University of Strathclyde

CLIMATE RESILIENCE AND VULNERABILITY ASSESSMENT

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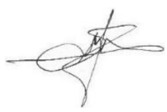
Signature			
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CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

1.1 OVERVIEW

WSP UK Ltd (WSP) has been appointed as sustainability and climate specialists to undertake a desktop high-level climate resilience assessment for the University of Strathclyde in Glasgow.

It can be expected that there will be a certain amount of climate change over the lifetime of the development due to historic greenhouse gas (GHG) emissions and a lag in the climate system, which may cause adverse impacts from warming in the long term.

Maintaining operations, safety, security, and reliability of the University estate requires understanding of the risks and vulnerability (to changes in climate) that it will be subjected to over time. It is vital to plan for, manage, and adapt to known climate-related effects, information/data gaps and therefore, potential risks.

1.2 APPROACH AND SCOPE

WSP has carried out a climate change risk vulnerability assessment for each of the sites within the University's estate across the City Region and has developed an adaptation plan for each group of assets. The work has been undertaken in three stages: a risk assessment, vulnerability assessment and development of an adaptation plan.

The high-level Climate Risk and Vulnerability Assessment (CRVA) has been undertaken to screen potential climate risks that may affect the project and allow for follow-up actions to be progressed by the University of Strathclyde.

WSP's approach to the climate change risk assessment involves identifying the baseline climate (i.e., historic, current, and future climate) using Met Office historic data and extreme weather observations[1], any relevant information in the State of the UK Climate 2019[2], The Climate of the UK and Recent Trends report[3] and UK Climate Projections 2018 (UKCP18)[4].

The project receptors identified that the estate was considered to have the potential to be at risk from climate change. WSP used a scoring matrix, to consider the likelihood of the potential risks, and the consequence/s, should they occur. This assessment is based on professional judgement, previous work undertaken by the University and feedback/information received during the six workshops (conducted with the University team, fabrics team, building services team, grounds and gardens, PNDC, AFRC management teams and Scottish Water). The assessment also takes embedded measures (i.e. already included in, and confirmed to be part of the design) into account.

1 Met Office historic data and extreme weather observations - https://www.metoffice.gov.uk/weather/climate/uk-climate

2 Kendon, M., McCarthy, M., Jevrejeva, S., Matthews, A., Sparks, T. and Garforth, J., 2021. State of the UK Climate 2020. International Journal of Climatology, 41, pp.1-76.

3 Jenkins, G.J., Perry, M.C., and Prior, M.J. (2008). The climate of the United Kingdom and recent trends. Met Office Hadley Centre, Exeter, UK.

4 UKCP18 Climate Projections https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

2 ASSESSMENT CRITERIA & METHODOLOGY

2.1 LEGISLATIVE CONTEXT, TECHNICAL GUIDANCE AND BEST PRACTICE

2.1.1 LEGISLATIVE CONTEXT

The applicable legislative framework comprises:

- Climate Change Act 2008 (2050 Target Amendment) Order 2019[5];
- Climate Change (Scotland) Act 2009[6]
- Planning and Energy Act 2008[7];
- Carbon Budgets, 2016[8]; and
- UK Climate Change Risk Assessment (2017)[9]
- The Carbon Plan: Delivering our Low Carbon Future, 201110

2.1.1.1 Climate Change Act 2008 (2050 Target Amendment)

The Climate Change Act 2008 sets targets for reducing the UK's impacts on climate change and the need to prepare for managing the impacts. The Act sets a target of 80% carbon dioxide (CO_2) emissions reduction by 2050 (against a 1990 baseline) and sets interim targets to ensure progress towards this target. In addition, the Act also requires a Climate Change Risk Assessment (CCRA) to be used to assess the risks from the impact of climate change to the UK. The first CCRA in the UK was presented to Parliament in an Evidence Report in 2012, with the second presented in 2017. The overall aim of the Reports was to assess the urgency of further action to tackle current and future risks, and realise opportunities, arising for the UK, from climate change. This Act requires the production of a national adaptation plan for the UK Government to implement to be ready for the challenges of climate change and a variety of organisations with key responsibilities (i.e. deemed to have adaptation reporting powers, ARP), were required to submit an ARP report of the steps they were and are taking to prepare for climate change.

2.1.1.2 Climate Change (Scotland) Act 2009

The Act aims at setting a target for the year 2050, an interim target for the year 2020, and to provide for annual targets, for the reduction of greenhouse gas emissions. It also aims at providing advice to the Scottish Ministers relating to climate change, confer power on Ministers to impose climate

5 HM Government, Climate Change Act 2008. Available at: https://www.legislation.gov.uk/ukpga/2008/27/introduction

6 Climate Change (Scotland) Act 2009. Available at: https://www.legislation.gov.uk/asp/2009/12/pdfs/asp_20090012_en.pdf

7 HM Government, Planning and Energy Act 2008. Available at: https://www.legislation.gov.uk/ukpga/2008/21/introduction

8 HM Government, 2016. The Carbon Budgets Order 2016

9 HM Government (2017). UK Climate Change Risk Assessment 2017. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584281/uk-climate-change-risk-assess-2017.pdf

10 DECC (2011). The Carbon Plan: Delivering our Low Carbon Future. Available at: https://www.ukgbc.org/sites/default/files/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf

change duties on public bodies, make further provision about mitigation of and adaptation to climate change, make provision about energy efficiency including provision enabling council tax discounts, make provision about the reduction and recycling of waste. The Act sets a target of 80% lower than the baseline carbon reduction target for the year 2050 and a 42% lower than baseline carbon reduction interim target for the year 2020. The Act also specifies setting annual targets for each year in the period 2010-2050 and setting a target for the maximum amount of the net Scottish emissions account. It also specifies ensuring that the net Scottish emissions account for each year in that period does not exceed the target set for that year.

2.1.1.3 UK and Local Carbon Budgets

Carbon budgets place restrictions on the amount of GHG emissions the UK can emit over a five-year period. The UK is the first country to set legally binding carbon budgets. Every tonne of human induced GHG emitted between now and 2050 will be counted towards the budget. If emissions rise in one sector, the UK will have to reduce emissions in another sector to balance the budget. The carbon budget for the 2018–2022 budgetary period is 2,544 million tonnes (Mt) of CO_2e; and for the 2023–2027 budgetary period, it is 1,950 MtCO2e. The Government has set the fifth budgetary period covering 2028 to 2032 at 1,725 MtCO2e. Note, 'CO_2e' describes a wider range of GHGs than just CO_2. It includes the equivalent from GHGs such as methane and nitrous oxide, which usually occur in smaller volumes than CO_2 but have a greater warming potential.

Carbon emissions of the Proposed Development have also been compared with the Local Carbon budgets[11] produced by the University of Manchester and Tyndall Centre for local authorities which presents climate change targets for Barking and Dagenham that are derived from the commitments enshrined in the Paris Agreement. These are informed by the latest science on climate change and defined in terms of science-based carbon setting. The report provides Barking and Dagenham with budgets for CO_2 emissions and from the energy system for 2020 to 2100 and recommends the following:

- To stay within a maximum cumulative carbon dioxide emissions budget of 3.9 MtCO_2 for the period of 2020 to 2100;
- To initiate an immediate programme of CO_2 mitigation to deliver cuts in GHG emissions averaging a minimum of -12.3% per year to deliver a Paris-aligned (the Paris Agreement, 2015) carbon budget;
- To reach zero or near zero carbon no later than 2043. This report provides an indicative CO_2 reduction pathway that stays within the recommended maximum carbon budget of 3.9 MtCO_2. In 2043, 5% of the budget remains.

2.1.2 POLICY AND REGULATION CONTEXT

The applicable policy and regulation context for the assessment of the University's Built Environment comprises:

11 https://carbonbudget.manchester.ac.uk/reports/E09000002/print/

- National Planning Policy Framework - NPPF (2021) [12]
- Building Regulations 2010, Approved Document L1A: conservation of fuel and power in new dwellings, 2013 edition with 2016 amendment [13];
- The Carbon Plan: Delivering our Low Carbon Future (2011)[14].
- Climate Change Plan 2018 - 2032[15]

2.1.2.1 Scotland 2045 - fourth National Planning Framework - draft: consultation 2021

Scotland 2045 - fourth National Planning Framework - draft: consultation[16]2021 is currently seeking out views and comments from stakeholders. Once adopted the framework will set out the Governments priorities and policies for the planning system up to 2045 and the approach of planning and development to help achieve a net zero, sustainable Scotland by 2045. NPF4 will work with the Scottish Government's wider programmes and strategies, including on infrastructure and economic investment, and will contribute to the following high-level outcomes:

- Meeting the housing needs of people living in Scotland including, in particular, the housing needs for older people and disabled people;
- Improving the health and wellbeing of people living in Scotland;
- Increasing the population of rural areas of Scotland;
- Improving equality and eliminating discrimination;
- Meeting any targets relating to the reduction of emissions of greenhouse gases; and
- Securing positive effects for biodiversity.

2.1.2.2 Building Regulations

The Building Regulations Part L governs the conservation of fuel and power in both new construction and refurbishment of the England and Wales building stock. Compliance with the Building Regulations is a regulatory requirement for all new developments. Carbon emissions of a development comparative to compliance with Part L is the key performance indicator for achieving many carbon targets.

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12 Ministry of Housing, Communities & Local Government (2021). National Planning Policy Framework. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf

13 HM Government, 2016. The Building Regulations 2010, Approved Document L1A: conservation of fuel and power in new dwellings, 2013 edition with 2016 amendments. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/540326/BR_PDF_AD__L1A__2013_with_2016_amendments.pdf

14 DECC (2011). The Carbon Plan: Delivering our Low Carbon Future. Available at: https://www.ukgbc.org/sites/default/files/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf

15 Update to the Climate Change Plan 2018 – 2032. Available at: https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/

16 Scotland 2045 - fourth National Planning Framework - draft: consultation, Available at: https://www.gov.scot/publications/scotland-2045-fourth-national-planning-framework-draft/

2.1.3 GLASGOW CITY REGION STRATEGY

2.1.3.1 Climate Ready Clyde[17]

Climate Ready Clyde (CRC) is a cross-sector initiative funded by fifteen member organizations (University of Strathclyde being one of them) and supported by the Scottish Government to create a shared Vision, Strategy, and Action Plan for an adapting Glasgow City Region (GCR). Increasingly they are impacted by the effects of climate change, both directly and from changes happening around the world. The project has setup a vision for the Clyde city region based on the three principles below:

- People at the centre
- Strive for economic resilience
- Work with nature, not against it.

2.1.3.2 Glasgow's Climate Plan[18]

Glasgow City Council declared a climate and ecological emergency on the 16th May 2019 and has set up a working group to tackle this issue through the report. The plan sets out 61 recommendations with the target for the city to achieve carbon neutrality by 2030. The actions which are described in this Climate Plan cover a range of areas - including transport, natural environment and biodiversity, the economy and energy - with the need for sustainability and social justice core to their delivery. They have also been aligned with the Sustainable Development Goals adopted by the United Nations.

The plan sets out two fundamental principles:

- Actions to address the climate crisis must not further disadvantage people, and communities who already experience significant inequalities. Ensuring that any barriers to their transition to net zero carbon are understood and addressed.
- Actions to create a safer, resilient and more sustainable city should be aimed at building a just and more equal city.

2.1.4 GLASGOW – CLIMATE NEUTRAL INNOVATION DISTRICT

Glasgow is amongst twelve non-European Union cities, including Sarajevo and Istanbul, selected as participants in the European Commission's 100 Climate-Neutral and Smart Cities scheme, the so-called Cities Mission.

17 Climate Ready Clyde. Available at http://climatereadyclyde.org.uk/adaptation-strategy-and-action-plan/

18 Glasgow's Climate Plan. Available at https://www.glasgow.gov.uk/CHttpHandler.ashx?id=50623&p=0

These cities will strive for climate neutrality across all sectors such as energy, buildings, waste management and transport, together with related investment plans. Glasgow's plans include the creation of a Climate Neutral District[19] within the Glasgow City Innovation District.

The Climate Neutral district's streets will act as climate and energy corridors that will help the local community to benefit from low carbon heat, power, improved transport, cycling and walking options which will all help provide space for people to move safely and more easily. The project will improve air quality in the centre of Glasgow, whilst a focus on greening the space and nature being allowed to flourish is part of the initiative.

2.1.5 GUIDANCE AND BEST PRACTICE

The guidance and best practice relevant to this chapter are presented below:

- Environmental Impact Assessment Guide to Climate Change Resilience and Adaptation (IEMA, 2020)[20];
- Environmental Impact Assessment Guide to Assessing Greenhouse Gas Emissions and Evaluating their Significance (IEMA)[21];
- Royal Institute of British Architects (RIBA) 2030 Climate Challenge (2021)[22];
- National Planning Practice Guidance on Climate Change[23];
- RICS guidance on Whole Life Carbon Assessment for the Built Environment (2017)[24].

2.1.6 UNIVERSITY OF STRATHCLYDE CONTEXT

University of Strathclyde aims for Net- Zero by 2040 with an additional target of 70% reduction in direct and indirect emissions by 2025.

The University met its strategic carbon reduction target of a 25% reduction of the 2009-10 baseline ahead of the 2020 target delivery point, but significantly greater intensity of action is now required, and the University's milestones and target reflect the determination to increase the pace of change.

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19 Climate Neutral Innovation District. University of Strathclyde. Available at https://www.strath.ac.uk/workwithus/cop26/casestudies/climateneutralinnovationdistrict/#:~:text=100%25%20climate%20neutral%20area%20within,City%20Innovation%20District%20(GCID).

