry standards and make certain that where industry standards for roads change, London Luton Airport implements improvements to required levels.	2020 / 2050	Current industry standards are used in all projects at London Luton Airport. This is included in LLA internal procedures where required.	Achieved
	Development and implementation of a surface water management plan.	2020 / 2050	LLA produced a Surface Water drainage Strategy in 2014 followed by London Luton Airport Surface Water Management Feasibility Study report was conducted in July 2018. The scope of the current drainage engineering works should be extended to include consideration for climate change.	Achieved
	Continue carrying out regular maintenance of equipment during periods of prolonged rainfall or high temperatures e.g. car park barriers.	2020 / 2050	Updated operating procedures include provision of increased inspections during periods of adverse weather conditions. These procedures are updated on an annual basis.	Achieved
	To continue to make certain that roads under the control of London Luton Airport meet current and future industry standards.	2050	Road maintenance has been focused on repairs in the last 10 years. Current industry standards are considered in all maintenance works as specified by internal procedures.	Achieved

Appendix B Approach to quantifying and managing risk

Quantifying physical risks

Temporal scope

The CCRA considers three time periods over the 21st century for the physical risk assessment. These time periods have been guided by the available data within the UK Climate Projections and specific conditions relating to LLA:

- **Baseline –** UK climate projections for the period 1981 – 2000 to represent baseline conditions.
- **Short-term** – the period 2021-2040 (2030s) is used to understand short term risks in the physical risk assessment. This time period is in line with LLA's concession agreement to operate the airport.
- **Longer-term** – the period 2061-2080 (2070s) is used to assess long term risks in the physical risk assessment, which covered the anticipated design life of assets at the airport.

Threshold for impact

Climate hazards present varying levels of risk to London Luton Airport and the aviation sector more generally. Climate hazard impacts are likely to directly effect LLA (i.e., damages result from direct contact with the hazard) such as infrastructure damage at the site or delay/cancellations to take off and landing procedures. Furthermore, there will be indirect effects (i.e., secondary damages attributed to a hazard event, but not its direct impact) such as disruption that occur within the wider aviation network but have implications for LLA. Impacts have the potential to impact the:

- functionality of the airport (i.e., the ability to transporting passengers in aircraft);
- performance (i.e., the customer experience at the airport and the efficiency of progresses);
- operations (non-aviation) at the airport (e.g., terminal building operations and safety procedures).

Where climate hazards have the potential to impact the functionality of the airport or safety protocols, there are often defined thresholds. These thresholds might represent a safety threshold above/below which it is unsafe to operate the airport under normal procedures.

Climate hazard events of the same type but varying magnitude may have different levels of impact on the airport, for example low temperatures around 0°C will cause minor delays due to increased de-icing pressures while significantly lower temperatures may cause increased safety concerns, and temporary closure of the airport due to snow clearance efforts. Where appropriate, multiple threshold values have been defined to represent these different levels of disruption to LLA as influenced by the magnitude of the climate event.

For the purposes of the CCAR, events of different magnitude have been scored separately to understand the full risk associated with events of all magnitudes.

Data for physical risk assessment

Climate projections

The quantitative risk assessment is grounded in the latest climate evidence and research and as such uses the UK Climate Change Projections 2018 (UKCP18)[19] as the basis for the risk assessment. UKCP18 provides data on changes in several climate variables based upon climate projections from recent science and climate models. UKCP18 projects have been used in many climate change impact and adaptation assessment in the UK and are used in this assessment. This evidence is supported by other climate change projections and professional knowledge of datasets such as CORDEX climate projections.

Local climate projections provide the best representation of local effects within the climate models. These projections provide the highest spatial and temporal resolution climate projections for assessing high-impact events across LLA. At the time of the first CCAR prepared by LLA in 2011, the previous generation of climate projections were used in the assessment UKCP09[20], which provided data for local areas at a resolution of 25km^2.

A suite of data is available in the UKCP18 projects and has been used for this assessment including data at a 2.2km^2, 12km^2, 25km^2 and 60km^2 resolution (**Error! Reference source not found.**). The higher-resolution local projections, available on a daily temporal scale, are useful for examining the risk of extreme weather events over the coming decades including summertime rainfall intensity and duration, short duration rainfall extremes and severe convective wind gusts.

Table B.2 Climate variables assessed in the physical risk assessment utilising UKCP18 climate projections

Climate variable	Projections used
Maximum temperature	UKCP18 Local projections at 2.2km^2
Extreme winds	UKCP18 Local projections at 2.2km^2
Rainfall	UKCP18 Regional projections at 2.2km^2
Snowfall	UKCP18 Regional projections at 2.2km^2
Mean and minimum temperatures	UKCP18 Regional projections at 2.2km^2
Sea level rise	UKCP18 Marine projections at 25km^2

An ensemble mean of 12 projections of 20 year 'time-slices' (i.e. an average value over the 20 year period) are considered for a range of key parameters. Note that while historical information has been considered, the baselines are not validated against observed data, so any biases are carried forward to the future projections.

Climate scenarios and pathways provide plausible representations of future states of the climate system, incorporating socio-economic, technological demographic and environmental development, these are used to force the climate models within UKCP18. The local and regional models are forced by a high/worse-case emission scenario, RCP8.5. The increase of global mean surface temperatures by the end of the 21st century relative to 1986-2005 is likely to be between 2.6°C to 4.8°C under RCP 8.5. Operations for weather-related hazards must be able to maintain functionality under extreme events and therefore assessing the risks under the greatest climate scenarios is deemed a conservative but appropriate response. Sensitivity testing is

[19] Met Office (2018), UK Climate Projections 2018, [online]. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index
[20] Met Office (2009), UK Climate Projections 2009: Archived, [online]. Available at: https://webarchive.nationalarchives.gov.uk/20181204111018/http://ukclimateprojections-ukcp09.metoffice.gov.uk/

conducted in Appendix C showing likely climate impacts in a 2°C world, represented by a lower emission scenario, RCP2.6 and a 4°C world, represented by the high emission scenario, RCP8.5.

Drainage modelling

Additionally, drainage modelling of London Luton Airport has been conducted by Wood to understand present and future risk of flooding at the site. Conclusions from this analysis has been used to support the climate change risk assessment process. Full details of the drainage modelling undertaken can be requested from LLA.

Assessing the severity

The approach adopted by LLA to assess risk is in line with corporate reporting processes described in Section **Error! Reference source not found.**. All risks have been assessed using a standardised approach for consistency based on the severity of impact and the likelihood of the event.

The consequence of each physical climate risk was determined based on the definitions in **Error! Reference source not found.**. Corporate indicators of risk factors spanning operation disruption, reputation, operability, infrastructure damage and casualties/injuries were integrated together to aid this assessment. The consequence of physical risks was ranked on a scale from negligible, where a noticeable event occurs but is managed through normal activity, to a catastrophic event with extremely devastating consequences.

Knowledge, secondary experience of current and recent past severe weather events and expert judgement was used to rank the extent to which climate and climate change hazards would impact on the operations at LLA.

Table B.3 Criteria used to assess severity of a physical climate change hazard event

Level	Risk Scoring	Financial costs	Safety	Environmental damage	Reputational damage	Loss / litigation potential	Operational disruption / airport closure
Catastrophic	5	Equipment or buildings destroyed or lost, requiring replacement	Multiple fatalities	Extensive, irreversible damage	International adverse publicity	10% (£15m) or more	Long term security closure, no access to terminal
Hazardous / substantial	4	Major building or equipment damage, requiring extensive repairs and temporary closure	Single fatality or multiple serious injury	Extensive, long term damage	National adverse publicity	5% (£7.5m) or more	Short term security closure, prolonged mass flight cancellations and major delays
Major	3	Adverse operating conditions but limited equipment or building damage	Serious injury or illness, inability to work	Localised, long term damage or extensive short-term damage	Local adverse publicity	2.5% (£3.75m) or above	Short term mass flight cancellations and major delays
Minor	2	Operating limitations only, no equipment or building damage	Lost time injury with professional	Localised short-term damage	Multiple negative complaints	1% (£150k) or above	Missed flights and/or minor delays

Level	Risk Scoring	Financial costs	Safety	Environmental damage	Reputational damage	Loss / litigation potential	Operational disruption / airport closure
			treatment required				
Negligible	1	Few consequences	Minor harm or near miss	Negligible environmental harm	Negligible complaints	0.1% (£15k)	Low impact on airport operations
None	0	No consequence	No consequences	No consequence	No consequence	No consequence	No consequence

NB: Note the terminology for the impact in the above table is based on the LLA Risk Management Process. AOA use the following definitions for the severity levels: (1) minimal; (2) minor; (3) moderate; (4) major and (5) catastrophic. The definition of the severity impacts by AOA are compatible with LLA's definitions.

