Lake District National Park Partnership

Climate Change Adaptation report

Lake District National Park Authority | May 2021

Lake District National Park Climate Change Adaptation Report

Contents

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1 Introduction

From Friday 4 to Sunday 6 December 2015 Storm Desmond brought high winds and heavy rainfall to southern Scotland, the north of England, Wales and Ireland. With already saturated ground conditions from the previous storms of Abigail, Barney and Clodagh, high rainfall and sustained high river flows caused wide spread flooding in Cumbria. This included the Lake District National Park with Honister Pass seeing the highest record for 24-hour rainfall in the UK with 341.4mm, and Thirlmere recording 405mm of rain in just 38 hours setting the highest 48-hour rainfall record (Met Office). The consequences were catastrophic. Rivers moved their courses, homes and businesses flooded, roads collapsed, bridges, barns and stone walls washed away. Miles of public rights of way damaged, and countless wildlife habitats were destroyed. The economic cost of this was estimated to have reached up to £500 million (PWC 2015), and left a question mark over the future sustainability of some local communities in the National Park as key social linkages and networks were lost or weakened.

In the same year Storm Desmond occurred, "The Paris Agreement" was reached. A multi-lateral agreement to try and limit global warming to well below 2 degrees above pre-industrial levels. This was the first time all nations were *"brought into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects"* (United Nations). One of the telling parts of the agreement was that to some extent climate change was accepted as being unavoidable; and that focus should not just be on mitigation, but also on adaptation.

1.1 Climate Change Act and Adaptation Reporting Power (ARP)

Adaptation Reporting Power (ARP) is a component of the Climate Change Act 2008 which gives the Government the authority to ask certain organisations to produce reports on the current and future likely impacts of climate change on their organisation and their proposals for adapting to climate change. The reports provide the evidence base that inform the UK-wide Climate Change Risk Assessment that the government undertakes every 5 years - also required under the Act.

The organisations that report under ARP are bodies with 'functions of a public nature' and 'statutory undertakers' such as water companies, energy providers, and regulators. The UK's National Park Authorities are exempt from ARP but have participated through invitation in the two previous rounds of reporting that informed the 2012 and 2017 UK Climate Change Risk Assessments. This piece of work is known as Climate Change Adaptation Reporting (CCAR) and is referred to throughout this report.

1.2 2012 and 2015 Lake District National Park Risk Assessments

The Lake District National Park Authority produced their first climate change risk assessment and CCAR under ARP in 2012 (link here). This was a comprehensive risk assessment that examined both the scale of risk and opportunity to assets across the short (2020s), medium (2050s) and long term (2080s) for the following sectors in the National Park;

- Access, recreation and tourism
- Biodiversity
- Community, culture and economy
- Historic Environment
- Farming and Land Management
- National Park Authority Business Continuity

In 2015 it was decided to undertake a light touch review of the 2012 report rather than re-running the full risk assessment (link here). However the 2015 report was completed before the catastrophic impact that Storm Desmond had in the Lake District. The increasing potential for

similar events in the future with climate change led the National Park Authority to decide a full risk assessment must be re-run when the time came for a third round of reporting.

A third round of CCAR is now due to inform the next UK Climate Change Risk Assessment in 2022, and provides an opportunity for the Lake District National Park to complete a full risk assessment of the impact of climate change.

This report has been undertaken to present a current risk assessment of how short, medium and long term climate change could impact the Lake District National Park and World Heritage Site. The outcomes and actions will be integrated the next Lake District National Park Partnership's Management Plan (2020-2025).

1.3 Lake District National Park Partnership Plan

The two previous CCARs were a separate, discrete pieces of work that the National Park Authority undertook; the output of which was reported directly to Defra. However in the third round of reporting Defra have instructed the National Park Authorities to integrate the risk assessment within their own statutory management plan review cycles.

The Lake District National Park Authority take a partnership based approach to the planning and delivery of their statutory Management Plan. To do this they work closely with the Lake District National Park Partnership (LDNPP); which was set up in 2006 and consists of 25 organisations that work together collectively to further the interests of the National Park, its environment, communities, economy and visitors.