20 Institute of Environmental Management and Assessment (2020) Environmental Impact Assessment Guide to: Climate Change Resilience and Adaptation Available at: https://www.iema.net/resources/reading-room/2020/06/26/iema-eia-guide-to-climate-change-resilience-and-adaptation-2020

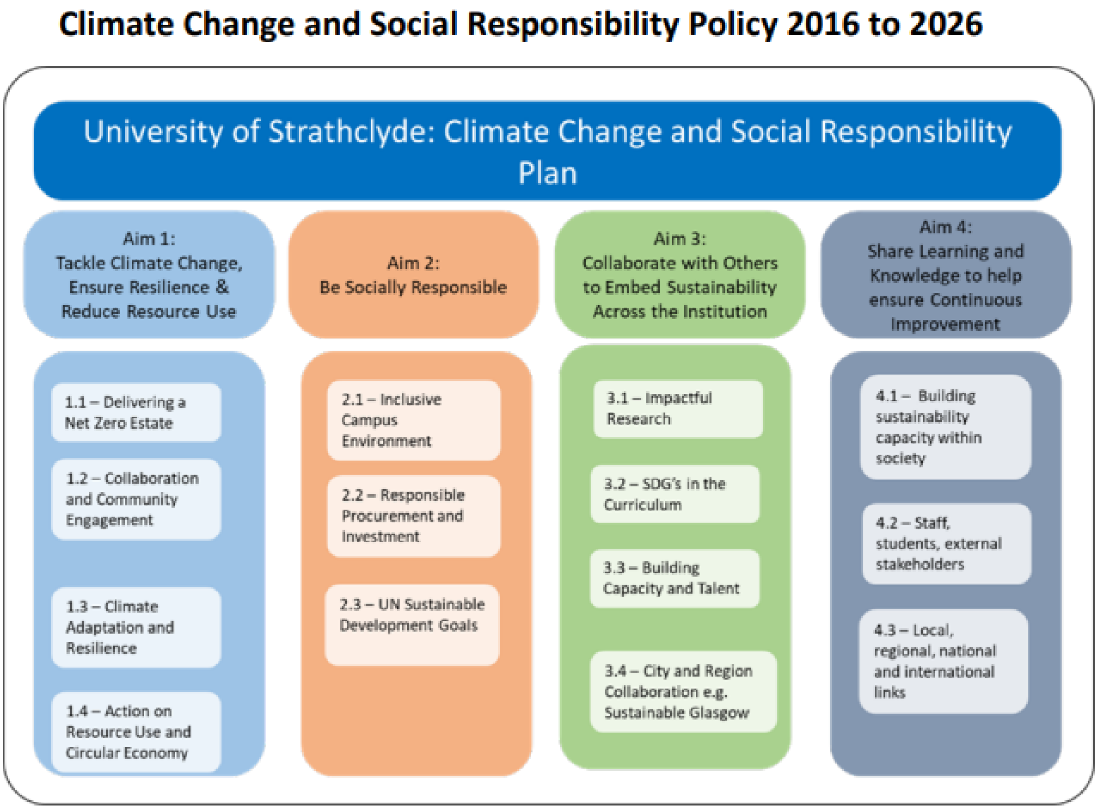
21 Institute of Environmental Management and Assessment (2017). Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance. Available at: https://www.iaia.org/pdf/wab/EIA%20Guide_GHG%20Assessment%20and%20Significance_IEMA_16May17.pdf

22 Royal Institute of British Architects, 2021. RIBA 2030 Climate Challenge version 2 2021. Available at: https://www.architecture.com/-/media/files/Climate-action/RIBA-2030-Climate-Challenge.pdf

23 Department for Communities and Local Government. National Planning Practice Guidance. Available at: https://www.gov.uk/government/collections/planningpractice-guidance

24 RICS (2017). RICS professional standards and guidance, UK Whole life carbon assessment for the built environment.

At the end of the financial year 2019/2020, the University's direct carbon emissions were 20,878 tonnes of CO_2e, a reduction of 30% since the baseline year, exceeding the 2020 carbon target.[25]



The Climate Change and Social Responsibility Policy has four main aims.[26]

- Tackle climate change and reduce resource use
- Be socially responsible
- Collaborate with others
- Share learning and knowledge to help ensure continuous improvement

2.2 BASELINE DATA COLLECTION

Baseline data for the climate resilience assessment has been sourced from the following locations:

- State of the UK Climate (2018)[27] (existing baseline);
- Climate of the UK: observed trends[28] (existing baseline); and

25 Estates_Committee_Annual_CCSR_Report_-_2019-2020_MASTER_V3.docx (live.com)

26 https://www.strath.ac.uk/media/ps/estatesmanagement/sustainability/SD_and_Climate_Change_Policy_Web_Version.pdf

27 Kendon, M. et al. (2019) State of the UK Climate 2018. International Journal of Climatology 39:1.

28 Met Office (2019) UK Climate maps and data. Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data (Accessed 21/07/2021).

- UK Climate Projections 2018[29] (UKCP18) (future baseline).

2.2.1 DEFINITIONS OF HAZARDS, UNIVERSITY ASSETS AND RISK

For the purposes of this assessment a hazard is defined as one of the effects of a changed climate which has the potential to do harm to the infrastructure and assets associated with the University of Strathclyde. The following climate hazards are considered in this risk assessment:

- Heat;
- Drought;
- Humidity;
- Ice and snow/cold;
- Insolation (solar irradiation);
- River, surface water and groundwater flooding;
- Storms/lightning strikes; and
- Wind.

The degree to which the frequency and intensity of these potential hazards may change as a result of climate change is explained in the UKCP18 climate change projections.

2.2.2 CLIMATE CHANGE RESILIENCE ASSESSMENT

Impacts from climate and weather-related events are some of the most significant risks that organisations face today. The global climate is changing, and changes in temperature and rainfall in the UK have already been observed.

Recent decades have been warmer, wetter, and sunnier than the twentieth century. The State of the UK climate report found that the year 2020 was the third warmest, fifth wettest and eighth sunniest on record, with no other year falling in the top 10 for all three variables for the UK. Six of the 10 wettest years for the UK in a series from 1862 have occurred since 1998. All the top 10 warmest years for the UK in the series from 1884 have occurred since 2002. The intensity, frequency and duration of heatwaves are projected to increase and summer temperatures are predicted to be 5°C hotter by 2070. This will pose significant threat to the water and supply, create significant health and wellbeing issues, and impact transport, building and energy.

Even with very significant measures to reduce future GHG emissions, a significant degree of climate change will still be experienced due to historic emissions and the lag in the effect of those in the climate system.

As such, extreme weather events/climate change and the failure of climate change mitigation and adaptation actions have featured consistently for the last decade in the World Economic Forum's top five global risks in terms of likelihood and impact.

The UK Climate Change Risk Assessment (CCRA), published in 2016, identified a range of specific climate- and weather-related risks to the built environment and real estate assets, including:

29 Met Office (2018) UK Climate Projections 2018. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index (Accessed: 21/07/2021).

- Risks to health and wellbeing from overheating in buildings - hotter temperatures will increase the risk of overheating in buildings leading to adverse health impacts and thermal comfort;
- Risks to buildings from flooding - increased frequency of flood events may result in higher insurance premiums, higher maintenance or repair costs and a potential decrease in rental income;
- Risks to buildings from moisture, wind and driving rain - buildings may experience more frequent damage from storm events and moisture encroachment into the building fabric; and
- Insurance risks - physical risks of climate change may disrupt current insurance; and arrangements, and if insurers were to become increasingly exposed re-pricing on an annual basis and/or withdrawal of coverage may occur.

Alongside these risks, changes in the UK weather and climate may bring about operational and strategic opportunities. For example:

- Increased average winter temperatures (and less days below 0°C) may mean that energy requirements for heating will reduce in winter, leading to cost savings; and
- Real estate that can demonstrate adaptation of built environment assets to climate- and weather-related risks may become more desirable (and therefore may have improved occupancy and rental income).

Climate risks with the highest risk ratings are prioritised in terms of the need for mitigation and response planning. We also provide recommendations on how climate resilience measures should be incorporated into the proposed project to reduce the identified climate risks.

3 CLIMATE CHANGE PROJECTIONS

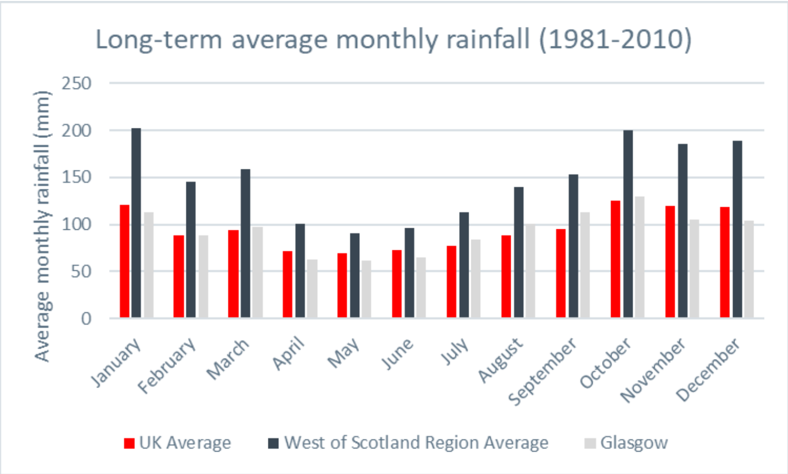
3.1 HISTORIC CLIMATE BASELINE

The University of Strathclyde is located in the Met Office climate profile of Western Scotland. The Springburn station (approximately three miles North of the University and the closest weather station to the University) has been chosen as representative of the local climate. To understand the local climate in the context of the regional and national climate, results for climate variables (temperature, precipitation, wind and sea level rise) are shown in combination with the West of Scotland Region and the UK average.

3.1.1 PRECIPITATION

The Figure below shows that the area of the Springburn Station is drier than both the West of Scotland Region and the UK average.

Figure 3-1 - Long-term average monthly rainfall for the West of Scotland region and Springburn Weather Station, in comparison to the rest of the UK. Source: Met Office UK (2021)



3.1.1.1 Extreme Precipitation

The table below shows the average total number of days where rainfall exceeds 1mm in summer and winter for Springburn weather station. In summer the average number of days that exceed 1mm is 12.9 days and winter is 15.1 days.

Table 3-1 - Long-term average of total number of days where rainfall exceeded 1mm for the baseline period (1981-2010). Source: Met Office UK (2021)

Period	Days of rainfall >1mm (1981-2010)	
	Springburn	UK Average
Summer	12.9	34.9
Winter	15.1	42.6
Annual	170.3	156.4

Periods of prolonged rainfall are often associated with Atlantic depressions or with convection. The Atlantic lows are more vigorous in autumn and winter. In summer, convection caused by solar surface heating sometimes forms shower clouds and a large proportion of rain falls from showers and thunderstorms at this time of year. Rainfall caused this way is normally more intense than winter rainfall which tends to be more frontal with falls occurring over longer periods.

3.1.2 TEMPERATURE

The figure below shows the long-term average mean monthly temperature for the Springburn weather station, the West of Scotland Region, and the UK for the period 1981–2010. It shows that average temperatures at University of Strathclyde are:

- Warmest month is July with 18.0° Celsius (64.4° Fahrenheit).
- On average, the coolest month is January with 5.0° Celsius (41° Fahrenheit).
- The average annual maximum temperature is: 11.0° Celsius (51.8° Fahrenheit)
- The average annual minimum temperature is: 5.0° Celsius

Figure 3-2 - Long-term average mean monthly temperature for the West of Scotland Region and Springburn Station, in comparison to the rest of the UK. Source: Met Office UK (2021)

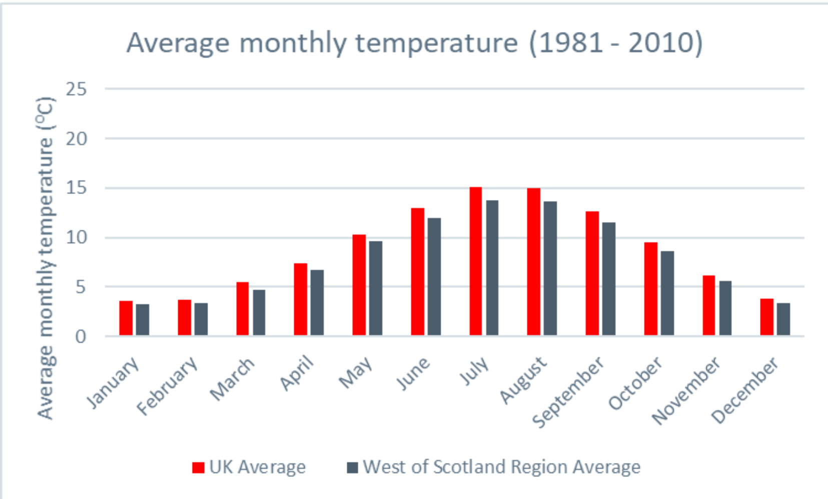
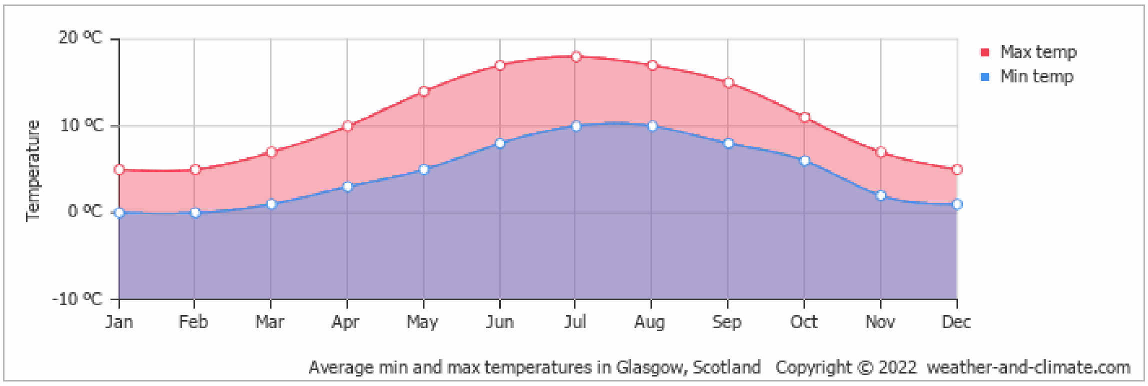


Figure 3-3 - Average min and max temperature in Glasgow, Scotland.



3.1.2.1 Extreme Temperature

Table 3-2 shows the average maximum and minimum summer (June, July, and August) and winter (December, January, and February) temperatures recorded between 1981 and 2010 for Springburn weather station. Whereby summer mean maximum and minimum temperatures are highs of 21.4°C and 12.4°C, respectively. Temperature lows reach 2.1°C for winter months from 1981-2010.