Assessing the likelihood

The likelihood of the climate change impact was determined based on the definitions in **Error! Reference source not found.**. Previous reporting on risk conducted by LLA has used a qualitative approach to assessing risk. In this report, a quantitative approach is used for physical climate risks where there is a good degree of data available for current and future projections. Where data is limited on climate projects a qualitative description has been used to assess likelihood.

Table B.4 Criteria to assess likelihood of climate change impacts

Level	Risk rating	Qualitative description	Quantitative description
Frequent	5	Likely that the event will occur many times (reoccurs frequently). Evidence/indications strongly suggests a transition from business as usual will occur with the impact anticipated to be substantial.	Climate projection ensemble mean for the percentage of years throughout the considered time period with an event occurrence is 100%.
Occasional	4	Likely that the event will occur sometimes (reoccurs infrequently). Evidence/indications suggests a transition from business as usual will occur with major impacts.	Climate projection ensemble mean for the percentage of years throughout the considered time period with an event occurrence is 50 - 99%.
Remote	3	Unlikely that the event will occur, but possible (has occurred rarely). Evidence/indications hint a transition from business as usual will occur although the impact are anticipated to be minimal.	Climate projection ensemble mean for the percentage of years throughout the considered time period with an event occurrence is 25 - 50%.
Improbable	2	Very unlikely that the event will occur (not known to have occurred). There is little indication or evidence of a transition occurring.	Climate projection ensemble mean for the percentage of years throughout the considered time period with an event occurrence is < 25%.
Extremely improbable	1	Almost inconceivable that the event or transition will occur.	Climate projection ensemble mean for the percentage of years throughout the selected time period has an event occurrence of 0%.

NB: Note the terminology for the likelihood in the above table is based on the LLA Risk Management Process. AOA use the following definitions for the likelihood levels: (1) highly unlikely / improbable; (2) unlikely; (3) possible / less than likely; (4) likely / more than likely and (5) almost certain / highly probable. The definition of the likelihood impacts by AOA are compatible with LLA's qualitative definitions.

Determining risk

The risk rating is determined by multiplying the likelihood by the severity rating as shown in **Error! Reference source not found.**. The risk score is used to determine the risk category as shown in the colouring used. The standard LLA risk management procedure defines three levels of risks from low, medium to high, these are shown by the colour of the text in **Error! Reference source not found.**. In contrast, the AOA template utilises more conservative thresholds and implements four risk categories from minor, moderate, major to severe.

Risk appraisal was considerate of current impacts as judged by operational experts at LLA to ensure agreement on current risk categorisation.

Table B.5 Risk scoring and categorisation used to assess risk levels for the risk assessment

Severity → Likelihood ↓	1 Negligible	2 Minor	3 Major	4 Hazardous / substantial	5 Catastrophic
5 Frequent	5	10	15	20	25
4 Occasional	4	8	12	16	20
3 Remote	3	6	9	12	16
2 Improbable	2	4	6	8	10
1 Extremely improbably	1	2	3	4	5

NB: Risk categories are shown in the colouring used in the table above, where the risk score value is used to define the risk category. The text colour represents the risk categories defined by LLA where low (green) risks are scored 1-4, medium (orange) risks are 5-14, high (red) risks are 15-25. The shading of the cell represents the risk categories defined by AOA where minor (green) risks are scored 1-3, moderate (yellow) risks are 4-9, major (red) risks are 10-19 and severe (dark red) risks are 20-25.

Accounting for uncertainty

Climate change projections are associated with considerable uncertainty associated with greenhouse gas emissions, model configurations, model bias, variability and non-linearities in the climate system. The impacts of climate hazard events of LLA are also uncertain as these will depend on the nature of the impact, its timing, the warning provided and future adaptation decisions. These uncertainties have been accounted for in this assessment through a confidence rating.

The confidence in the severity and likelihood of risks has been determined on a scale of 1 to 3 dependent on the criteria described in **Error! Reference source not found.**. Model certainty in future climate projections that have been assessed quantitatively have been based on the inter-quartile range (IQR) which describes the middle 50% of values and therefore represents statistical dispersion in the model results. Climate hazard data and future projections associated with a high IQR has greater uncertainty between the model outputs.

Table B.6 Criteria used for assessing confidence in the risk assessment

Likelihood → Severity ↓	Low – IQR > 50% or qualitative information used	Medium – 10% < IQR < 50%	High – IQR < 10%
Low - Uncertain outcomes due to limited past exposure and/or research	Low	Low	Low
Medium – Some understanding of impacts due to aviation sector research and/or experience	Low	Medium	Medium

Likelihood → Severity ↓	Low – IQR > 50% or qualitative information used	Medium – 10% < IQR < 50%	High – IQR < 10%
High – High levels of understanding due to past experience of similar events at LLA and/or strong evidence across the aviation sector **or linked sectors**	Low	Medium	High

Quantifying transition risks

The assessment of transition risks represents LLA's first assessment of transition risks and is considered at a high-level at this stage. Further reporting, in line with frameworks such as the Climate Wise Transition Framework and TCFD recommendations for scenario analysis, would be needed to determine the threshold for impact at LLA, quantify the likelihood of transition risks and determine their financial materiality.

Transition risks presented are common to the aviation sector and are anticipated to have the potential to impact business operations at LLA. Analysis would be needed to understand LLA's sensitivity to these impacts and determine thresholds for when they may become significant.

Temporal scope

The CCRA considers three time periods over the 21st century for the transition risk assessment. These time periods have been guided by the available data on publicly available scenarios for the aviation and transport sector, recommendations from TCFD and specific conditions relating to LLA:

- **Baseline –** Current legislation and strategies are considered to represent baseline conditions.
- **Short-term** – As for the physical risk assessment, the 2030 is used to understand short term transition risks.
- **Longer-term** –projected trends in the 2050s are used to assess long term risks in the transition risk assessment. Uncertainty in potential pathways to achieve a low carbon economy mean that assessment in later years is not possible. Scenario development in the future will allow for greater certainty in projections used.

Data for transition risk assessment

Impacts of transition risks will be greatest under a lower emission scenario where the trend for decarbonisation happens rapidly and with the greatest magnitude of change. To fully understand the potential likelihood of transition risks detailed scenario analysis would need to be conducted accounting for emission scenarios, socio-economic factors and critical assumptions including those made about policy changes, technology development/deployment, energy mix and timing of potential impacts.

For this report, such scenario analysis has not been conducted. However, the likelihood of the transition risks is assessed using a qualitative approach based on the current trajectory for the UK. This assessment is based on the assumption that the UK is transitioning to a net zero economy as legislated in the Climate Change Act 2008[6]. It is assumed further investment will be made in technology development within the aviation sector to support this goal, as highlighted in recent Committee on Climate Change recommendations[21] and the Government's Ten Point Plan[22].