"The Partnership's Plan" sets out how the partners work together to proactively and effectively manage the Lake District as a National Park and World Heritage Site. It describes the shared commitment to deliver "The Vision" for the Lake District *"to be a place of sustainable development in action by 2030"*. It considers the risk and issues, and management and protection of the Lake District; outlines strategies that will be used to inform decisions about the Lake District and actions that are required to deliver the Lake District's vision.

The impact of climate change is relevant to each and every sector in the National Park and will strongly influence how both the National Park and World Heritage Site is managed. By integrating Climate Change Adaptation Reporting into the Management Plan future proofs the actions and strategies adopted in the plan and provides the best opportunity that the 2030 Vision for the Lake District is achieved.

The next Partnership Management Plan for the Lake District is due to be published in 2021 and the outputs of this report will be integrated.

1.4 Outcomes and benefits

Rather than just being a reporting exercise to Defra, undertaking CCAR has a number of benefits locally for the National Park Authority and Partnership. It provides an opportunity to understand how the climate is going to change in the National Park and identifies which areas potentially could be most at risk and those that could stand to benefit. Having this understanding strengthens Partnership working in the Lake District in several ways;

- Allows actions undertaken by the Partnership to be prioritised to where the need is most urgent
- Enables the Partnership to anticipate the opportunities climate change will bring to the National Park

- Highlights the areas of synergy between sectors on climate action and therefore helps initiate new partner collaboration
- Facilitates resource provision and supports the Partnership in leveraging funding to support local climate action
- Ensures a joined up approach and collective understanding across stakeholders and organisations in the Lake District of how climate change is / should be prepared for
- Through integration into the Partnership Management Plan ensures the focus on key challenges, area planning and the Park-wide strategies contained within the plan are grounded in the context of a changing climate.

1.5 This Report

This report is the Lake District National Park Authority's contribution to the third round of CCAR to government under ARP. It represents the final output of a comprehensive risk assessment that has been undertaken in 2020 into the vulnerabilities and opportunities climate change will bring to the National Park's most valuable assets and services over the next 50 years.

The purpose of this report is not only to provide the government an understanding of what locally the Lake District National Park Authority is doing to address the impact of climate change, but also to use the key messages from its results to inform and influence the strategies, objectives and actions that go into the next Partnership Management Plan addressing action on climate change.

This report now goes on to present the methodology and approach used in the risk assessment, a description of the results obtained, as well as presenting an analysis of these results and what conclusions and key messages were found when thinking about action to address climate change in the Lake District National Park.

2 Methodology

To complete CCAR the Lake District National Park adopted a three stage approached which was adapted from guidelines set out by Natural England and is illustrated in Figure 1.

"Gather Evidence" is the first stage and sets the context for adaptation planning. Agreed measures of value and importance for the National Park are examined from which key assets and services are derived. In parallel an understanding of how climate change is going to alter the climate in the National Park as well as how the environment will change as consequence is also established.

The **"Risk Assessment"**, the second stage, aims at assessing the assets and services of the National Park in light of this new climatic and environmental context, and quantify the level of vulnerability (or opportunity) assets and services will experience as a consequence of climate change.

The third and final stage, **"action planning"** analyses the results of the risk assessment to determine what the key messages are for the National Park in terms of climate change impacts; where action must be prioritised in order to build resilience where there is vulnerability, and facilitate benefits where there are opportunities.

Figure 1: Three staged process for completing Climate Change Adaptation Reporting

The next several sections will now provide more detail about each of these three stages.

2.1 Gather Evidence: Climate change in the Lake District (UKCP18)

To understand how climate change is going to impact the Lake District National Park, regional data taken from UK Climate Projections 18 (UKCP18) was used to forecast how a number of climatic variables will change in the National Park over the short (2030), medium (2050) and long term (2080). UKCP18 is the latest data available in the freely available (here) climate analysis tool from the Met Office's Hadley Centre Climate Programme.