Table 3-2 - Long term average of mean maximum temperature (°C) for Springburn weather station for 1981 – 2010. Source: Met Office UK (2021)

Period	Mean Maximum Temperature (°C) (1981-2010)	Mean Minimum Temperature (°C) (1981-2010)
Summer	6.2	10.5
Winter	12.2	6.2

Air frost is defined as when the air temperature falls to or below freezing point of water at a height of at least 1m above the ground. The Table below shows that from 1981-2010 the average number of fair frost days was 25.8 in winter which is 70% of the number of days per year.

Table 3-3 - Average number of days of air frost for the baseline period (1981-2010). Source: Met Office UK (2021)

Period	Days of air frost (1981-2010)
Summer	0.0
Winter	10.7
Annual	47.9

3.1.3 SEA LEVEL AND FLOOD RISK

There is a long history of flooding within this area. Many of the river floods which caused damages to properties and people occurred prior to the Clyde being canalised and widened to the south (1700's and 1800's), however the city was very different at this time.

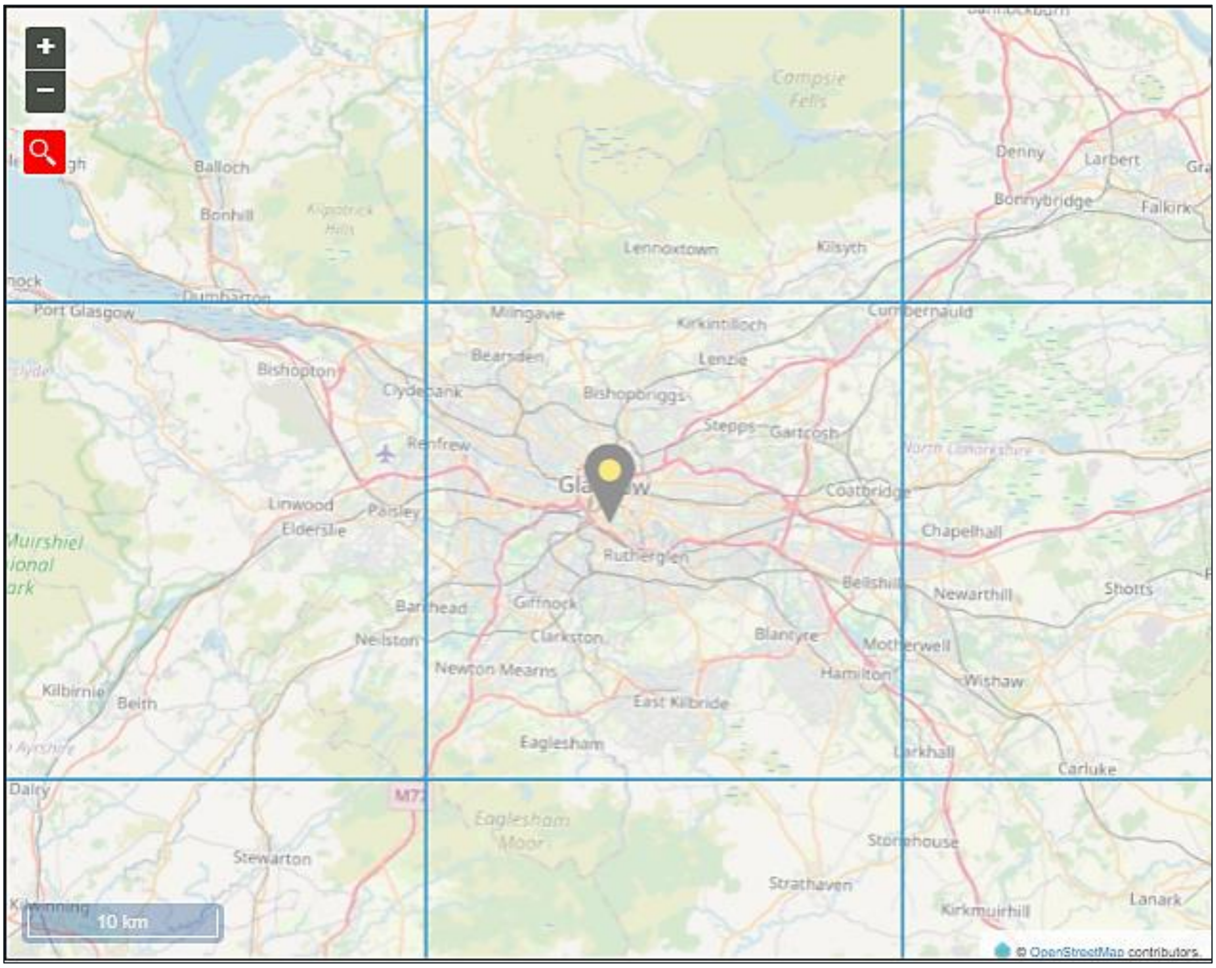
Between 10- 12 December 1994 major flooding occurred in rivers and urban watercourses across Glasgow and surrounding areas. A slow-moving weather system delivered persistent rain over a 48-hour period across a wide geographical area. Previously recorded peak river flows were exceeded in all major catchments in the region. The River Clyde is thought to have reached its highest level in 150 years, and the total cost of the damage reached in the region of £100 million. This flood had a magnitude of 50–100-year return period. There were 700 homes and many businesses affected in Strathclyde. This flood severely affected Glasgow City and completely inundated the grounds of the Scottish Exhibition and Conference Centre.

There have been no coastal floods recorded within this Potentially Vulnerable Area; however, it is likely that many of the early river flood events could be attributed to tidal surges from the Clyde.[30]

3.2 FUTURE BASELINE

The UKCP18 provide data on projected change in climate variables for the UK. Probabilistic projections for the 25km grid square where the University of Strathclyde is located have been used (Figure 3-4).

Figure 3-4 - 25km grid square used for probabilistic projections



The UKCP18 are the most up-to-date projections of climate change for the UK, providing projections until the end of the 21st Century. UKCP18 includes probabilistic projections of a range of climate variables for different emissions scenarios, termed Representative Concentration Pathways (RCPs) and for a range of time slices to the end of the 21st Century. The probabilistic projections mean that rather than a single 'best-guess' of the impact of climate change, they provide a range of outcomes

30 Glasgow City Centre (Potentially Vulnerable Area 11/16) https://www2.sepa.org.uk/FRMStrategies/pdf/pva/PVA_11_16_Full.pdf

based on an 'ensemble' of multiple climate model runs. This better represents the uncertainty of climate prediction science. To help demonstrate consideration of uncertainty inherent within climate modelling, projections for the 10th, 50th (central) and 90th percentiles are stated, where possible.

Climate projections are provided for the emissions scenario RCP8.5. This is a high emissions scenario which combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies. The IEMA guidance states that "Recommended best practice is to use the higher emissions scenario (RCP 8.5 in the latest UKCP18 projections) at the 50th percentile, for the 2080s timelines".

The future baseline has been presented for the 2050s and 2080s to identify the anticipated climate conditions over the life of the University's existing assets.

3.2.1 PRECIPITATION

Climate change is projected to lead to wetter winters and drier summers although natural variation, including extreme events such as storms and heat waves, will continue to punctuate these trends. The projected changes to average summer and winter rainfall for the 2050s and 2080s are summarised in Table 3-4.

Table 3-4 - Projected change in mean summer and winter precipitation (%) for the 2050s and 2080s, RCP8.5

Season / Timescale		Precipitation change (%) - Percentile change		
		10th	50th	90th
Summer	2050s	-29.09%	-14.47%	+0.28%
	2080s	-39.84%	-21.31%	-2.98%
Winter	2050s	-0.57%	+9.43%	+20.24%
	2080s	-2.27%	+14.53%	+33.78%

The 10th and 90th percentile provide the lower and upper estimates of precipitation change. For example, for the summer in the 2050s, precipitation is very unlikely to decrease by more than 29% or increase by more than 0.3%. The central estimate predicts that there will be a decrease in summer rainfall by approximately 14.5% for the 2050s, and a decrease of 21.3% by the 2080s. In contrast, winter precipitation is predicted to increase by 9.4% for the 2050s and 14.5% for the 2080s (central estimate).

3.2.1.1 Extreme Precipitation

Climate change means that more rainfall will fall during 'intense' events, particularly in winter. Projections for 1 in 20-year extreme precipitation are available at the 25km scale from UKCP18 as seasonal average 1-day totals under the RCP 8.5 scenario for the time periods of 2021-2040 and 2061 – 2080 for summer and winter presented in Table 3-5 for the 50th percentile.

Table 3-5 - 1 in 20-year, average mean 1-day total precipitation (mm) summer and winter for the 2030s and 2070s, RCP8.5

Season / Timescale		50th percentile
Summer	2030s	45.56
	2070s	47.63
Winter	2030s	39.39
	2070s	42.88

3.2.2 TEMPERATURE

In general, UKCP18 predicts that climate change is projected to lead to hotter summers and warmer winters. Table 8.3 summarises the UKCP18 projections for changes in mean temperature for the 25km grid square where the University is located, in the 2050s and 2080s under RCP 8.5.

Table 3-6 - Projected change in mean summer and winter temperature (°C) for the 2050s and 2080s, RCP8.5

Season / Timescale		Temperature change (°C) - Percentile change		
		10th	50th	90th
Summer	2050s	+0.51	+1.87	+3.37
	2080s	+1.57	+3.96	+6.52
Winter	2050s	+0.37	+1.59	+2.85
	2080s	+1.07	+2.96	+4.92

The 10th and 90th percentile provide the lower and upper estimates of warming. For example, for the summer in the 2050s, temperature increase is unlikely to be less than a 0.5°C increase, or more than a 3.4°C increase. The central estimate predicts that there will be an increase in summer temperature by 1.9°C for the 2050s and a further increase to 4°C for the 2080s. Winter temperature is also predicted to increase, by 1.6°C for the 2050s and 3°C for the 2080s.

3.2.2.1 Extreme Temperature

Table 3-7 summarises the UKCP18 projections for changes in maximum and minimum temperature for the University of Strathclyde’s 25km grid square for summer and winter in the 2050s and 2080s under RCP 8.5. Note, the values below represent mean maximum and minimum temperature changes. Therefore, individual days may exceed these values.

Table 3-7 - Projected change in maximum and minimum mean summer and winter temperatures (°C) for the 2050s and 2080s, RCP8.5

Season / Timescale		Temperature change (°C) - Percentile change					
		Maximum (°C)			Minimum (°C)		
		10th	50th	90th	10th	50th	90th
Summer	2050s	+0.59	+2.13	+3.74	+0.49	+1.54	+2.70
	2080s	+1.69	+4.35	+7.17	+1.41	+3.29	+5.45
Winter	2050s	+0.40	+1.56	+2.77	+0.25	+1.52	+3.01
	2080s	+1.08	+2.88	+4.77	+0.77	+2.83	+5.24

3.2.2.2 Humidity

Humidity is a measurement of the amount of water vapour in the air. UKCP18 projections predicts that climate change will lead to changes in specific humidity. Table 3-8 summarises the UKCP18 projections for changes in specific humidity for the 25km grid square where the University is located in the 2050s and 2080s under RCP 8.5.

Table 3-8 - Projected change in specific humidity % for the 2050s and 2080s, RCP8.5

Season / Timescale		Humidity change (%) - Percentile change		
		10th	50th	90th
Summer	2050s	+0.28%	+9.65%	+19.68%
	2080s	+4.07%	+19.17%	+35.36%
Winter	2050s	+0.15%	+10.12%	+21.04%
	2080s	+5.47%	+20.75%	+37.51%

The 10th and 90th percentile provide the lower and upper estimates of specific humidity. For example, for the summer in the 2050s, humidity decrease is unlikely to be less than a 0.3% or increase more than a 19.7%. The central estimate predicts that there will be an increase in humidity by 9.7% for the 2050s and a further increase to 19.2% for the 2080s. Winter central estimates for humidity are also predicted to increase, by 10.2% for the 2050s and 20.8% for the 2080s.

In line with the available guidance and information, the applicability of climate variables for the project is determined as follows:

Table 3-9 - Climate variables scoped in or out of the assessment

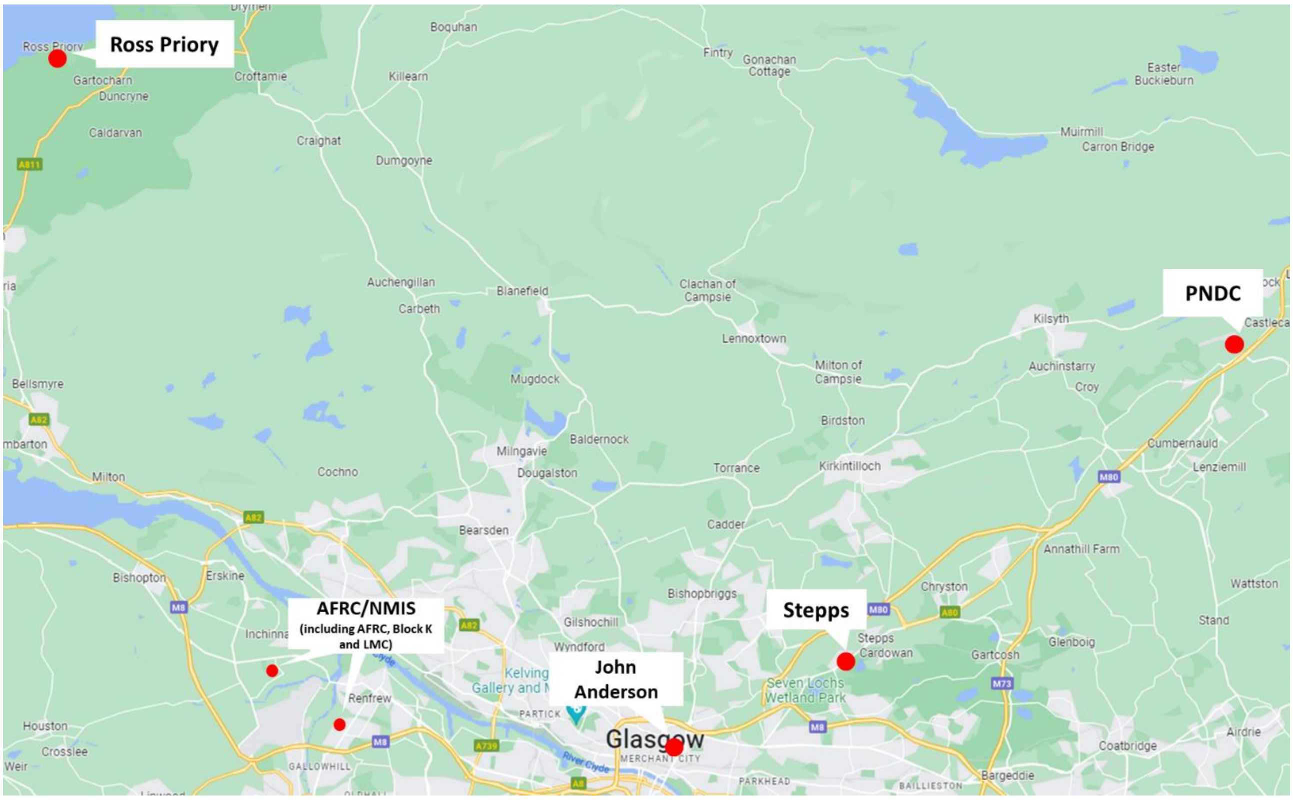
Climate variable		Scoped In	Scoped Out	Justification
Sea	Sea level rise;		Y	Given the inland location of the University of Strathclyde, variables associated with sea level and sea temperature will not affect the existing assets.
	Storm surge and storm tide;			
	Surface temperature; and			
	Currents and waves.			
Precipitation	Changes in annual average	Y		Given the impacts of climate change in terms of rising temperatures. Precipitation levels have a direct relationship which this change and can have large impacts in the annual average of precipitations.
	Drought		Y	Given the predicted levels of precipitation on the University of Strathclyde, variables associated with drought climatic events may not affect the existing assets.
	Extreme precipitation events.	Y		Given the history of precipitation-related flooding in the Glasgow area extreme precipitation events have been scoped into the assessment.
Temperature	Changes in annual average.	Y		Given the UKCP18 data on climate predictions the associated areas around the University assets are likely to experience temperature changes related to climate change.
	Extreme temperature events.	Y		
Wind	Gales and extreme wind events	Y		
	Storms (lightning, hail)	Y		
Humidity	Changes in annual average	Y		UKCP18 projections predicts that climate change will lead to changes in specific humidity which has direct impacts to other climate variables such as precipitations. Humidity is an important variable that can affect he operations and functions of the University assets.
	Evaporation	Y		