[21] Committee on Climate Change (2020), The Sixth Carbon Budget – The UKs path to Net Zero, [online]. Available at: https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf
[22] UK Government (2020), The ten point plan for a green industrial revolution, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

Data on the likelihood of climate change impacts has been sourced from a suite of scenario datasets:

- **The International Energy Agency (IEA) Energy Technology Perspectives (ETP)** report provides a detailed analysis on the infrastructure sectors (including aviation) and the IEA **World Energy Outlook (WEO)** presents a holistic scenario analysis across all sectors dependent on energy. The 2020 report develops different pathways out of the COVID-19 crisis with a key focus on the next ten years to 2030.
- **Bloomberg New Energy Finance (BNEF), 2020 New Energy Outlook** provides long term scenario analysis on the future of the energy economy. This is used to identify transition risks and assess their likelihood. It includes a more in-depth aviation scenario view, which includes a holistic assessment on the latest business-as-usual market outlook for the aviation sector (based on ICAO and World Bank data, and BNEF analysis) from 2019 through 2050.
- **UK Committee on Climate Change (CCC) 6th Carbon Budget** which assessed pathways for the UK to achieve its net zero for 2050. Consideration has been given by CCC into technological advances driving further decarbonisation, aviation demand management and further opportunities for UK airport expansion.

Assessing the severity / impact

Qualitative descriptions have been used to describe the potential severity of transition risks in this assessment. These descriptions have been derived based on the levels set within the LLA and AOA risk matrix templates (**Error! Reference source not found.**).

Table B.7 Qualitative descriptions to assess severity of a transition climate change risk

Level	Risk Scoring	Description
Catastrophic	5	A transition that results in substantial impacts requiring a fundamental shift in the business model, and results in a substantial change in the functionality/operations of the business e.g. large reductions in passenger demand, and/or large capital investment costs.
Hazardous / substantial	4	A transition that requires the business to respond to, but also results in a change in the functionality/operations e.g. a decrease in passenger demand or a reasonable capital investment costs.
Major	3	A transition that requires the business to respond to in order to maintain current functionality.
Minor	2	A relatively small impact where the business is able to make a voluntary commitment (either financial, investment or through a small change in operations) to address
Negligible	1	Minimal impacts that are compatible with business-as-usual procedures
None	0	No consequences

Assessing the likelihood

The transition risk assessment is conducted at a high level and full scenario analysis is beyond the scope of this assessment. The likelihood of transition risks are assessed using the qualitative descriptions provided in **Error! Reference source not found.**

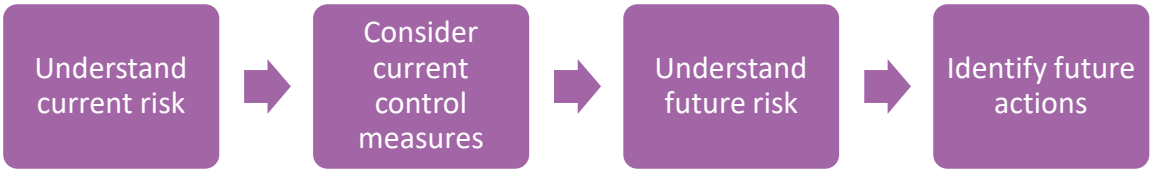
Assessing the risk

In this assessment, the transition risk as been determined based on the severity and likelihood as described previously. For full disclosure and assessment of transition risk, analysis of financial models would need to be conducted. This is beyond the scope of this assessment.

Methodology for the CCAR

The approach to quantifying risk from climate variables and identifying adaptation measures to mitigate and reduce this risk is shown in **Error! Reference source not found.**. This approach ensures that LLA is operated to be resilient to climate change and is based on ISO 14090: Adaptation to climate change – principles, requirements and guidelines.

Figure B.1 Methodology for assessing risk within the CCAR



Stage A: Understand current risk and thresholds for impact

Current vulnerabilities to climate and climate change have been considered and assessed to understand current levels of risk at LLA. In particular, the following physical climate change risks are considered to cause disruption at LLA at present and have therefore been scoped into the assessment:

- Extreme temperatures (including daily and seasonal minimums and maximums);
- Snowfall and ice events;
- Low visibility (e.g. fog, cloud ceiling height, blizzards, extreme rainfall etc.);
- Extreme precipitation events and flood risk (surface water and fluvial);
- Strong winds and gusts; and
- Thunderstorms and lightning.

Thresholds for impact are based on LLA procedures and operational policies in place at the airport. Where necessary these have been supported by literature studies of thresholds for the wider aviation sector.

One physical climate change risks of great prominence to the global aviation sector as a whole, is the risks of inundation from sea level rise and storm surges[23]. Therefore, it should be considered that LLA is at low physical climate risk in the context of its global peers although it may be affected by some physical climate risks and interdependencies with destination / origin airports which is explored further in the CCAR.

In the UK, the Government has legislated a goal for net zero carbon emissions by 2050 in the Climate Change Act[6]. This amendment to the Act in 2019 started the shift towards a low carbon economy in the UK and as such the following transition risks are scoped into the assessment:

- Changing aviation demand;

[23] Pek and Caldecott (2020), Physical climate-related risks facing airports: an assessment of the world's largest 100 airport – Briefing paper, [online]. Available at: https://www.smithschool.ox.ac.uk/research/sustainable-finance/publications/Physical-climate-risks-facing-airports-briefing-paper-September-2020.pdf

- Changing market share;
- Policy shifts; and
- Introduction of low carbon technologies.

Consideration has also been given to unprecedented events that could occur in the current climate but have not yet been recorded in the historical record. The extreme rainfall in the winter of 2013/2014 is considered an example of such an event where a succession of storms hit the UK causing January rainfall to be 30% higher than previous years in over a century[24].

These unprecedented events may cause significant disruption across the aviation sector and to intendencies and customers. LLA's risk management approach includes learning from lived experience and the standard operating procedures are regularly updated to capture this learning. It is therefore deemed that while such events have the potential to cause impacts, these would likely be wider than LLA alone and current procedures would be sufficient to ensure learning and necessary actions are captured following the event. No further consideration has been given to such events in this report.

Stage B: Consideration of current control measures

LLA take a proactive approach to managing risk and are able to absorb the impacts of most extreme weather events within their operating procedures. Current actions, plans and procedures that are in place to reduce the risk have been considered and the magnitude of the risks in the baseline scenario reassessed.

For transition risks, no actions have yet been taken by LLA to manage these risks and hence this stage of the process has not been conducted.

Stage C: Understanding future risks

In order to assess future vulnerabilities from climate change the climate variables are considered in line with best available data on climate projections. As described above, the future likelihood of the climate change variable has been considered to understand future risk. The likelihood assessment will consider adaptation and control measures that are already in place and identified in Stage B. The severity/impact of a climate change event is considered to be non-evolving through time and is therefore equal to the baseline assessment.

All climate variables described here have been assessed under future climate projections to understanding if the risk of these events changes.

Stage D: Identifying future actions

Where current adaptation and control measures are deemed insufficient, either in the baseline or future scenarios, these risks will be prioritised to develop appropriate adaptation actions and programmes as required. Implementation of the identified actions will increase resilience to climate related risks and reduce the potential impacts of these risks.

To ensure effective action, the CCAR identifies ways to ensure that adaptation is fully integrated into existing London Luton Airport processes, with defined monitoring plans, timescales and responsibilities. As part of this process it is recognised that the adaptation cycle is an ongoing process and progress on actions will be monitored while the risk assessments are periodically updated as necessary.

[24] Thompson et al. (2017), High risk of unprecedented UK rainfall in the current climate, [online]. Available at: https://www.nature.com/articles/s41467-017-00275-3

Three types of early adaptive actions are included within the action plan based on the adaptation framework used in CCC progress reports and included in the second round of adaptation reporting, CCRA2. It is anticipated that this framework will also be used in CCRA3, due for publication in 2021. These include:

- '**No-regret' or 'low-regret' actions** that reduce risks associated with current climate variability, whilst also building some level of future climate resilience.
- **Near-term actions and decisions** that consider future climate change early and avoid 'lock-in' or expensive retrofitting options at a later stage.

Adaptative management approaches where there is significant uncertainty and taking immediate action may not be beneficial. A framework is established to provide metrics for triggering future decisions whilst incorporating future evidence or understanding in future decisions.

Appendix C Impacts at LLA in a 2°C and 4°C world

Recent advice by the CCC is based on the principle of adapting to a 2°C world but considering the risks of a 4°C world. This approach allows for uncertainties in global emission trajectories which are dependent on recent global net zero pledges and commitments being delivered in full and extended further.

This sensitivity assessment is based on the comparison of a business-as-usual "BAU" trajectory (global temperature rise by the end of the 21st century of ~3-4°C) versus a low-carbon transition scenario (~2°C). The 2°C scenario projects global GHG emissions to reach net zero emissions by 2070, and is seen as in line with the UK's net zero target by 2050, and LLA's commitment to reaching this target.

Future climate scenarios

Recent climate observations from the Met Office Hadley Centre show an overall warming in the UK during recent decades[25]. Warming of the climate system is unequivocal and continued emissions of GHG will cause further global warming[2], with projections of a business-as-usual scenario suggesting ~4°C of temperature increase by the end of the century. However, the requirement to mitigate GHG emissions and reduce global warming has been widely recognised and action is being taken globally.

The RCP8.5 projections, reflecting an approximate +4°C global average increase in temperature by 2100, represent a worse-case scenario with the largest projected climate hazards for physical risk. This scenario has been utilised for the main climate risk analysis within this adaptation report (see Appendix B). This is in keeping with latest advice from the Environment Agency that the UK should be adapting to higher degree of global warming[26]. Using the RCP8.5 'worst-case' projections ensures an inherently more conservative estimate of future climate risks is applied[27].

However, it is also important to also model the lower range of future estimates in order to assess the potential variation in future climate, should a lower emission scenario play-out in future. In particular, lower emission scenarios will necessarily be associated with greater mitigation efforts to reduce greenhouse gas emissions. The transition risks associated with such as scenario are therefore likely represent worst-case projections for transition climate risks.

Physical risks

In order to compare physical risks in a +2°C and +4°C world the UKCP18 climate projections have been used as described in Appendix B. Probabilistic climate projections at a 25km^2 scale are used as these are available for climate projections at both a lower emission scenario, RCP2.6, and a high emission scenario, RCP8.5. A 25km spatial resolution is selected as this is the lowest resolution available through UKCP18 that includes both the RCP2.6 and RCP8.5 projections. To perform the comparison a selection of key climate variables were chosen and compared to examine the likely variation. The variables compared are:

- Summer Maximum Temperature (June, July, August)

[25] Met Office (2018), UKCP18 Fact Sheet: Temperature, [online]. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-temperature.pdf

[26] Boyd (2020) Adapting to 4°C of global warming, [online]. Available at: https://www.gov.uk/government/speeches/adapting-to-4c-of-global-warming

[27] It should be noted that all climate projections are associated with uncertainties regarding emission pathways, socio-economic development and technology change, among other impacts. Projections should therefore not be treated as predictions.

- Winter Minimum Temperature (December, January, February)
- Annual Mean Temperature
- Summer Precipitation (June, July, August)
- Winter Precipitation (December, January, February)
- Cloud Cover (Annual)

For this assessment UKCP18 'anomaly data' is utilised. Anomaly data is the projected 'change' in a climate variable (e.g., temperature/precipitation rate) relative to a baseline, rather than providing an absolute value, and provides a more informative view of the expected change of time.

For this sensitivity assessment, a baseline period of 1981-2000 is selected and compared with future epochs of 2030, 2070 and 2099. The results are shown in **Error! Reference source not found.** to **Error! Reference source not found.**. The box plots in each figure show the range in projected change from the baseline (1981-2000) to the referenced future time periods under the RCP2.6 and RCP8.5 emission scenarios. Each box plot displays the range from the 90th percentile to 10th percentile of results, whilst also including the mean and upper and lower quartiles of projections.

Figure C.2 Variation in summer maximum temperature between RCP2.6 and RCP8.5 scenarios

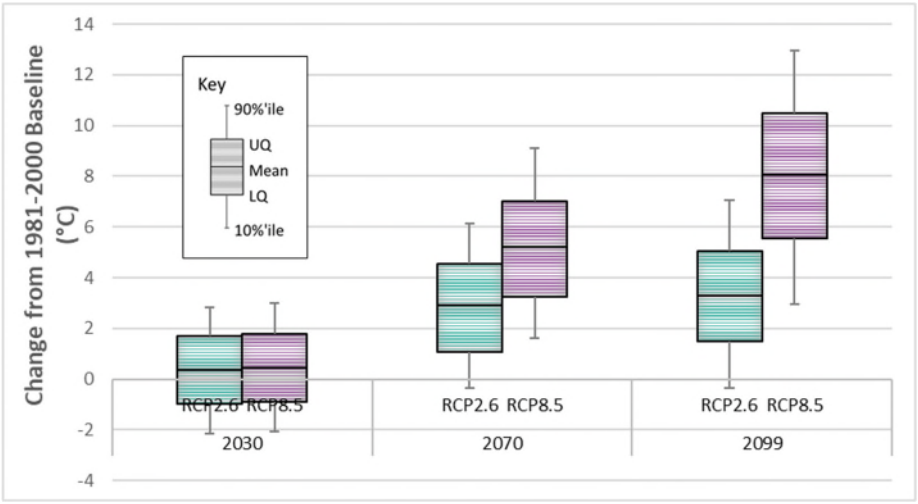


Figure C.3 Variation in winter minimum temperature between RCP2.6 and RCP8.5 scenarios

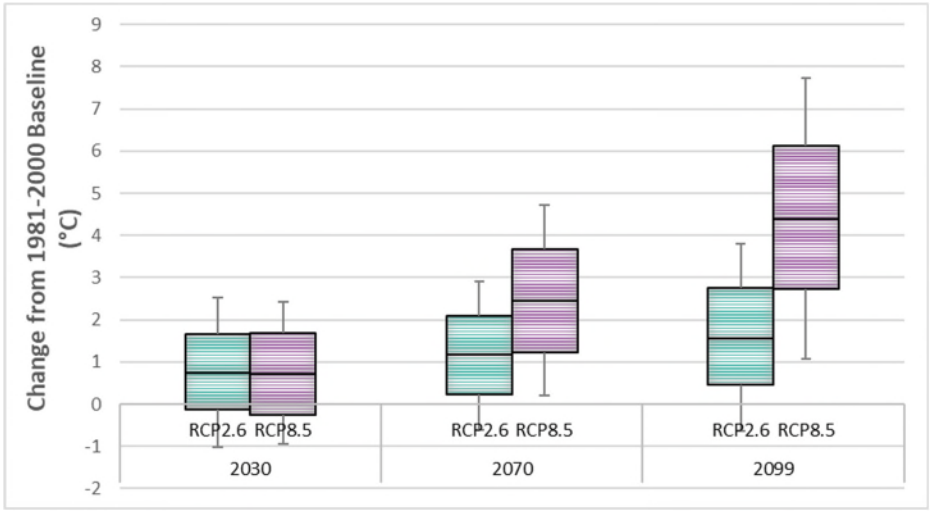


Figure C.4 Variation in annual mean temperature between RCP2.6 and RCP8.5 scenarios