4 CLIMATE CHANGE RISK AND VULNERABILITY ASSESSMENT

The University of Strathclyde Estate has been built over the course of more than two centuries, and as a result the buildings/assets are highly diverse in their nature. When considering measures to address heat risk, options will be more effective in different types of building. To undertake a comprehensive climate change risk and vulnerability assessment, different WSP divided the study in five campuses and further characterised three typical university building typologies to provide an indication of which measures may suit different buildings. Whilst not all buildings fit into these typologies, and those that do have unique circumstances that affect the suitability of measures, they may offer useful pointers to help identify promising options.

The five campuses location and their characteristics are as follows:

Figure 4-1- Location map of 5 campuses included in the assessment



- **John Anderson Campus:** As an urban campus, the main teaching and research centre of the University is comprised of a series of buildings in Glasgow City Centre.



- **National Manufacturing Institute Scotland (NMIS):** Based near Glasgow International Airport, this design and manufacturing research centre houses advanced technology which is crucial to the international work of Strathclyde. The campus consists of AFRC, Block K and Light Manufacturing Centre (LMC).


- **Power Networks Demonstration Centre (PNDC):** PNDC is located on the outskirts of Cumbernauld and comprises of a single building and outdoor energy network simulation structures and has a SuDs basin as well.



- **Stepps Playing Fields:** The Strathclyde University playing fields are located in Stepps and comprises of 5 football pitches (amenity/recreation grassland), 2 rugby pitches (amenity/recreation grassland), a hockey pitch (blaize), 1 multi-purpose synthetic pitch. It is 20.6 hectares in area with a perimeter of 2.3 km. The Site contains 5 buildings including the Estate Manager's Bungalow, Equipment Storage shed, Machinery Shed, Estate Team Office and Sports Pavilion.



- **Ross Priory:** On the banks of Loch Lomond, the historic building and grounds of Ross Priory serve as a conferencing and events venue for the University.


The campuses are further divided into three major building typologies based on the age of the building:

- **Victorian and Edwardian buildings** - These buildings tend to have a high thermal mass (ability to store heat in the walls, floors, and ceilings), high ceilings and solid walls. Internal temperatures can usually be maintained relatively well. These buildings often benefit from improved night ventilation, as well as measures that intercept sunlight before entering the building, such as tree planting and blinds. They also tend to have external rainwater pipes which can be disconnected and diverted into SuDS such as rain planters or green space.
- **Late 20th century buildings** - These university buildings typically have low thermal mass, single glazing, high glass coverage, poor air tightness and insulation, and are often oriented to the south. They typically have the highest heat risk. The load carrying capacity of these roofs should be checked for suitability to support a green roof. Light-weight reflective surfaces like cool roof coatings, and solar shading such as blinds and awnings may be suitable solutions
- **Modern buildings** - University buildings built in the 21st century tend to have a moderate thermal mass, with higher insulation standards than the other typologies, which can contribute to overheating if insufficient ventilation is provided. Modern buildings often incorporate a large area of glass façade, which may present comparatively higher heat risk. These buildings may have a higher structural integrity that could support measures such as green roofs. Adequate night ventilation is important to release built-up heat during the day.

4.1 CLIMATE CHANGE RISK ASSESSMENT

An understanding of the likelihood of an impact occurring is needed to identify the risk to the University from climate change. The risk assessment therefore considers the likelihood of a hazard occurring that could result in an impact on the assets associated with the University. In addition, the risk to the existing assets will depend on the severity of the consequence of the impact, and the vulnerability of the asset itself. The definitions of these terms can therefore be summarised as follows:

- Hazard is the ***potential*** to cause an impact.
- Risk is the ***likelihood*** of impact occurring multiplied by consequence of impact of hazard.
- Vulnerability is the ***degree*** *to which* infrastructure or assets are susceptible to adverse impacts and is influenced by sensitivity, adaptive capacity and magnitude of impact.

4.1.1 PREVIOUS WORK:

The University of Strathclyde Adaptation Plan 2021[31], based on the Climate Change workshop conducted in November 2015 provides information on three risks that were identified to pose the biggest challenge from climate change perspective. These were:

- Buildings need to be fit for purpose in a future climate.
- Climate change will affect health and wellbeing of individuals and communities.

[31] The University of Strathclyde Adaptation Plan 2021. Available at: University of Strathclyde Climate Change Adaptation Plan

- Effective land use management and development planning has a critical role in adapting to climate change

The plan provides a brief overview of the risks and vulnerabilities to the estate and does not go into details of individual campuses or building on the estate. The adaptation measures also provide an overview of a few potential measures. It is unclear how many buildings were studied for drafting the adaptation plan.

4.1.2 WORKSHOPS BY WSP CLIMATE CHANGE TEAM:

The WSP Climate change team conducted total six workshops till date with the University team, fabrics team, building services team, Grounds and gardens, PNDC, AFRC management teams and Scottish Water to understand the risks and vulnerabilities associated with climate change and pertinent to the University.

Table 4-1 builds on the previous study and information provided by the project teams during the workshops and provides an overview of the identified hazards and risks and provides an evaluation of the impact on each campus along with individual building type.

Table 4-1- Hazard and Risk analysis for each Campus

CLIMATE VARIABLE	JOHN ANDERSON CAMPUS:		
	Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events have a very high potential to cause flooding.	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events have a very high potential to cause flooding.	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events have a very high potential to cause flooding.
	Risk estimation: **High** Risk evaluation: The older asset groups are susceptible to flooding due to poor flood management in these buildings. The Royal college building was identified to be impacted majorly due to poor flood/drainage management in place.	Risk estimation: **High** Risk evaluation: The older asset groups are susceptible to flooding due to poor flood management in these buildings. Additionally, the drainage system in these buildings is also improper and in advent of unpredictable rainfall, a spike is observed in the water levels in few buildings. The drainage system does not have capacity to deal with extra volume of water and can potentially lead to flooding. Third party assets and their management are also adding to the pressure created by under capacity rainwater management of the combined sewer. Eg- Scottish Water Infrastructure surrounding the campus. Additionally, the campus is positioned on top of a hill increasing potential impact on downstream flooding, linked to surface water run-off from impermeable paving surfaces and buildings.	Risk estimation: **High** Risk evaluation: The modern buildings too do not have proper rainwater and flood management and are at risk of flooding. Th newer buildings have certain degree of flood management, however, is limited to systems like leak detection.
Humidity	Hazard identification: Expansion of doors and windows and rusting. Hazard evaluation: Increase in humidity has medium potential to cause rusting and expansion of building components.	Hazard identification: Expansion of doors and windows and rusting. Hazard evaluation: Increase in humidity has medium potential to cause rusting and expansion of building components.	Hazard identification: Expansion of doors and windows and rusting. Hazard evaluation: Increase in humidity has low/no potential to cause rusting and expansion of building components.
	Risk estimation: **Medium** Risk evaluation: Rusting of cladding may be a risk along with the expansion of fire doors in older	Risk estimation: **Medium**	Risk estimation: **Low**

	buildings. The effect was observed in Royal college building where the fire door expanded due to increase in humidity.	Risk evaluation: Rusting of cladding may be a risk in older buildings due to increased humidity. This risk was especially identified in the Livingston Tower.	Risk evaluation: As the modern buildings will mostly account for the changes in humidity, the risk is comparatively lower in modern buildings.
Temperature	Hazard identification: Warping Hazard evaluation: Change in temperatures have high potential to cause warping to many buildings.	Hazard identification: Overheating Hazard evaluation: increase in temperatures have high potential to overheat the internal rooms.	Hazard identification: Overheating and warping Hazard evaluation: increase in temperatures have low/no potential to overheat the buildings.
	Risk estimation: **High** Risk evaluation: there is a high risk of warping to many buildings as it is predominantly felt coverings. The increased temperatures will also cause the buildings to become more hotter and generate a need of mechanical ventilation in future thus increasing the energy use in the buildings. This is especially applicable to Barony Hall, 4 Park Circus buildings as these have single glazed windows.	Risk estimation: **High** Risk evaluation: The increased temperatures will also cause the buildings to become more hotter and generate a need of mechanical ventilation in future thus increasing the energy use in the buildings. This risk was observed in John Anderson building where internal rooms are at a risk of overheating due to the lack of ventilation in the building and Livingston tower which has no insulation to curb the heat due to increased temperatures. Some buildings in this typology also do not have overhangs to provide shade and will thus contribute to heating the internal spaces.	Risk estimation: **Medium** Risk evaluation: The increase in temperatures do not pose high risk to the buildings in terms of overheating. Many of the buildings in this typology, however, do not have overhangs which might become an issue in the future in case of persistent temperature rise. The buildings are double glazed which helps in curbing the effects of increased temperatures.
Wind	Hazard identification: Tree felling and property damage Hazard evaluation: Extreme wind events and storms have medium potential to cause damages to vegetation and assets	Hazard identification: Tree felling and property damage Hazard evaluation: Extreme wind events and storms have medium potential to cause damages to vegetation and assets	Hazard identification: Tree felling Hazard evaluation: Extreme wind events and storms have medium potential to cause damages to vegetation and low potential to cause damage to assets.
	Risk estimation: **Medium** Risk evaluation: There is a risk of mature tree felling in the campus. Stronger winds may cause window failures across the campus and cladding panels to come loose.	Risk estimation: **Medium** Risk evaluation: There is a risk of mature tree felling in the campus. Stronger winds may cause window failures across the campus and cladding panels to come loose. This risk was especially identified in the Livingston Tower.	Risk estimation: **Low** Risk evaluation: Although the risk to mature trees remain medium, the risk to properties is low as modern buildings will take into account the current wind load and design accordingly.
CLIMATE VARIABLE	**ROSS PRIORY CAMPUS:**		
	Victorian and Edwardian Buildings (1837 – 1911)	**Late 20th Century Buildings**	**Modern Buildings**

Precipitation	Hazard identification: Flooding and contamination Hazard evaluation: Extreme rainfall events have a very high potential to cause flooding.	Hazard identification: Flooding and contamination Hazard evaluation: Extreme rainfall events have a very high potential to cause flooding.	Not applicable as there are no Modern buildings in the campus
	Risk estimation: **High** Risk evaluation: Oil generators are being used throughout the campus and flooding could cause disruption to the oil deliveries and also leaking boilers can cause ground and water contamination. There is no flood management system in place and flooding due to increased precipitation can cause untreated sewage to get mixed with stormwater and is a potential health hazard. The proximity to the loch and remote location makes the campus vulnerable to the potential impacts of flooding during times of increased rainfall. This regular flooding as a result to high water levels in Loch Lomond impacts the ability of the Reedbed to operate at its full capacity. This consequentially also jeopardises the University's ability to meet surface water discharge consent standards for this area which the University is legally bound to comply with via Scottish Environment Protection Agency (SEPA).	Risk estimation: **High** Risk evaluation: Oil generators are being used throughout the campus and flooding could cause disruption to the oil deliveries and also leaking boilers can cause ground and water contamination. There is no flood management system in place and flooding due to increased precipitation can cause untreated sewage to get mixed with stormwater and is a potential health hazard. The proximity to the loch and remote location makes the campus vulnerable to the potential impacts of flooding during times of increased rainfall. This regular flooding as a result to high water levels in Loch Lomond impacts the ability of the Reedbed to operate at its full capacity. This consequentially also jeopardises the University's ability to meet surface water discharge consent standards for this area which the University is legally bound to comply with via Scottish Environment Protection Agency (SEPA).	
Humidity	Hazard identification: Cracking of materials Hazard evaluation: Increase in humidity has high potential to cause cracking of the building material.	Hazard identification: Cracking of materials Hazard evaluation: Increase in humidity has high potential to cause cracking of the building material.	
	Risk estimation: **Medium** Risk evaluation: Cracking and freeze thaw is a risk across this campus. Increased humidity may also cause a risk due to the poor ventilation systems implemented across the sites. This kind of situation usually results in mould issues which can pose a severe health hazard. It was observed that the biggest risk is to Ross Priory main building in winter when the sandstone can crack due to unfreezing and freezing.	Risk estimation: **Medium** Risk evaluation: Cracking and freeze thaw is a risk across this campus. Increased humidity may also cause a risk due to the poor ventilation systems implemented across the sites. This kind of situation usually results in mould issues which can pose a severe health hazard.	
	Hazard identification: Overheating or overcooling	Hazard identification: Overheating or overcooling	