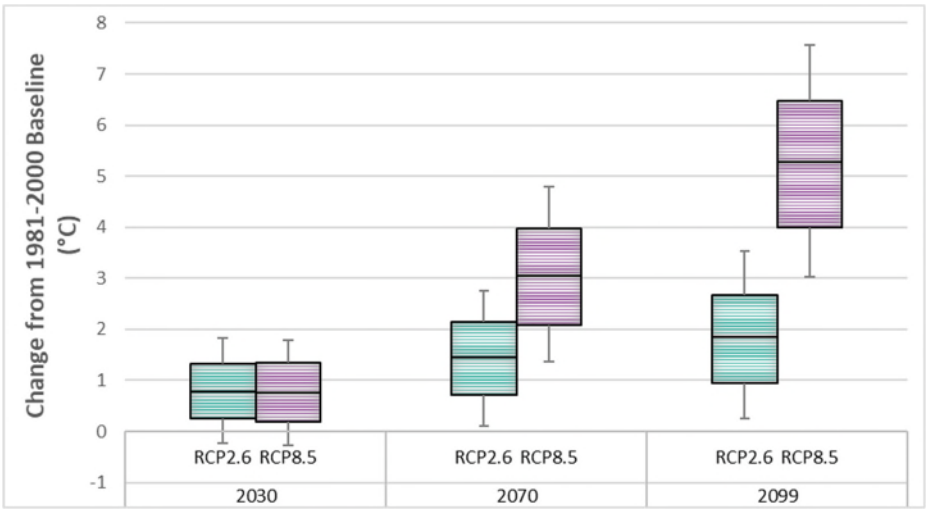


Figure C.5 Variation in summer precipitation between RCP2.6 and RCP8.5 scenarios

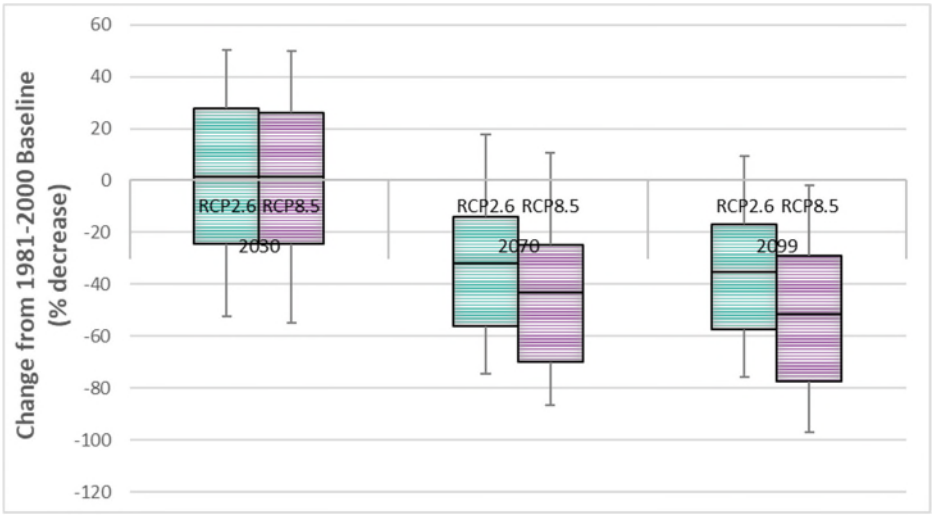


Figure C.6 Variation in winter precipitation between RCP2.6 and RCP8.5 scenarios

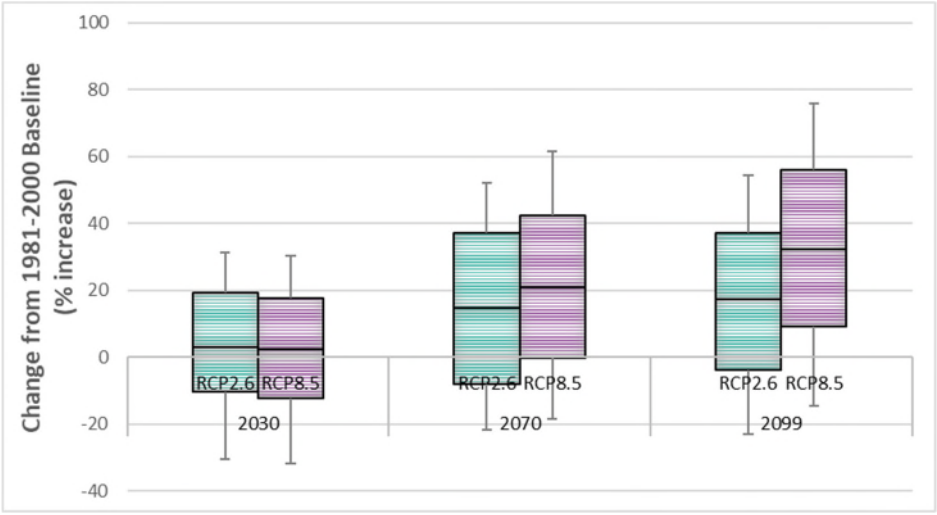
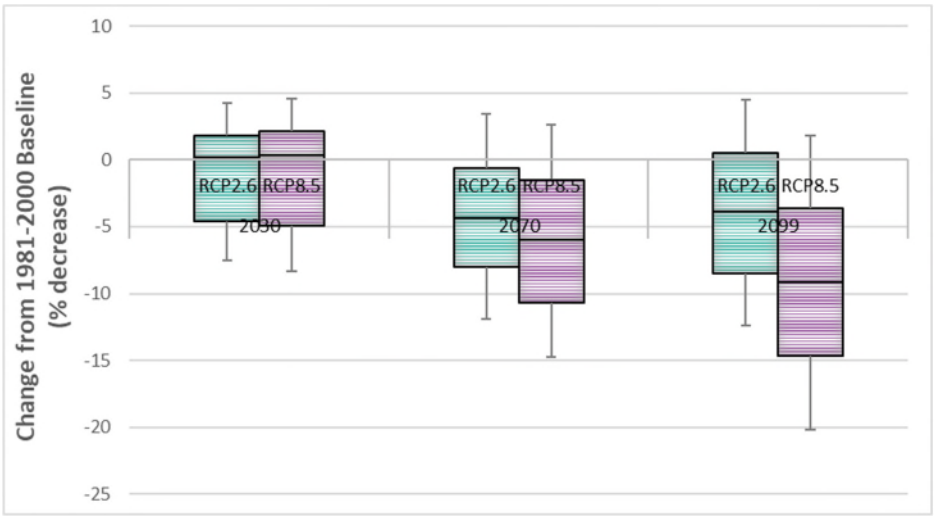


Figure C.7 Variation in annual cloud cover between RCP2.6 and RCP8.5 scenarios



The climatic variation between a 2°C future vs a 4°C future is shown to be fairly negligible in 2030 across the parameters, with no material difference in temperature, cloud cover or precipitation exhibited. By 2070 a more significant variation is indicated between the scenarios with a 1-2°C change in mean and extreme and temperatures and an increasing percentage precipitation and cloud cover change. This is exaggerated further by 2099 where a 3-5°C variation in the temperature variables is modelling and an approximately 15-20% (decrease) in summer and (increase) in winter precipitation levels.

This supports the notion that an increase in climate change intensity will lead to increasing average and extreme temperatures, and lead to wetter winters and drier summers in the UK. As the climatic variation in RCP scenario utilised is fairly un-substantial until after 2070, this supports the sole use of the more extreme RCP8.5 projections to provide a more conservative but also not overly exaggerated climate risk assessment, when assessing the short and longer-term physical climate impacts at London Luton Airport.

Transition risk

Transition risk occurs due to the shift to a lower-carbon economy which may entail extensive policy, legal, technology, and market changes. While the overall scale of global climate change will be determined by global efforts to mitigate GHG emissions, the policies, actions and ambitions to mitigate climate change will likely occur at a local or national level.

The UK Government declared a climate emergency in 2019 and amended the climate change act to increase the ambition of the UK's efforts to reduce GHG emissions, often referred to as the 'net zero' target. For the purposes of this risk assessment, the risks have been assessed based on this trajectory and current UK Government policy, influenced by global trends.

Full scenario analysis will need to be conducted in the future to determine the sensitivity of transition risk impacts to LLA with respect to increased or changed ambition from the UK Government and across the aviation sector.

Appendix D
Direct and indirect physical risks identified and included in the assessment

Table E.8 Direct physical risks identified at LLA and included in the assessment.

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
Maximum temperature				
PR1: Infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac	Increased risk of structural integrity impacts are determined by LLA to be more likely to occur above 26°C. At this temperature threshold LLA's High Temperature Plan is implemented which entails initiating surface inspections with a focus on joints and over banding to recognise any potential surface failures. The Plan also includes details of reporting and monitoring procedures.	Under high temperatures there is a risk of structural damage to the surface and sub-surface of the runway and aprons caused by temperatures exceeding design standards i.e. melting, cracking. UK tarmac standards (roads, aprons) begin to lose integrity once temperatures in the shade exceed 32°C. Tarmac itself is black, absorbs heat and can hit 80°C at such temperatures. Runway surfaces, based on current design standards, are intended to withstand far higher temperatures to be able to cope with aircraft braking. The temperature threshold used at LLA to initiate the High Temperature Plan is conversative due to the safety critical nature of these features.	Financial costs to repair damage; Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	Increased maintenance activities occur when temperatures go beyond 26°C as indicated by the High Temperatures Plan. Monitoring of soft, sticky joints or overbanding; rippling or bubbling tarmac and surfaces observed to be affect by vehicles is conducted. Surfaces will be treated pre-emptively with water where depend necessary. When temperatures are above 35°C, aircraft larger than Boeing 737-800 are not allowed turn on the runway except in turning circles to minimise damage to the tarmac surface.
PR2: Impacts on maximum take-off weight (MTOW)	Specific thresholds at LLA do not yet exist and hence the decision threshold for the purpose of the CCAR is based on a literature review of airports with comparable characteristics in terms of runway length and elevation. Based on other comparable airports and a typical	Maximum temperature influences surface air density and thus lift produced, having impacts on maximum take-off weight (MTOW). This is an issue that is primarily dealt with by the airlines and LLA do not have experience of MTOW being impacted by extreme temperatures. It should be noted that London Luton Airport's market is based on short haul flights, so the aircraft are likely to be small and	Operational disruption	Airlines are assumed to have appropriate control measures. No measures at LLA.

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
	aircraft that is flown from LLA, this is anticipated that MTOW may become impacted at approximately 30°C although more detailed analysis is needed to refine this threshold and ensure it is appropriate for LLA.	therefore light. Additionally, aircraft lift improves with every generation of aircraft and this will in some way offset the impacts of climate change. It is not known to what extent new generation aircrafts (e.g. lighter aircraft) will influence the decision threshold, so this potential change has not been included in the assessment at this stage. .		
PR3: **Delays to construction and maintenance works**	At present, there is no legislation on maximum working temperature although in the Workplace (Health, Safety and Welfare) Regulations 1992 employers have a legal obligation to ensure the temperature is "reasonable". The Trades Union Congress (TUC) has called for a maximum temperature of 30°C to be set by employers. Thermal comfort modelling is outside the scope of this assessment. A threshold of 30°C outside air temperature has been used in this assessment.	Delays to construction and/or maintenance activities could cause safety concerns or for facilities to be closed for longer duration placing increased pressure on other facilities.	Financial costs due to programme delays; Safety risk; Environmental damage	Best practice advice and guidance (including from the UK Government, CIBSE and others) will be implemented as standard across construction and maintenance programmes at LLA. The High Temperature Plan also includes requirements for staff working in high temperatures specifically the provision of sunblock, sun hats and lightweight clothing, refreshment breaks and cooled water supply.
PR4: Impacts thermal comfort of staff and passengers in terminal buildings and aircraft on stands	LLA define unacceptable levels of comfort as excesses of 28°C across the airport. CIBSE Guide A Environmental design suggests that inside building temperature in airports should not be >24°C in winter or >25°C in summer. Thermal comfort modelling is outside of the scope of this assessment. The High Temperature Plan is implemented when temperatures are above 26°C and therefore this outside air threshold is used in this assessment.	Thermal comfort describes a person's state of mind in terms of whether they feel too hot or too cold. The temperature is difficult to define as it varies with the person's preference, clothing, activity level and the environment around them. This is a direct impact that affects the performance and operations (non-aviation) at LLA. Thermal comfort has caused issues in the past at LLA with specific areas of the airport (e.g. the walkway) becoming too hot and air conditioning needing to be installed.	Financial costs to repair damage; Safety risk; Reputational damage; Loss / litigation potential	Air conditioning units are installed around the terminal building and offices where they are required. These are deemed adequate for the current conditions but further measures are anticipated to be required in the future. The High Temperature Plan is implemented when temperatures are greater than 26°C. This includes monitoring the terminal temperature using thermometers during periods of hot weather.

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
PR5: Impacts on the surface integrity of surface access routes leading to and around the airport	Increased risk of structural integrity impacts are determined by LLA to be more likely to occur above 26°C. At this temperature threshold LLA's High Temperature Plan is implemented which entails initiating surface inspections with a focus on joints and over banding to recognise any potential surface failures. The Plan also includes details of reporting and monitoring procedures.	In high temperatures there is a risk of structural damage to the surface and sub-surface of roads in and around the airport caused by temperatures exceeding design standards i.e. melting, cracking. UK tarmac standards (roads) begin to lose integrity once temperatures in the shade exceed 32°C.	Financial costs to repair damage; Safety risks; Reputational damage; Loss / litigation potential	Increased maintenance activities occur when temperatures go beyond 26°C as indicated by the High Temperatures Plan. This threshold is below the point at which damage is anticipated to occur. Reports of affected or failing surfaces will be treated with the application of sand or cement dust.
Extreme winds				
PR6: High wind speeds or gusts impacting take off procedures	The threshold for disruptions due to winds is variable depending on the aircraft type and the runway conditions. Based on literature studies, minor impacts are anticipated to occur at airports when wind speeds are approximately 15 knots or wind gusts are ≥ 45 knots. Based on available data in UKCP18, wind speed is used as the basis of this assessment and a threshold value of 15 knots is used. This is in line with manufacture limits for the Boeing 737 aircraft (which accounted for 13% of movements at LLA in 2019) during wet conditions	Due to the east-west orientation of its runway, and its relative height above sea-level, LLA is vulnerable to changes in wind direction and speeds, and disruptions caused by cross-winds. Increased wind speed can lead to a decrease in controllability of aircraft during take-off and there cause negative impacts on the take-off distance required, ultimately leading to delays. Other impacts could include monitoring of stand allocations, the need to secure ground equipment and impacts to ground handlers and catering teams.	Safety risks; Reputational damage; Loss / litigation potential; Operational disruption	During times of high winds operators will follow Precautions due to strong wind operating procedures.
PR7: High wind speeds or gusts causing damage to high structures	Based on literature studies, major impacts are anticipated to occur at airports when wind speeds are approximately 30 knots or Wind gusts are ≥ 45 knots. Based on available data in UKCP18 (as discussed in assumptions column), wind speed is used as the basis of this assessment and a value of 30 knots is assessed.	High wind speeds could cause further delays to the take-off procedures and also cause damage to high structures at the airport. The impacts may include airside disruptions, staff and passenger welfare arrangements and restrictions on stand use.	Financial costs to repair damage; Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	During times of high winds operators will follow Precautions due to strong wind operating procedures.
Rainfall / surface water flooding				

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
PR8: Exceedance of drainage infrastructure capacity associated with minor surface (pluvial) flooding events	Drainage models for LLA is currently ongoing and detail has been provided on models including a climate change allowance in this report. A 3.33% AEP (1 in 30) event is considered to be a reasonably frequent event and is typically considered minimum best practice design standard for drainage systems. The drainage modelling show that pooling of water across the airport site is anticipated.	Water on the airfield and runway have the potential to cause reduced friction and poor visibility. There is the potential for inundation of airport facilities and for flooding of current surface water drainage provisions, sewer surcharging and 'first flush' impacts leading to deterioration in water quality of receiving watercourses. The Flood Risk Assessment produced by Jacobs states that in 2007, a 30mm rainfall event caused flooding of the Airport Way underpass. The underpass, terminal buildings and the main soakaway are all identified as areas of vulnerability in the drainage model.	Financial costs to repair damage; Safety risks; Environmental damage; Reputational damage; Loss / litigation potential; Operational disruption	Drainage systems are installed across the airport. The current drainage system requires upgrading to enable the infrastructure to be resilient to large surface water events in terms of water quantity and also to prevent any degradation in terms of water quality. The design of this work has been started and will occur over approximately the next four years. The feasibility study for the drainage systems which was completed in 2018, will be updated to include uplifts for climate change including in extreme events. The aim is to create a surface water drainage system that is fit for purpose and resilient to future climate change. Movement area inspections of paved surfaces will be conducted more frequently during periods of heavy rain in accordance with LLA procedures.
PR9: Exceedance of drainage infrastructure capacity associated with moderate flooding events	Drainage models for LLA is currently ongoing and detail has been provided on models including a climate change allowance in this report. A 1% AEP (1 in 100) event is considered to be an infrequent event and is used for sensitivity testing within drainage system design. The drainage modelling show that pooling of water across the airport site is anticipated.	A major induration event has the potential to close the airport operations thereby affecting the functionality of the airport itself. Flood on surface access roads may also impact the accessibility of the airport.	Financial costs to repair damage; Safety risks; Environmental damage; Reputational damage; Loss / litigation potential; Airport closure	
Snowfall				
PR10: Increased snow hazard and de-icing requirements due to a minor snowfall event.	When there is a higher than 40% risk of snow with accumulations of more than 1cm aspects of LLA's Snow Plan (part of the Winter Operations plan) is implemented.	Any prolonged period of extreme cold temperatures, and the associated meteorological hazards such as snowfall and blizzards, could disrupt UK airports. Snow could cause delays and /or strategic cancellation to flights. There is likely to be increased pressure on critical de-icing equipment for aircraft resulting in reduced efficiency in operational procedures due to increased time to de-ice planes.	Financial costs associated with winter operation procedures; Safety risks; Environmental damage; Operational disruption	LLA Winter Operations Plan is in place between 1st November - 30th April to respond to the adverse effects of snow, frost or freezing conditions. In particular the procedures