Temperature	Hazard evaluation: Extreme temperature events have high potential to cause overheating or overcooling in the buildings.	Hazard evaluation: Extreme temperature events have high potential to cause overheating or overcooling in the buildings.	
	Risk estimation: **Low** Risk evaluation: Currently, the buildings are only naturally ventilated and do not face issues due to change in temperatures. In case of any increase in temperatures in future, however, mechanical ventilation might be required to be installed for comfort cooling thus making it a future risk. The buildings also have single glazed panels which might contribute to overheating or overcooling of internal spaces thus increasing the energy use for heating/cooling in the future.	Risk estimation: **Low** Risk evaluation: Currently, the buildings are only naturally ventilated and do not face issues due to change in temperatures. In case of any increase in temperatures in future, however, mechanical ventilation might be required to be installed for comfort cooling thus making it a future risk. The buildings also have single glazed panels which might contribute to overheating or overcooling of internal spaces thus increasing the energy use for heating/cooling in the future.	
Wind	Hazard identification: Repairs and Reduced access and property damage Hazard evaluation: Extreme wind events and storms have medium potential to impact the access to the property and damage the assets.	Hazard identification: Repairs and Reduced access and property damage Hazard evaluation: Extreme wind events and storms have medium potential to impact the access to the property and damage the assets.	
	Risk estimation: **Medium** Risk evaluation: Due to wind events, repairs have been required across the campus. Ageing roofs has resulted in loose tiles which could pose a hazard. Safety checks are completed once a year to determine the risk and maintenance requirements. The remote location of the campus results in reduced access during storms.	Risk estimation: **Medium** Risk evaluation: Due to wind events, repairs have been required across the campus. Ageing roofs has resulted in loose tiles which could pose a hazard. Safety checks are completed once a year to determine the risk and maintenance requirements. The remote location of the campus results in reduced access during storms.	
CLIMATE VARIABLE	**STEPPS CAMPUS:**		
	Victorian and Edwardian Buildings (1837 – 1911)	**Late 20th Century Buildings**	**Modern Buildings**
Precipitation	Not applicable as there are no Victorian and Edwardian Buildings in the campus	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events have a very high potential to cause flooding.	Not applicable as there are no Modern buildings in the campus

		Risk estimation: **High** Risk evaluation: Maintaining water levels and subsequent flooding due to it is an issue with Stepps campus. To combat the flooding, the pumps are changed to centrifugal pumps in order to maintain the height of the bund. Flooding can damage the staff flats if the water level goes up. Frankfield Loch pond is in close proximity of the campus and in case of increased precipitation might aggravate the issue of flooding of the playing fields in the future.	
Humidity		Hazard identification: Cracking Hazard evaluation: There are no definitive hazards identified accrued to humidity for the campus currently, but cracking can be a hazard in the future.	
		Risk estimation: **Low** Risk evaluation: Cracking of materials may be a risk in the buildings due to increased humidity in future. Currently, it's not an issue.	
Temperature		Hazard identification: Overheating Hazard evaluation: increase in temperatures have high potential to overheat the outdoors and result in Urban Heat Island effect.	
		Risk estimation: Medium Risk evaluation: The increased temperatures will cause Urban Heat Island effect. Since the campus majorly comprises of outdoor playing fields, the increased temperatures have a risk of rendering them underutilised. The buildings are also at risk of overheating as there is no mechanical ventilation installed currently.	
Wind		Hazard identification: Tree felling and property/playfield damage Hazard evaluation: Extreme wind events and storms currently have low potential to cause damages to vegetation and assets including the playing fields	
		Risk estimation: **Low**	

		Risk evaluation: There is a potential risk of mature tree felling in the campus. Stronger winds may cause damage to the playing fields as well resulting in additional cost and resources spend on maintenance. Though the risk is considered low in present scenario.	
CLIMATE VARIABLE	**AFRC CAMPUS:**		
	Victorian and Edwardian Buildings (1837 – 1911)	**Late 20th Century Buildings**	**Modern Buildings**
Precipitation	Not applicable as there are no Victorian and Edwardian Buildings in the campus	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events currently have a Low high potential to cause flooding.	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events currently have a Low high potential to cause flooding.
		Risk estimation: **Low** Risk evaluation: The risk of flooding due to White Cart Water is minimal as the Block K building is located quite far from the river.	Risk estimation: **Medium** Risk evaluation: There could be a future risk of flooding due to the White Cart River being very near to the Lightweight Manufacturing Centre building (approx. 800m). Car Park is built on softscape area so can get flooded in future. The risk to AFRC, however, is low as the building is located far from the Black Cart Water. The risk is considered medium as a combined impact.
Humidity		Hazard identification: Expansion of doors and windows and rusting. Hazard evaluation: Increase in humidity has currently low/no potential to cause rusting and expansion of building components.	Hazard identification: Expansion of doors and windows and rusting. Hazard evaluation: Increase in humidity has currently low/no potential to cause rusting and expansion of building components.
		Risk estimation: **Low** Risk evaluation: Rusting of cladding may be a future risk in older buildings due to increased humidity.	Risk estimation: **Low** Risk evaluation: As the modern buildings will mostly account for the changes in humidity, the risk is comparatively lower in modern buildings, however, since the AFRC building is cladded, it might prove to be a future risk.

Temperature		Hazard identification: Overheating or overcooling Hazard evaluation: increase in temperatures currently have no/low potential to overheat the internal rooms.	Hazard identification: Overheating or overcooling Hazard evaluation: increase in temperatures have high potential to overheat the buildings.
		Risk estimation: **Low** Risk evaluation: The increased temperatures will also cause the buildings to become more hotter and generate a need of mechanical ventilation in future thus increasing the energy use in the buildings. This risk was observed in, Block K as it does not have any windows hence the ventilation and overheating might become a problem in future.	Risk estimation: **High** Risk evaluation: In AFRC, 99% of glazing is east facing and the internal areas gets heated as a result. The windcatchers are not generally open and a number of the manually operated windows are also closed. As a result, there was limited fresh air in the office spaces and central kitchen area. Some offices in the central area also does not have sufficient cooling. Open plan offices have passive cooling only and natural ventilation that might be an issue in future. The building also does not have overhangs to provide shade and will thus contribute to heating the internal spaces. The workshop was reported to be cold during the winter months and portable heaters were seen around the work areas. The lightweight manufacturing building gets cold due to concrete floors. In future, this might generate a need for increased heating thus increasing the energy consumption.
Wind		Hazard identification: Property damage Hazard evaluation: Extreme wind events and storms have no/low potential to cause damages to the assets.	Hazard identification: Property damage Hazard evaluation: Extreme wind events and storms have low potential to cause damages to damage to the assets.
		Risk estimation: **Low** Risk evaluation: There are no current risks related to the wind.	Risk estimation: **Low** Risk evaluation: Structure is pitched to a single direction so in case of wind coming from opposite direction is an issue.
CLIMATE VARIABLE	**PNDC CAMPUS:**		
	Victorian and Edwardian Buildings (1837 – 1911)	**Late 20th Century Buildings**	**Modern Buildings**

Precipitation	Not applicable as there are no Victorian and Edwardian Buildings in the campus	Not applicable as there are no Late 20th Century Buildings in the campus	Hazard identification: Flooding Hazard evaluation: Extreme rainfall events have a low potential to cause flooding.
			Risk estimation: **Medium** Risk evaluation: The building is maintained regularly by Skanska and hence is at low risk of flooding. There are SUDS basin in front of the building which also contributes to managing the stormwater and reducing the risk of flooding of the building. The terrain of the PNDC site is flat which also ensures there is no waterlogging on site.
Humidity			Hazard identification: Expansion of doors and windows and rusting. Hazard evaluation: Increase in humidity has low/no potential to cause rusting and expansion of building components.
			Risk estimation: **Low** Risk evaluation: As the modern buildings will mostly account for the changes in humidity, the risk is comparatively lower in the building.
Temperature			Hazard identification: Overheating Hazard evaluation: increase in temperatures have low/no potential to overheat the buildings.
			Risk estimation: **Low** Risk evaluation: The increase in temperatures do not currently pose high risk to the buildings in terms of overheating. Many of the buildings in this typology, however, do not have overhangs which might become an issue in the future in case of persistent temperature rise. The buildings are double glazed which helps in curbing the effects of increased temperatures. The building does get warm in summer as one side does not have windows.
			Hazard identification: Property damage

Wind			Hazard evaluation: Extreme wind events and storms have no/low potential to cause damages to the assets. Risk estimation: **Low** Risk evaluation: There are no current risks related to the wind.

4.1.3 OTHER RISKS:

Apart from the risks arising through climate variables, following additional risk were identified for overall University and individual campuses:

- **Overall Campus:** This year, the changed compost type in the campus is causing the grounds to dry out faster so the plants need to be watered 3-5 times a day as against once a day in the past years. This is resulting in increase of water use. This can be a huge risk in the future with respect to scarcity of water. Currently, there is no stormwater/rainwater management provisions in the buildings, and this can possibly contribute to the flooding in the campuses.
- **John Anderson:** Due to its central location, the John Anderson Campus is crossed by various busy roads. This will impact on air quality and increased GHG emissions. The intensity of road traffic makes it particularly challenging for the University to encourage cycling. It also means that pedestrians must be very aware of the need to adhere to road crossings and safe walking routes to and from the University. This can be perceived as a future risk. As an urban campus, the main risks from a changing climate here come from extreme rainfall and high temperatures. This could be made worse by the urban heat island effect.
- **Ross Priory:** These are also listed buildings and therefore any changes/mitigation may be difficult to implement. The original building construction dates back to 1816 and is Category A listed.
- **Stepps:** No additional risks identified.
- **AFRC:** No additional risks identified.
- **PNDC:** No additional risks identified.

4.2 CLIMATE CHANGE VULNERABILITY ASSESSMENT

The vulnerability of assets and receptors to climate change is a function of:

- The typical '**sensitivity**' of receptors to climate variables – based on literature review and expert judgement and rated as high, moderate, or low; and
- The '**exposure**' of receptors to projected change in climate variables – based on the baseline information presented above and rated as high, medium, or low.

The vulnerability of assets to climate variables is determined from the combination of the sensitivity and exposure ratings, using the matrix shown in the table below. At this point, climate variables to which the University of Strathclyde is likely to have a 'low' vulnerability to are scoped out of further assessment. Climate variables to which the assets are likely to have a 'medium' or 'high' vulnerability are taken forward for further assessment.

This is a qualitative assessment informed by expert opinion and supporting literature. A Red Amber Green (RAG) system is used for the allocation of low (green) to high (red) vulnerability as shown in Table 4-2.

Table 4-2 - Vulnerability matrix

SENSITIVITY	EXPOSURE		
	Low	Medium	High
Low	Low vulnerability	Low vulnerability	Low vulnerability
Moderate	Low vulnerability	Medium vulnerability	Medium vulnerability
High	Low vulnerability	Medium vulnerability	High vulnerability

4.2.1 SENSITIVITY

The sensitivity of the receptor/receiving environment is the degree of response of a receiver to a change and a function of its capacity to accommodate and recover from a change if it is affected, see**Error! Reference source not found.** Table 4-3 below.

Sensitivity does not consider any design measures which may improve the tolerance of receptors to climate change (this is considered after).

Table 4-3 – Sensitivity descriptors

Sensitivity	Sensitivity description
High	Receptor is highly susceptible to be altered by the projected changes to climate (e.g. lose much of its original function and form).
Moderate	Receptor can tolerate some climatic conditions without being fully altered though remains susceptible to being altered to some extent.
Low	Receptor is not susceptible to be altered by the projected changes to climate as the climatic factors have little influence on the receptor.

Source: Adapted from IEMA guidance

Table 4-4-Table 4-8 identifies how the assets may be sensitive to the climate variables.

Table 4-4 – Sensitivity of the asset to climate change – John Anderson Campus

CLIMATE VARIABLE		John Anderson Campus Sensitivity of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	High	High	High
	Extreme precipitation events	High	High	High
Humidity	Changes in annual average Evaporation	Medium	Medium	Low
Temperature	Changes in annual average	High	High	Medium
	Extreme temperature events	High	High	Medium
Wind	Gales and extreme wind events	Medium	Medium	Low
	Storms (incl. hail, lightning)	Medium	Medium	Low

Table 4-5 - Sensitivity of the asset to climate change – Ross Priory Campus

CLIMATE VARIABLE		Ross Priory Campus Sensitivity of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	High	High	Not Applicable
	Extreme precipitation events	High	High	Not Applicable
Humidity	Changes in annual average Evaporation	Medium	Medium	Not Applicable
Temperature	Changes in annual average	Low	Low	Not Applicable
	Extreme temperature events	Low	Low	Not Applicable
Wind	Gales and extreme wind events	Medium	Medium	Not Applicable
	Storms (incl. hail, lightning)	Medium	Medium	Not Applicable

Table 4-6 - Sensitivity of the asset to climate change – Stepps Campus

CLIMATE VARIABLE		Stepps Campus Sensitivity of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	High	Not Applicable
	Extreme precipitation events	Not Applicable	High	Not Applicable
Humidity	Changes in annual average Evaporation	Not Applicable	Low	Not Applicable

Temperature	Changes in annual average	Not Applicable	Medium	Not Applicable
	Extreme temperature events	Not Applicable	Medium	Not Applicable
Wind	Gales and extreme wind events	Not Applicable	Low	Not Applicable
	Storms (incl. hail, lightning)	Not Applicable	Low	Not Applicable

Table 4-7 - Sensitivity of the asset to climate change – AFRC Campus

CLIMATE VARIABLE		AFRC Campus Sensitivity of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	Low	High
	Extreme precipitation events	Not Applicable	Low	High
Humidity	Changes in annual average Evaporation	Not Applicable	Low	Low
Temperature	Changes in annual average	Not Applicable	Low	High
	Extreme temperature events	Not Applicable	Low	High
Wind	Gales and extreme wind events	Not Applicable	Low	Low
	Storms (incl. hail, lightning)	Not Applicable	Low	Low

Table 4-8 - Sensitivity of the asset to climate change – PNDC Campus

CLIMATE VARIABLE		PNDC Campus Sensitivity of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	Not Applicable	Low
	Extreme precipitation events	Not Applicable	Not Applicable	Low
Humidity	Changes in annual average Evaporation	Not Applicable	Not Applicable	Low
Temperature	Changes in annual average	Not Applicable	Not Applicable	Low
	Extreme temperature events	Not Applicable	Not Applicable	Low
Wind	Gales and extreme wind events	Not Applicable	Not Applicable	Low
	Storms (incl. hail, lightning)	Not Applicable	Not Applicable	Low

4.2.2 EXPOSURE

Based on the baseline climate and climate change information presented in Section 3,

Table 4-9-Table 4-13 summarises the exposure of the development to change in climate variables.

Table 4-9 - Exposure of the climate variables to climate change – John Anderson Campus

CLIMATE VARIABLE		John Anderson Campus Exposure of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	High	High	High
	Extreme precipitation events	High	High	High
Humidity	Changes in annual average Evaporation	Medium	Medium	Medium
Temperature	Changes in annual average	High	High	High
	Extreme temperature events	High	High	High
Wind	Gales and extreme wind events	Low	Low	Low
	Storms (incl. hail, lightning)	Low	Low	Low

Table 4-10 - Exposure of the climate variables to climate change – Ross Priory Campus

CLIMATE VARIABLE		Ross Priory Campus Exposure of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	High	High	Not Applicable
	Extreme precipitation events	High	High	Not Applicable
Humidity	Changes in annual average Evaporation	Medium	Medium	Not Applicable
Temperature	Changes in annual average	High	High	Not Applicable
	Extreme temperature events	High	High	Not Applicable
Wind	Gales and extreme wind events	Low	Low	Not Applicable
	Storms (incl. hail, lightning)	Low	Low	Not Applicable

Table 4-11 - Exposure of the climate variables to climate change – Stepps Campus

CLIMATE VARIABLE		Stepps Campus Exposure of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	High	Not Applicable
	Extreme precipitation events	Not Applicable	High	Not Applicable

Humidity	Changes in annual average Evaporation	Not Applicable	Medium	Medium
Temperature	Changes in annual average	Not Applicable	High	Not Applicable
	Extreme temperature events	Not Applicable	High	Not Applicable
Wind	Gales and extreme wind events	Not Applicable	Low	Not Applicable
	Storms (incl. hail, lightning)	Not Applicable	Low	Not Applicable

Table 4-12 - Exposure of the climate variables to climate change – AFRC Campus

CLIMATE VARIABLE		AFRC Campus Exposure of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	High	High
	Extreme precipitation events	Not Applicable	High	High
Humidity	Changes in annual average Evaporation	Not Applicable	Medium	Medium
Temperature	Changes in annual average	Not Applicable	High	High
	Extreme temperature events	Not Applicable	High	High
Wind	Gales and extreme wind events	Not Applicable	Low	Low
	Storms (incl. hail, lightning)	Not Applicable	Low	Low

Table 4-13 - Exposure of the climate variables to climate change – PNDC Campus

CLIMATE VARIABLE		PNDC Campus Exposure of:		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	Not Applicable	High
	Extreme precipitation events	Not Applicable	Not Applicable	High
Humidity	Changes in annual average Evaporation	Not Applicable	Not Applicable	Medium
Temperature	Changes in annual average	Not Applicable	Not Applicable	High
	Extreme temperature events	Not Applicable	Not Applicable	High
Wind	Gales and extreme wind events	Not Applicable	Not Applicable	Low
	Storms (incl. hail, lightning)	Not Applicable	Not Applicable	Low

4.2.3 VULNERABILITY

Based on the sensitivity and exposure analysis and as per matrix in Table 4-2, Table 4-14-

Table 4-18 summarises the vulnerability of the development to change in climate variables.

Table 4-14 – Vulnerability of scheme assets to climate change- John Anderson Campus

CLIMATE VARIABLE		John Anderson Campus		
		Victorian and Edwardian Buildings (1837 – 1911)	**Late 20th Century Buildings**	**Modern Buildings**
Precipitation	Change in annual average	High vulnerability	High vulnerability	High vulnerability
	Extreme precipitation events	High vulnerability	High vulnerability	High vulnerability
Humidity	Changes in annual average Evaporation	Medium vulnerability	Medium vulnerability	Low vulnerability
Temperature	Changes in annual average	High vulnerability	High vulnerability	Medium vulnerability
	Extreme temperature events	High vulnerability	High vulnerability	Medium vulnerability
Wind	Gales and extreme wind events	Low vulnerability	Low vulnerability	Low vulnerability
	Storms (incl. hail, lightning)	Low vulnerability	Low vulnerability	Low vulnerability

Table 4-15 – Vulnerability of scheme assets to climate change- Ross Priory Campus

CLIMATE VARIABLE		Ross Priory Campus		
		Victorian and Edwardian Buildings (1837 – 1911)	**Late 20th Century Buildings**	**Modern Buildings**
Precipitation	Change in annual average	High vulnerability	High vulnerability	Not Applicable
	Extreme precipitation events	High vulnerability	High vulnerability	Not Applicable
Humidity	Changes in annual average Evaporation	Medium vulnerability	Medium vulnerability	Not Applicable
Temperature	Changes in annual average	Low vulnerability	Low vulnerability	Not Applicable
	Extreme temperature events	Low vulnerability	Low vulnerability	Not Applicable
Wind	Gales and extreme wind events	Low vulnerability	Low vulnerability	Not Applicable
	Storms (incl. hail, lightning)	Low vulnerability	Low vulnerability	Not Applicable

Table 4-16 – Vulnerability of scheme assets to climate change- Stepps Campus

CLIMATE VARIABLE		Stepps Campus		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	High vulnerability	Not Applicable
	Extreme precipitation events	Not Applicable	High vulnerability	Not Applicable
Humidity	Changes in annual average Evaporation	Not Applicable	Low vulnerability	Not Applicable
Temperature	Changes in annual average	Not Applicable	Medium vulnerability	Not Applicable
	Extreme temperature events	Not Applicable	Medium vulnerability	Not Applicable
Wind	Gales and extreme wind events	Not Applicable	Low vulnerability	Not Applicable
	Storms (incl. hail, lightning)	Not Applicable	Low vulnerability	Not Applicable

Table 4-17 – Vulnerability of scheme assets to climate change- AFRC

CLIMATE VARIABLE		AFRC		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	Low vulnerability	High vulnerability
	Extreme precipitation events	Not Applicable	Low vulnerability	High vulnerability
Humidity	Changes in annual average Evaporation	Not Applicable	Low vulnerability	Low vulnerability
Temperature	Changes in annual average	Not Applicable	Low vulnerability	Low vulnerability
	Extreme temperature events	Not Applicable	Low vulnerability	Low vulnerability
Wind	Gales and extreme wind events	Not Applicable	Low vulnerability	Low vulnerability
	Storms (incl. hail, lightning)	Not Applicable	Low vulnerability	Low vulnerability

Table 4-18 - Vulnerability of scheme assets to climate change- PNDC Campus

CLIMATE VARIABLE		PNDC Campus		
		Victorian and Edwardian Buildings (1837 – 1911)	Late 20th Century Buildings	Modern Buildings
Precipitation	Change in annual average	Not Applicable	Not Applicable	Low vulnerability
	Extreme precipitation events	Not Applicable	Not Applicable	Low vulnerability
Humidity	Changes in annual average Evaporation	Not Applicable	Not Applicable	Low vulnerability
Temperature	Changes in annual average	Not Applicable	Not Applicable	Low vulnerability
	Extreme temperature events	Not Applicable	Not Applicable	Low vulnerability
Wind	Gales and extreme wind events	Not Applicable	Not Applicable	Low vulnerability
	Storms (incl. hail, lightning)	Not Applicable	Not Applicable	Low vulnerability

4.3 CURRENT IMPLEMENTED/PLANNED ACTIONS

The University is currently implementing or have planned certain measures to manage the climate change impacts and ensure smooth functioning of the campuses in advent of any climate related events. WSP has also referred to various studies undertaken for the campuses (ecological surveys, feasibility assessments and so on) and policies and reports available on the University of Strathclyde website as listed in Table 4-19. In accordance with these, following actions are currently in place for each campus:

Table 4-19 - List of documents referred for assessment

#	Name of the document	Link (if available)
1.	The University of Strathclyde's Strategic Plan 2020-2025	https://www.strath.ac.uk/media/1newwebsite/documents/Strategic_Plan_2025.pdf
2.	UoS Climate Change and Social Responsibility Policy 2016 to 2026	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustainabilitytemp/SD_and_Climate_Change_Policy_Web_Version.pdf
3.	University of Strathclyde- Water Management Plan- 2021	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/UoS_Water_Strategy_2021.pdf
4.	Sustainable Development Goals and Strathclyde's CCSR Plan	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/SDGs_in_Strathclyde's_CCSR_Plan.pdf
5.	University of Strathclyde-travel plan 2021	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/University_Travel_Plan_2021.pdf
6.	UoS Waste Management Policy- 2021	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/Waste_Management_Policy_2021_Update.pdf
7.	UoS Water Management Plan- 2021	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/UoS_Water_Strategy_2021.pdf
8.	The University of Strathclyde Estates Services Sustainable Design Quality Standards December 2019	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/Sustainable_Design_Quality_Standards_2019.pdf
9.	Project management guide for a sustainable campus v.3- University of Strathclyde	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/Project_Management_Guide_v3_July_2010.pdf
10.	Biodiversity Policy	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/UoS_Biodiversity_Policy.pdf
11.	University of Strathclyde- Carbon Management Implementation Plan 2019	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/UoSCMIPNovember_2019.pdf
12.	University of Strathclyde Climate Change Adaptation Plan	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/Strathclyde_University_Adaptation_Plan_(2021_Update).pdf
13.	Vision Paper- Delivering Climate Neutral, Climate Resilient Districts June 2021	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/Climate_Neutral_Districts_Vision_Paper_June_2021.pdf
14.	Feasibility Study: Carbon Neutral Glasgow City Innovation District (CNGCID)	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/CNID_Routemap.pdf
15.	Environmental and engine idling policy	https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/Engine_Idling_Policy.pdf
16.	UoS Public Realm Specification	

17.	Grounds & Gardens- Soft Landscaping Specifications for New and Refurbished Areas.	
18.	Ross Priory Strathclyde University- Ecology Surveys	
19.	Strathclyde University- Preliminary Ecological Appraisal & Biodiversity Enhancement Plan of John Anderson Campus	
20.	Stepps Campus Strathclyde University- Extended Phase 1 Habitat Survey	
21.	University of Strathclyde- AFRC - Building Services Feasibility Study	
22.	University of Strathclyde- PNDC- Building Services Feasibility Study	
23.	University of Strathclyde- Ross Priory- Building Services Feasibility Study	
24.	University of Strathclyde- Stepps playing fields- Building Services Feasibility Study	

4.3.1 OVERALL ESTATE:

Sustainable Travel: The University's Strategic Plan Vision 2025 commits the University to a 70% reduction in carbon emissions by 2025 against a reviewed baseline figure of 37,500 tonnes. This target now explicitly includes business travel, and commuting emissions from staff and students, and will require the University to further improve its environmental performance, including the impact of carbon from travel and transport emissions. The University is planning to incorporate the sustainable travel hierarchy of promoting walking, cycling, public transport and car sharing in preference to single occupancy car use for movement of people. Particularly for shorter, everyday journeys. The Travel Plan developed will use the sustainable travel hierarchy as seen in the Scottish Governments National Transport Strategy as a basis for future strategic planning and as a template from which to prioritise modes of transport. As far as the GHG emissions are related, the post-covid targets are in process of getting finalised for reduction of carbon impact via travel. Integration of campus infrastructure with Glasgow's City Council Strategic Plan for Cycling 2015 to 2025 and the Development Plan - City Plan 2 and future updates is ongoing with good progress being made.

Air Quality: It is the policy of University of Strathclyde that drivers of all vehicles coming to the University campuses turn the engine off when a vehicle is stationary for more than 30 seconds, except when in traffic. This will ensure reduction in air pollution while also improving the operational fuel efficiency and reduce fuel costs.

Building services: There are plans to undertake lighting upgrades for buildings (at least 1-2 buildings every year). Older buildings that still have old lighting like T12 are planned to get tackled first.

Waste management: The University's waste contractor records and monitors the amount of waste that is disposed of and recycled on a daily basis. This monitoring data includes regular audits of the recycling as well in order to ensure that it is uncontaminated by other inappropriate materials. The monitoring data is recorded and reported on a regular basis to internal and external stakeholders including the Scottish Government. A strategy is currently being developed to streamline sharing and reuse of furniture both internally within the university and to make materials and good available to external organisations to improve reuse and boost circular economy activity in terms or resource management.

Monitoring: Monitoring is currently undertaken by remote automation and Building Management System (BMS). Alarms are in place to tackle any issues like lighting, temperature, rainfall issues and flooding. The monitoring type is active as well as reactive.

Awareness initiatives: The University of Strathclyde is currently working towards Bronze Carbon Literate Organisation accreditation and offers a training course on carbon literacy for its staff and students. The course is a three weeklong interactive series of workshops, providing an awareness of the carbon dioxide costs and impacts of everyday activities, and the ability and motivation to reduce emissions, on an individual, community and organisational basis. Additionally, there are multiple sustainability and climate change awareness initiatives for staff and students under the Development and Training (DAT) system. Some examples include Annual Sustainability Bash, Community Garden Catch Up, Electric Vehicle Information lunch, Litter Picking, Love Food Hate Waste, Sustainable Labs Lunch and so on.

Centre for Sustainable Development: The centre is a university-wide resource operating across all faculties and operational activities. The centre aims at co-creating solutions with the global partners across academia, civil society, and the public and private sectors in order to create an impact.

4.3.2 JOHN ANDERSON:

Traffic management: The University and the Council manages traffic flows around and within the Campus relatively well. There is a robust car parking infrastructure and management process to control the usage of the University’s car parking. There is investment in cycle parking and associated facilities. Disabled parking provision and access at the site remains an area of focus.

Biodiversity and Landscape: The Rottenrow Gardens provides a centre point for students and staff to interact with nature, within an urban setting. The University is looking to implement the 'Heart of Campus' campaign. This will action measures such as permeable paving and landscape gardens and is solely associated with the John Anderson Campus and is due to kick off in 2023.

Renewable: Planned solar panels plan on the roofs undergoing on 30 Richmond Street.