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
PR11: Substantial snow hazard and de-icing requirements due to a major snowfall event.	A threshold of ≥ 20mm/24hr of lying snow is used to describe a moderate event based literature studies of other UK airport Adverse Weather Plans and anecdotal evidence from LLA's Operations Team.	At LLA, periods of snowfall and ice conditions have led to historical closures of the airfield in 2005, 2009/10, 2011 and most recently in 2017. Prior to 2011, and the first Adaptation Report, the closures were primarily related to inefficient equipment, training and planning. In 2011 typical runway clearance times in snow were 1 hour 20 minutes leading to significant closures of around 12 hours. Since 2011, considerable investment in winter operation equipment has been implemented and the winter Snow Plan has been updated. Equipment investment has reduced the runway clearance time down to 20 minutes. Snow build up may cause cancellation of flights and/or temporary closures of the airfield as snow clearance procedures are required to remove build up and prevent surfaces freezing, including clearing the runway and the closure time required to do so.	Financial costs associated with winter operation procedures; Safety risks; Environmental damage; Airport closure	ensure adequate snow clearance and de-icing. Substantial improvements have been made in the de-icing facilities. The Airside Operations Tactical Snow Plan includes the requirement for surface inspections to be instigated at +3°C when temperatures are forecast to fall to zero or below.
Extreme cold				
PR12: Low temperatures	Tmean ≤ 0°C	Low temperatures will reduced the runway friction impacting take-off procedures as directed by the airline procedures. There will be increased de-icing requirements which could lead to delays (and indirect water quality impacts).	Financial costs associated with winter operation procedures; Safety risks; Environmental damage; Reputational damage; Loss / litigation potential; Operational disruption	LLA Winter Operations Plan is in place between 1st November - 30th April to respond to the adverse effects of snow, frost or freezing conditions. In particular the procedures includes de-icing procedures which have been substantial improved in recent years. A Freezing Conditions Runway Reporting Report form will be used during periods of low temperatures.
PR13: Low temperatures	Tmean ≤ -7°C	Low temperatures will reduced the runway friction impacting take-off procedures as directed by the airline procedures. There will be increased de-icing requirements which could lead to delays (and indirect water quality impacts). Planes may be grounded by ice at gates.	Financial costs associated with winter operation procedures; Safety risks; Environmental damage; Reputational damage; Loss / litigation potential; Airport closure	
Low visibility (including fog and low ceiling height)				
PR14: Risks associated with reduced visibility, increasing risk of	Implementation of the Low Visibility Procedures at LLA are based on quantitative descriptions of the	Poor visibility can reduce the capacity of an airport leading to ground delays, flight diversions, flight cancellations and extra operating costs. In low visibility conditions planes will	Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	Low Visibility Procedures are in operation at the airport to

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
accidents and collisions due to fog occurrences	Instrumented Runway Visual Range (IRVR). It is beyond the scope of this assessment to determine the relationship between this and climate indices used to determine fog, therefore a qualitative assessment of likelihood has been developed based on anecdotal and secondary evidence.	be spaced further apart when taking off, landing and taxiing about the airport to reduce the chance of collisions. The Low Visibility Procedures at LLA are implemented based on definitions of the Instrumented Runway Visual Range (IRVR).		deal with periods of fog and cloud cover.
PR15: Risks associated with reduced visibility, increasing risk of accidents and collisions due to low ceiling height	Implementation of the Low Visibility Procedures at LLA are based on quantitative descriptions of the cloud ceiling height. However, this information is not typically available in climate projections and therefore qualitative descriptions based on anecdotal and secondary evidence have been used.	In the US, the weather is responsible for 87% of ground delays of which 35% are caused by low cloud bases. This is therefore likely to be risk to airports. Low cloud ceiling height may cause reduced visibility at the airport having implications for take-off and landing operations involving the use of Low Visibility Procedures.	Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	Low Visibility Procedures are in operation at the airport to deal with periods of fog and cloud cover.
Lightning / Thunderstorms				
PR16: Lightning strikes and associated fire risk	Literature data suggests that occurrences of lightning (or reports of lightning) within 5-8 miles of the airport could have impacts on fuelling operations. The exact threshold for suspending ground operations and fuelling will be determined by airside operators. Data on average delay time due to thunderstorms in the US (Goodman and Griswold (2019)) suggests 74 minutes for departures and 68 minutes for arrivals. This is relative to no weather impact delays of 16 minutes for departures and 48 minutes for arrivals. Lightning data is not currently available within UK Climate Projections and therefore a qualitative assessment has been provided based on secondary evidence.	Dangerous phenomena include the presence of cumulus or cumulonimbus clouds, thunderstorms or lightning. They may also be associated with secondary hazards such as wind gusts, hail heavy rain, or fog, exacerbating the impacts. Dangerous phenomena may cause reduced visibility and safety concerns around take-off and landing operations resulting in delays/cancellations. Other potential impacts include increased fire risk due to direct strikes and safety concern for ground crew workers. A recent example in 2018 of airport disruptions in the UK occurred in May 2018 when lighting strikes damaged aircraft fuelling systems at Stansted airport grounding flights and causing significant disruption. The aircraft fuelling system was unavailable for a period of time. According to news reports 200 planes were delayed at the airport while over 50 flights were cancelled.	Financial costs to repair damage; Safety risks; Reputational damage; Loss / litigation potential; Airport closure	Operations in Adverse Weather procedures include the requirement for suspension of runway activities if deemed necessary from thunderstorms.
Blizzard				

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
PR17: Blizzard risk (combined impact of snowfall, wind and low temperatures)	Blizzards are a combination of meteorological hazards and are typically defined by the following conditions: Lying snow ≥ 100cm; wind gust ≥ 17 m/s; Tmean ≤ 0 °C. UK climate projections cannot be used to assess this threshold at the current time as they are not available in a spatially coherent format without error. A qualitative assessment has been provided based on secondary evidence.	Snow fall during blizzards could reduce the runway friction and will have a significant impact on visibility. These conditions therefore have the potential to cause delays and/or cancellations and the requirement for low visibility procedures to be implemented.	Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	Winter operation procedures are in place for snowfall and low visibility procedures will be implemented when necessary, according to the procedures in place.
Extreme weather events				
PR18: Risk of passenger flight disruption due to the cumulative impact of extreme weather events (e.g. extreme snowfall during a period of low temperatures) or impacts greater than current projections suggest.	Extreme weather encompasses a range of different meteorological phenomena and there is no one defined threshold value. Extreme weather is considered significant different from the average or usual weather pattern. Values are determined based on secondary evidence and professional judgement, qualitative values are used.	Poor weather can cause runway and/or facilities closure leading to flight disruptions to passenger flights. This impact could also cause possible loss of airlines due to disruptions.	Financial costs associated with reduced movements; Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	Standard operational procedures for Winter Operations include provisions for extended periods of time.
PR19: Risk of delays and loss of capacity in cargo facilities due to the cumulative impact of extreme weather events (e.g. extreme snowfall during a period of low temperatures) or impacts greater than current projections suggest.	Extreme weather encompasses a range of different meteorological phenomena and there is no one defined threshold value. Extreme weather is considered significant different from the average or usual weather pattern. Values are determined based on secondary evidence and professional judgement, qualitative values are used.	Poor weather can cause runway and/or facilities closure leading to disruptions to cargo operations.	Financial costs associated with reduced movements; Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	
Sea level rise				