4.3.3 ROSS PRIORY:

Electric charging points: Funding was secured to install additional charge points at Ross Priory and AFRC to support the electric vans secured through a subsequent round of Switched-on fleets. These will be departmental vans, replacing existing Ford Transits and the minibus at Ross Priory. These vans were delivered between July 2020 and September 2020 with the Charge points being installed at similar times to provide a dedicated point for each vehicle.

Renewable: Ground mounted solar grid (6MW) with battery storage is being investigated for the renewable energy generation at the campus.

Eco-friendly chemicals: No pest management system has been implemented. Plant based fertilisers for golf course. This will ensure the chemicals do not harm the environment and contribute to climate change.

4.3.4 PNDC:

Sustainable Travel: Active travel plans are in consideration for the future mobility. The plans are currently communicated verbally and supported by the council; however, the investment confirmation is awaited.

Maintenance: Maintenance is covered by Skanska and is undertaken regularly for the plants. The external contractor has its own hazard and risk assessment for the chemicals being used in the building for pest control and should consider sustainable and eco-friendly options for the same.

Sustainable Urban Drainage System (SuDs): there is SuDs system in front of PNDC which help manage the stormwater on site. The current capacity and future feasibility of the system is not known and can be assessed as a next step.

4.4 CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES

Climate change adaptation refers to actions that reduce the negative impact of climate change while also taking advantage of potential new opportunities. It also involves adjusting policies and actions and can be reactive or anticipatory.

Climate change mitigation on the other hand refers to efforts to reduce or prevent emissions of greenhouse gases. This can mean use of new technologies and renewable energy, making older equipment more energy efficient or simply changing management practices or consumer behaviour.

The section presents the adaptation and mitigation measures to be integrated into the assets to reduce the risk of the potential effects. The adaptation measures are provided as short, medium, and long-term objectives and are applicable to the whole estate while the mitigation measures are specific to the campus.

Based on the information available, data gaps exist where it is not clear if climate risks have been considered and confirmed built-in resilience measures incorporated to projected climate risks. The adaptation and mitigation measures presented in this section are provided based on the available information, previous project experiences and outputs from the workshops with the University teams.

4.4.1 ADAPTATION PLAN

The adaptation plan is divided into short-, medium- and long-term objectives, recommendations and KPIs and includes the governance, built environment and natural environment aspects. The plan touches upon strategic level objectives and measures and do not provide technical details and assessment. It is recommended that the University should undertake further studies to quantify/assess the results and outcomes of these measures as a next step. The short-, medium- and long-term objectives are defined as per the following:

- **Short-term objectives:** The short-term objectives are measures that are considered as low hanging fruits or need immediate attention and should be implemented sooner (generally within 1-2 years).
- **Medium term objectives:** The medium-term objectives are the measures that can be implemented within 5 years timeline.
- **Long-term objectives:** The long-term objectives are the measures that can be implemented within 10 years timeline.

There are gaps in knowledge about how extreme weather will change over the next few decades and scientific and technical understanding will change and improve within this timescale. It is important for the University of Strathclyde to monitor changes in climate change science and projections and periodically update the Climate Risk and Vulnerability Assessment (CRVA) report. It would also be prudent to regularly review and update emergency plans, business continuity plans and other response mechanisms to ensure climate change and extreme weather events are considered and updated over time.

The sections below provide short-, medium- and long-term objectives, KPI and resource links to further reading for following topics:

- Governance and university community;
- Built environment; and
- Natural environment.

4.4.1.1 GOVERNANCE AND UNIVERSITY COMMUNITY

Table 4-20- Governance and university community objectives

Objectives	KPI	Good read
SHORT TERM OBJECTIVES		
Developing and implementing a clear governance framework will be critical to driving forward the consideration of climate in all key development (and maintenance/ operations) decisions. Short-, medium- and long-term actions and activities can be documented in a climate action plan, while there may be a need for a network of risk coordinators, energy champions and HSE specialists including Estate managers.	Climate change adaptation plan is regularly updated. The adaptation plan is reviewed for its relevancy by a dedicated committee every year.	Article: This is how universities can lead climate action: https://theconversation.com/this-is-how-universities-can-lead-climate-action-147191
The business continuity plan should include the strategies to effectively communicate information on extreme weather events to staff and students.	Business Continuity Plan includes climate change adaptation and mitigation measures	Adapting to Climate Change using your Business Continuity Management System: https://www.bsigroup.com/localfiles/en-gb/iso-22301/resources/bsi-sustainability-report-adapting-to-climate-change-using-your-business-continuity-management-system-uk-en.pdf
The University already implements numerous initiatives to improve the climate change related awareness of the staff and students. Maintaining and adding in the current flow of initiatives will help in achieving the required climate change adaptation goal for the University.	Current climate change related workshops and seminars are diligently conducted for staff and students. Silver or Gold Carbon Literate Organisation (CLO) is targeted. Climate change champions are elected amongst the students and staff of the University.	CLO organisations: https://carbonliteracy.com/organisation/our-organisations/ Race to Zero- Universities and colleges: https://www.educationracetozero.org/home#:%7E:text=The%20Global%20Universities%20and%20Colleges,Race%20to%20Zero%20by%20UNFCCC.&text=The%20aim%20is%20to%20get,and%2013%20(Climate%20Change).
MEDIUM TERM OBJECTIVES		
Adequate documentation and reporting of climate change impacts and the adaptation progress would be required at the organisational level to keep an updated	Climate change adaptation risks are added to the risk register	Climate change risk register template: https://www.dit.sa.gov.au/__data/assets/excel_doc/0020/724430/DOCS_AND_FILES-

record of the challenges and issues that need to be addressed. Climate risks should be included in the risk registers and lessons learned within the site should be incorporated into portfolio level initiatives. Also, it is necessary to regularly review and update emergency plans, business continuity plans and other response mechanisms.		16005203-v1-Climate_change_risk_assessment_template_v0_1_002.XLSX
Monitor and collect the data related to ongoing measures and financial impacts of the climate change.	Mechanism in place for monitoring and collecting the data.	
LONG TERM OBJECTIVES		
Working in partnership with Climate Ready Clyde, GCV Green Network Partnership, MGSDP and Central Scotland Green Network Trust, consider the opportunity for creation of a series of 'climate corridors' which integrate energy, transport and climate adaptation (such as on High Street and George Street, integrating with the City Deal Avenues and Places for Everyone works on both these streets), which incorporate service corridors for heat and power and climate adaptation solutions.	Number of solutions implemented in collaboration with other stakeholders.	
The use of an early warning system (EWS) can be an important adaptive measure to be better prepared for the increased frequency and intensity of extreme weather events. This might involve the use of an integrated communication system to support the occupants, and this might be delivered in conjunction with the local council and other relevant stakeholders (eg., Scottish water). This might also become available in the form of a Digital Twin or third-party subscription service to help prepare and protect people, infrastructure, and assets from the adverse effects of extreme weather. The National Digital Twin Programme's Climate Resilience Demonstrator (CReDo) and Meteoalarm are two such examples. Additionally, such an initiative can be taken up by the students at the University as an academic project.	EWS developed and used.	National Digital Twin programme: https://digitaltwinhub.co.uk/about/national-digital-twin-programme/

Encourage use of active travel and public transport thus resulting in reduced air pollution. Green transport links should be encouraged with inclusion of bus stops, cycle stands and cycle routes.	The University's policy has more exhaustive guidelines on the aims for sustainable practices on campus and needs to be implemented diligently. % Modal split data is published from staff/student travel survey.	
University should explore the options of enrolling in reuse programmes and opt for sustainable procurement and sustainable supply chain options. This will not only ensure spreading awareness about use of sustainable products amongst the staff and students but will also help reduce the environmental sustainability impacts of purchased goods in the long run.	Options explored.	Sustainable procurement case studies of other universities: University of Cambridge: https://www.environment.admin.cam.ac.uk/sustainable-procurement University of Waterloo: https://uwaterloo.ca/sustainability/projects-and-initiatives/sustainable-procurement University of Edinburg: https://www.ed.ac.uk/procurement/sustainableprocurement/sustainable-procurement
Under the Centre for Sustainable Development, the University should sponsor and support more academic research in climate related domains, especially live research projects on climate change adaptation of the University campuses.	Sponsorship for academic research related to climate domain especially climate change adaptation of the campus. Number of academic research projects completed on Climate change.	Climate Change Adaptation Student Research Showcase: Columbia Climate School: https://www.earth.columbia.edu/articles/view/2672

4.4.1.2 BUILT ENVIRONMENT:

Table 4-21- Built Environment objectives

Objectives	KPI	Good read
	SHORT TERM OBJECTIVES	
Undertake flood risk assessment for the five campuses and develop a flood risk resilience plan. The existing buildings should be mapped for flooding, structural and	Flood risk assessment undertaken, and resilience plan developed.	

overheating risks especially the older buildings. Flooding issues should be considered on priority in the design of new buildings for present and future changes. Develop a sustainable design standard considering mandatory inclusion of future climate projections for future designs.		
A major challenge related to climate change for the University currently is nonexistence of rainwater management in the buildings. It is strongly recommended that the university should incorporate various strategies and design interventions to manage the rainwater in the buildings. Provide an integrated rainwater harvesting system for the buildings and reuse this water for non-potable uses and irrigation purposes.	Integrated rainwater management strategy developed.	Rainwater Harvesting at the University of Arizona case study: https://repository.arizona.edu/bitstream/handle/10150/627518/Corneliussen_CapFinal_04242018.pdf?sequence=5&isAllowed=y
A site-level drainage management plan should be formulated for each of the campuses to facilitate adequate stormwater drainage to curb the problem of flooding. The plan should be based on the principles of Sustainable Drainage Systems (SuDS). This would involve steps such as the slope analysis of the site for identification of low-lying areas which could be proposed as detention basins or infiltration trenches to manage stormwater runoff. However, prior study of the physical and hydrogeological properties of the soil is necessary before proposing any SuDS related schemes for the site to prevent adverse effects to ground stability and water quality.	Drainage management plan developed	
Future proof buildings: Ensure that the Sustainable Design Quality Standards are followed for all the new construction. Include individual project targets, key performance indicators and detail site environmental management tools for the new buildings. Undertake microclimate analysis, climate change risk and mitigation assessment and low carbon design analysis for every new building at all the applicable lifecycle stages (concept, design, construction, and operation). Ensure that the buildings are not only designed for present but also future climate change projections.	Sustainable Design Quality Standard formulated by the University of Strathclyde followed for all new designs: https://www.strath.ac.uk/professionalservices/media/ps/estatesmanagement/sustainability/sustdocuments/Sustainable_Design_Quality_Standards_2019.pdf	Future proofing construction: https://www.designingbuildings.co.uk/wiki/Future_proofing_construction

A post adverse event inspection protocol for building elements and fabric should be developed to assess the risks or any vulnerabilities caused to the buildings	Building inspection protocols in place.	
Collaborate with Historic Environment Scotland for any adaptation measures planned and implemented for listed and older buildings.		
	MEDIUM TERM OBJECTIVES	
Increase the proportion of electric fleet vehicles within the campus thus reducing the particulate emissions from estate owned vehicles in the future. In order to do this, undertake a study to understand the user uptake and engagement with the existing electric vehicle (EV) fleet and associated charging infrastructure and evaluate the potential future demand for EV and e-bike services within the campuses. Post the evaluation, create a plan to install multiple solar-powered EV and E-bike hubs within the campuses.	% Target set for fleet composed of electric vehicles. EV uptake study undertaken.	
Sustainable management and maintenance methods (such as use of peat free composts and non-residual herbicides where these are necessary, though fertilisers, herbicides and insecticides should be minimised). Proactive maintenance of infrastructure and services is advised with regular inspection of assets for deterioration, particularly following extreme weather events.	Proactive maintenance protocol in place.	
Sourcing of recycled and local materials where possible should be taken into account along with sourcing of timber from sustainably managed sources, such as FSC certified suppliers. By doing so, the University will be able to build the supply chain resilience. Additionally, in case of extreme climate events like heavy rainfall, the supply chain will be less disrupted owing to local sourcing. The objective will also indirectly contribute in fulfilling credit requirements for green building	Sustainable suppliers identified and enrolled for new construction.	What Is A Green Procurement Policy? https://greenbusinessbureau.com/blog/what-is-a-green-procurement-policy/

certifications like BREEAM and LEED in case the University opts for it in the future.		
Green procurement policy should be developed for office supplies. Green procurement will help the university meet their sustainability and UNSDG related targets, improve overall efficiency, cost reduction, environmental impact and performance and brand enhancement in the future. The policy will also help in better performance on the Environment, Social and Governance (ESG) goals if any.	Green office product list prepared and suppliers identified.	Sustainable Office Supply Purchasing Guide: https://ocs.umich.edu/wp-content/uploads/2020/09/Sustainable-Office-Supply-Purchasing-Final.pdf
Incorporate low water use fittings, dual flush toilets and rainwater collection options in the new buildings. Water consumption benchmarks based on assumed occupancy must be in line with industry best practice.	Water consumption benchmark defined, and flow and flush fixtures installed are low water use.	Waterwise tips for saving water: https://www.waterwise.org.uk/save-water/
Extreme temperature events can lead to deformation or melting of paved surfaces. It is therefore necessary to coat such surfaces, exposed to sunlight, with an appropriate paint or coating to provide protection against UV exposure. Excessive build-up of moisture in materials due to increased humidity should also be prevented using suitable coatings.		
Develop a heating, ventilation and cooling guidance for each campus. Focus on naturally ventilated buildings. CIBSE TM52 Overheating assessments would future proof new buildings from overheating.	CIBSE TM52 Overheating assessments.	
LONG TERM OBJECTIVES		
Lighting and other electrical or mechanical items and processes should be energy efficient, without compromising safety and security. Fixtures like LED bulbs are not only energy efficient but also has less heat gain and are therefore better for managing overheating. Energy efficient methods of maintenance should be included, and the construction methods should be energy efficient.	Low energy materials considered for the buildings. Star rated equipment and energy certified lighting installed in the buildings.	The role of energy demand reduction in achieving net-zero in the UK: Materials and products: https://low-energy.creds.ac.uk/wp-content/uploads/CREDS-Low-energy-demand-materials.pdf Centre for sustainable energy: Lighting: https://www.cse.org.uk/advice/advice-and-support/lighting

		Energy saving trust- Buying energy efficient products- Lighting: https://energysavingtrust.org.uk/advice/lighting/
Optimise the Building management system to ensure that the internal environment is well maintained within the limits as specified by industry best practice (ASHRAE standards, BB 101, CIBSE TM59 and so on).	Overheating assessment, building efficiency assessment undertaken.	
Updating the building information systems for improved climate responsiveness for the future climate change scenarios will help in dealing with the extreme weather events better. The data acquired from the systems can also feed the city-wide databank.		
The flood management systems that are present in the newer buildings are limited to local systems, such as leak detection. This system is therefore not linked to any drainage systems. A system that could be planned for this campus and provide improvement is water attenuation which can also be in the form of rain gardens.	Flood management measures implemented.	

4.4.1.3 NATURAL ENVIRONMENT

Table 4-22- Natural Environment objectives

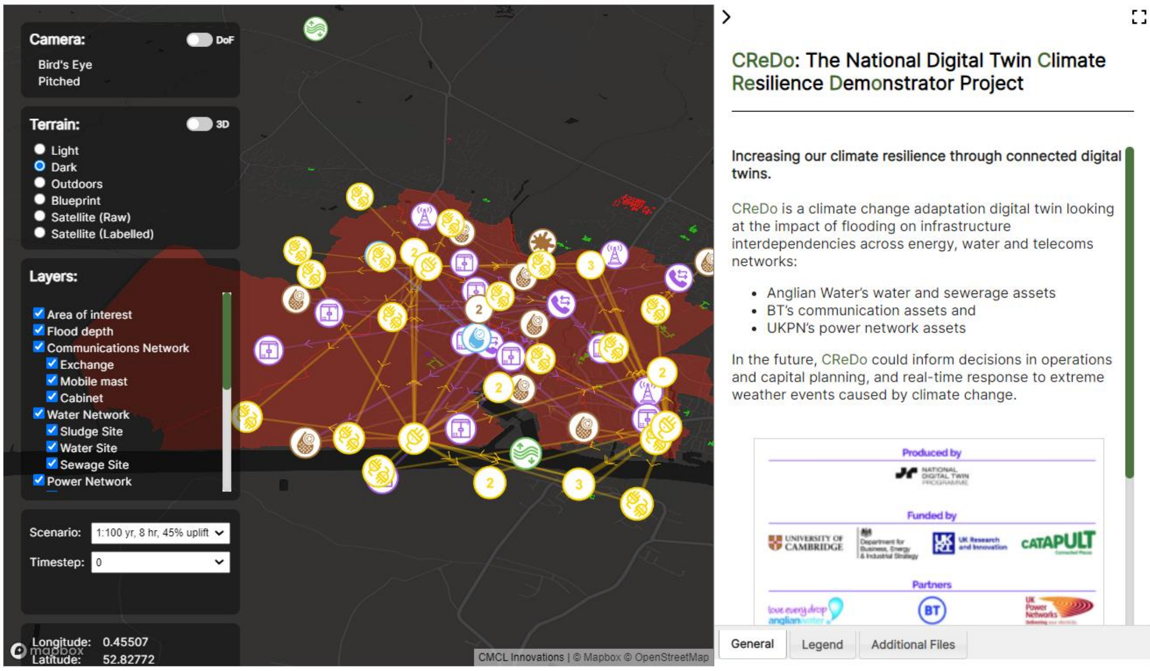
Objectives	KPI	Good read
SHORT TERM OBJECTIVES		
Undertake a campus wide assessment of green spaces and review the potential to replace any lawns with wildflower meadows.	Green spaces assessment undertaken	
Explore opportunities to develop green corridors throughout the campus		
Use of native planting should be sourced locally where possible. Where planting is non-native, it should be demonstrated that the selected species have some wildlife or amenity value. Planting with low irrigation requirements should be selected.	At least 75% of planting is native and sourced locally	Native Scottish Plants: http://www.historicscottishgardens.co.uk/scottish-plants What are Scotland's native woodlands?: https://forestry.gov.scot/forests-environment/biodiversity/native-woodlands/scotlands-native-woodlands#:~:text=Scotland's%20most%20common%20native%20trees,juniper%2C%20elder%20and%20wild%20cherry
MEDIUM TERM OBJECTIVES		
Explore opportunities to reduce the size of lawns/mowed areas and replace them with wildflower meadows. This will help in reducing the maintenance costs and improve biodiversity potential.	Lawn areas and green areas requiring exhaustive maintenance reduced.	
By acting as heat sinks, green spaces can play a significant role in reducing local temperatures. Measures like green roofs can help to retain rainwater, thereby preventing events such as waterlogging or flooding. Green roof surfaces also keep indoor temperatures under check as the heat transfer is lesser for a green roof as compared to a conventional roof. Include green roofs in new developments (and consider retrofitting existing buildings). They can be	Percentage of green roofs installed	Everything you need to know about green roofs / sedum roofs: https://www.renewableenergyhub.co.uk/main/green-roof-information/

installed on most roof types and can also be retrofitted onto existing roofs providing the building is able to structurally support the saturated weight of a green roof. Alongside the biodiversity benefits, green roofs are visually attractive and provide heat and noise insulation and are often included in sustainable drainage systems design because they intercept rainfall and reduce run-off rates. The University could consider placing rain garden planters under downpipes across the Campus therefore further increasing green space around the campus.		
Plantation of native tree species is encouraged within the campuses' premise which would help reduce the cooling load of buildings and provide shade and shelter. However, trees and shrubs should be planted in groups to reduce vulnerability to wind.	Percentage of native species planted.	9 Trees that Can Survive Flooding: https://arbordayblog.org/treeplanting/9-trees-that-can-survive-flooding/
Changing weather patterns could lead to increase in invasive plant species over time. Therefore, plantation of drought and flood tolerant species is advised as these are less likely to be affected by environmental stresses.	Drought/flood tolerant species planted.	Can trees and woods reduce flooding? https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/flooding/
LONG TERM OBJECTIVES		
Explore and assess options to capture and retain rainwater on the campuses (especially Stepps playing fields), so that it can be used for irrigation of the playing fields during the drier periods.	Rainwater captured and used for irrigation.	
Elements like green and blue infrastructure that are key adaptation measures in urban environment should be deployed in order to provide significant benefits and opportunities not only to improve the experience of the campus but also to improve the biodiversity value.	Blue and green infrastructure installed.	Enhancing blue-green Infrastructure & Social performance in high density urban Environments: https://ramboll.com/-/media/38fc23d12a5d47dcb7b3821716d69270.pdf
Undertake Biodiversity Net Gain (BNG) assessment. Target a minimum of 10% BNG for the campuses. Vegetation influences the macro and microclimate of a place and hence protecting and enhancing the ecosystem will help in improving climate resilience and adaptation capability of the campuses.	Targeted percentage of BNG achieved.	Biodiversity metric: calculate the biodiversity net gain of a project or development: https://www.gov.uk/guidance/biodiversity-metric-calculate-the-biodiversity-net-gain-of-a-project-or-development

Figure 4-2 - Risk register example[32]

Climate Change Adaptation Risk Register - List of potential risks to council services from future climate change							
The Impact and Probability are scored between 1 and 3 (1 low risk 3 high risk). These are multiplied together to give a score between 1 - 9. This is then multiplied by the influence the council has over this risk (scored between 1 - 3, 3 highest influence, 1 little or no influence) to give the final overall risk rating.							
Type	**Risk? (Effect)**	**Result**	**Impact**	**Probability**	**Score**	**Influence**	**Overall Risk**
Flash Flooding Pluvial (Rain)	Lack of capacity in the storm/sewer and highway drainage system due to lack of maintenance and cleaning or inadequate size	System unable to cope with increased rainfall and speed of runoff leading to localised flooding	The impacts of this type of flooding will be severe but localised	There is an increasing probability of such events occurring as the frequency and intensity of extreme rainfall events increases and the sewer system reaches capacity and maintenance is reduced to a reactive basis by the water service companies	6	2 The council has some responsibility working with the water service company (Severn Trent)	12
	Road network flooding due to flash storm events	1. Residents unable to use road network 2. The council employees unable to get to work 3. The council employees unable to deliver key services due to disruption to transport network 4. Disruption to public transport 5. Emergency vehicles unable to reach victims of flooding	The impacts of the road network flooding will have more significant implications than that of flooding of the sewer network	The probability of the road network flooding will increase as the duration and intensity of localised rainfall events increases	6	2 The council has shared reponsibility for development control and street cleaning with LCC has total responsibility for maintenance and operation of the road network with exception of major trunk routes	12

Figure 4-3 – CreDO sample screen



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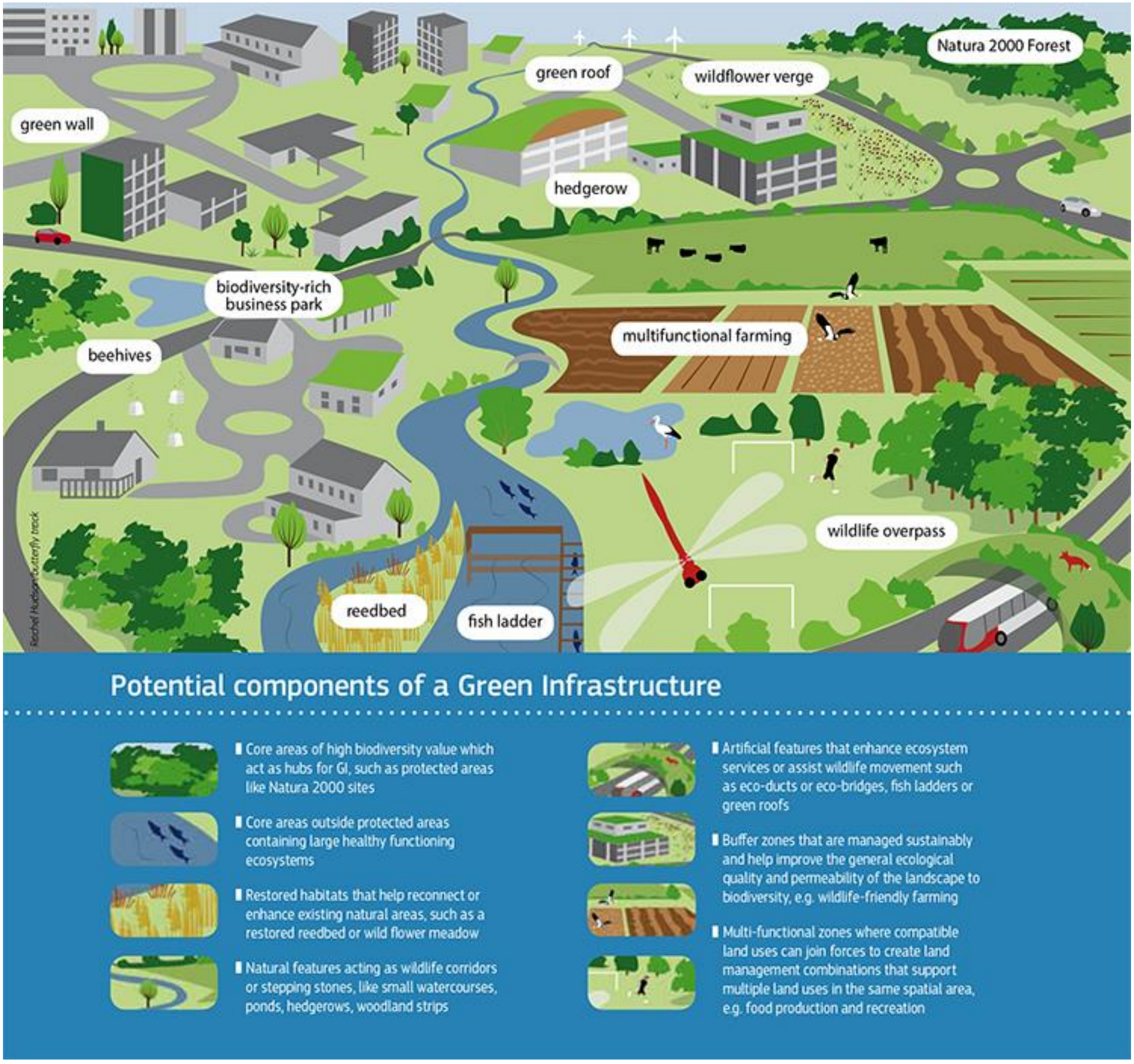
32 https://w3.blaby.gov.uk/decision-making/documents/s5368/A1%20-%20NI188.pdf

Figure 4-4 - Green infrastructure components



Appendices

APPENDIX A

APPENDIX A:

Table 4-23 provides list of university buildings that are being considered for the assessment.

Table 4-23 – List of the University's Assets that are being evaluated in this report.

	University of Strathclyde Asset Grouping								
	Victorian and Edwardian Buildings (1837 - 1911)		Late 20th Century Buildings					Modern Buildings	
University of Strathclyde Assets	4 Park Circus	Barony Hall	15 Martha Street	Corn Street	James Goold Hall	Robertson Wing	Stepps - floodlighting	Advanced Forming Research Centre	Hamnett Wing
	Ross Priory – Lochside Cottage	Ross Priory Lodge House	181 St James Road	Curran Building	James Weir Building	Stenhouse Wing	Stepps all-weather pitch	Inovo Building	Rottenrow Gardens
	Ramshorn Graveyard	St Pauls	Andrew Ure Hall	Duncan Wing	James Young Hall	Students' Union	Stepps Grass Field 1	Strathclyde Sport	Technology Innovation Centre
	Royal College Building	Ramshorn Building	Architecture Building	Forbes Hall	John Anderson Building	Thomas Campbell Court	Stepps Grass Field 2	Power Networks	Lightweight Manufacturing Centre
	Ross Priory	West Boathouse	Birkbeck Court	Garnett Hall	Livingstone Tower	Thomas Graham Building	Stepps Outbuildings		
			Cathedral Wing	Graham Hills Building	Lord Hope Building	University Centre	Stepps Pavilion - Staff Flat		
			Chancellor's Hall	Henry Dyer Building	Lord Todd	Wolfson Building	Stepps Pavilion 1		
			Collins Building	Hydrodynamics Laboratory	McCance Building	Ross Cottage 2	Stepps Pavilion 2		

		Colville Building	James Blyth Court	Murray Hall	15 Avenue End Road	Block K	
		30 Richmond Street	Stepps Grazing Land				

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