Risk (and risk code)	Decision threshold	Narrative	Potential consequence	Control Measures
PR20: Risk of inundation of airport due to sea level rise.	UKCP18 projections on sea level impacts are only anticipated in coastal locations and therefore data is not available for the location of London Luton Airport. The risk is assessed as being negligible.	Anticipated sea level rise as a result of climate change has the potential to cause major inundation of coastal areas. LLA is located at a high elevation in a non-coastal location and therefore sea level rise is not a direct risk to LLA operations.	Financial impacts of commercial arrangements changing; Operational disruption	There are no current measures in place as there is a very low risk of this issue occurring currently.

Table E.9 Indirect physical risks identified at LLA and included in the assessment.

Risk	Narrative	Potential consequence	Control Measures
Maximum temperature			
PR21: Local ecosystem changes	An indirect effect of meteorological changes (including increased summer temperature, precipitation extremes and wind speed changes) may be changes to the local ecosystem changes at LLA. Risk could include increased presence of birds, including migratory birds, increasing the risk of wildlife-strike; increased rates of plant growth and longer summer seasons increasing maintenance operations such as grass cutting; increased risk of standing water proximal to the airfield increasing presence of wildlife; or changes in propagation and migration of invasive species with wind speed changes increasing presence of wildlife. These impacts may ultimately lead to increased presence of wildlife on the airport site which in turn is associated with an increased safety risk due to the potential for wildlife-strikes. The management of this risk would therefore increase leading to non-aviation operational system changes.	Financial costs to control wildlife; Safety risks; Environmental damage; Reputational damage; Operational disruption	The Wildlife Strike Hazard Reduction Plan includes a number of control measures and strategies to reduce both airborne and ground dwelling strike hazards on the airfield. This is focused on maintaining a sterile airfield environment and deterring any wildlife or bird hazards. Provisions are made for active wildlife management on a 24/7 basis.
PR22: Increased fire risk of combustible materials	Increased temperatures have an associated increased fire risk of combustible materials, especially if accompanied by period of drought or low precipitation. Under the Regulation Reform (Fire Safety) Order 2005, Fire Risk Assessments are required at many institutions including airports. Each airport is given a fire category which determines the type of aircraft the station has	Financial costs of increased fire operations; Safety risks; Environmental damage; Reputational damage; Operational disruptions; Airport closure	There is an on-site Fire and Rescue Station and this will be on high alert through the implementation of the High Temperatures Plan.

Risk	Narrative	Potential consequence	Control Measures
	the capacity to deal with and the number of crew required to deal with emergencies, LLA is fire category 7.		
PR23: Increased risk of communicable disease and epidemics	Many of the root causes of climate change (e.g. deforestation and dietary patterns) also increase the risk of pandemics by causing forced migration of animals due to habitat loss and increased risk of infection in new places or close interactions between wild animals and humans. The impacts of climate change on temperature, humidity and rainfall patterns will likely make the conditions more favourable for the spread of some infectious diseases including Lyme disease and mosquito-borne diseases such as malaria and dengue fever. The COVID-19 pandemic has shown that aviation as a sector is particularly vulnerable to pandemic risk. Figures from the International Air Transport Association (IATA) show a 65.2% drop in air passenger kilometres in Europe for the year-to-date ending July compared to the same period in 2019. The prevalence of disease and pests including mosquitos may also have an impact on the desirability of flight destinations causing changes in the operational procedures.	Financial costs; Operational disruptions; Airport closure	Pandemic risk is largely outside the control of any individual airport. Mitigations will be put in place to support the return of air travel following the COVID-19 pandemic in the near term.
Interdependency risk			
PR24: Interdependencies / cascade risk due to disruptions in the electrical and power supply	Extreme weather events (especially wind and flooding events) could cause electrical distribution and power outage at the airport. Extreme wind conditions may cause disruptions and power outages to electricity. Thresholds are given for wind gusts > 25 m/s (~48 knots) causing fallen trees, electricity cuts and delays in air traffic while wind gusts > 32 m/s (~62 knots) will cause long-lasting power failures and closure of airfields.	Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	LLA have the capacity for on-site generation to provide electricity to critical areas for at least 72 hrs. If needed this could continue beyond this as long as there was a fuel supply available.
PR25: Interdependencies / cascade risk due to disruptions in water supply	Extreme weather events and decreased water availability as a result of changes in precipitation patterns could cause disruptions to the water supply at LLA (especially related to low water availability and droughts). This could impact operations at LLA especially if affecting safety services (e.g. fire services).	Safety risks; Reputational damage; Loss / litigation potential; Operational disruption; Airport closure	Contracts for water provision are in place at LLA. Tankers would be able to deliver water to the Site if necessary.
PR26: Interdependencies /	Extreme weather events could cause disruptions to site concessions and delivery partners, e.g. unavailability of staff,	Financial impacts; Reputational damage; Operational disruptions; Airport closures	LLA regularly engage with on site concessions and delivery partners.

Risk	Narrative	Potential consequence	Control Measures
cascade risk due to disruptions to services provided by site concessions and delivery partners.	equipment failures etc. If these services are critical to the operation of the airport there could be flight schedule consequences. Challenges can include resource availability, changing regulation and unintended negative environmental consequences for carrying out everyday operations (e.g. pollution, waste and resource overuse).		
Aviation sector risks			
PR27: Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a short term period (i.e. hours to days).	The impacts of extreme weather events may cause short-term (hours to days) impacts to the wider aviation sector, causing direct impacts to destination / origin airports that LLA serves and therefore cascade impacts to LLA. The short-term impacts of extreme weather events, and the associated temporary closures might impact operations at LLA. Airlines may need to respond with flight cancellations and/or route changes depending on the nature of the impacts.	Reputational damage; Operational disruption	Routes and destinations are within the control of the airlines, with LLA only having an influencing role. For short term disruptions at origin/destination airports, the airlines will decide to cancel flights as necessary and LLA do not need to take any control measures.
PR28: Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a medium term period (i.e. weeks to months).	The impacts of extreme weather events may cause medium-term (weeks to months) impacts to the wider aviation sector, causing direct impacts to destination / origin airports that LLA serves and therefore cascade impacts to LLA. Medium-term impacts may occur due to prolonged periods of extreme weather events, or associated repairs and closures as a result of these impacts. Airlines may need to respond with flight cancellations, route changes and/or the use of alternative proximal airports depending on the nature of the impacts.	Financial impacts of commercial arrangements changing; Reputational damage; Operational disruption	Routes and destinations are within the control of the airlines with LLA only having an influencing role. For medium term disruptions at origin/destination airports, airlines will decide whether to re-route flights to a nearby location or to use alternative routes. LLA do not deem it necessary to take additional control measures.
PR29: Interdependencies / cascade risk from origin/destination airports being inundated due to sea level rise causing long term closures.	Long-term climate change impacts (e.g. sea level rise) have the potential to cause major disruption to origin / destination airports making these routes unviable. The biggest risk to European airports of this nature is sea level rise causing inundation of airports. A number of the airports that LLA serves are vulnerable to sea level rise (notably Amsterdam) in the future. Loss of these airports may require routes to change.	Financial impacts of commercial arrangements changing; Operational disruption	There are no current measures in place as there is a very low risk of this issue occurring currently.