Using an unmitigated emissions scenario (Representative Concentration Pathway 8.5) data was downloaded for the following climatic variables: Sea Level Rise (M), Summer Rainfall % (Mean average over June, July and August), Winter Rainfall % (Mean average over December, January, February), Summer Temperature °C (Maximum Air Temperature at 1.5m over June, July, August) and Winter Temperature °C (Maximum Air Temperature at 1.5m over June, July, August).

Anomaly values were selected instead of absolute values. This was in order to represent the data for each variable as a percentage change against a baseline set between the years 1981-2000. Using a regional scale (12km) data set, data was cut to cover the entirety of the National Park boundary including all of its coastline. Several data points for each of the climate variables were then produced which represented a spread of geographic coordinates across the National Park for each year from 2010 until 2080. The data points for each year representing different geographic coordinates were averaged to give one value for the National Park, and then these values across four 10 year time frames were averaged to give one value to represent the present (2010-2020), short (2030-2040), medium (2050-2060) and long term (2070-2080). This was done for each climate variable except sea level rise. For sea level rise a data square (one value to represent a particular area) was chosen to cover all the coastline under LDNP designation. For each time-frame (short, medium and long term) the 10th, 50th and 90th percentiles were chosen to illustrate the predicted sea level rise with climate change. Table 1 below shows the data outputs for each of climate variables mentioned.

Climate Change in the LDNP						
1981-2000 baseline	**Percentile**	**Sea Level Rise (M)**	**Summer Rainfall (%)**	**Winter Rainfall (%)**	**Winter Temperature (°C)**	**Summer Temperature (°C)**
Current Average (2010-2020)	10th	0.04	-11.16%	+5.32%	+0.80°C	+1.34°C
	50th	**0.06**				
	90th	0.09				
Future Short Term (2030-2040)	10th	0.07	-7.85%	+6.19%	+1.26°C	+2.16°C
	50th	**0.10**				
	90th	0.14				
Future Medium Term (2050-2060)	10th	0.15	-23.83%	+16.58%	+2.18°C	+3.56°C
	50th	**0.21**				
	90th	0.43				
Future Long Term (2070-2080)	10th	0.30	-32.28%	+26.20%	+3.2°C	+5.30°C
	50th	**0.43**				
	90th	0.6				
Rainfall Intensity: % increase in severity of extreme rainfall events for England (Environment Agency 2016). As national figures likely to be a conservative estimate for the wetter north west where the Lake District National Park is situated.						
Based 1961-90 baseline		Uplift: Factors are advised for return periods greater than 5 years. Estimates based on maximum daily total rainfall.				
Future Short Term (2030-2040)		+10%				
Future Medium Term (2050-2060)		+20%				
Future Long Term (2070- 2080)		+40%				

Table 1: Climate change projections for the LDNPA using emissions scenario RCP 8.5. Rainfall Intensity taken from Environment Agency national guidance due to lack of available data.

Rainfall intensity is also an extremely important meteorological variable to consider in the context of climate change and the National Park, not least because of the catastrophic impact that Storm Desmond in 2015 had on the Lake District. However due to the complexity in extracting data for rainfall intensity from the climate analysis tool that the Met Office provide and the UKCP18 data,

national figures published by the Environment Agency (Environment Agency, 2019) have been used.

As can be seen from the tables above, in a worst case emissions scenario the Lake District would experience an extremely significant shift in its climate by the 2070s. Sea level would rise by over half a metre, summer rainfall would reduce by over 30%, winter rainfall would increase by over 25%, average winter temperatures would increase by over 3 degrees, summer temperatures would increase by over 5 degrees, and rainfall intensity would increase by 40%. All this would lead to effectively increasingly hotter, drier summers, warmer wetter winters, as well as extremely variable weather patterns.

2.2 Gather Evidence: Environmental change in the Lake District

If the projected changes in climate for the National Park come to fruition, this will initiate a number of different environmental responses in the Lake District. As will be seen later in this report an understanding of these changes is important in determining the level of vulnerability and opportunity assets and services within the Lake District will experience with climate change. To understand what these may be, and over what time frame they will have significance, a literature review (see appendix A for full details) of peer reviewed research into the impacts of climate change on the environment and its ecosystems was undertaken, which was then substantiated through consultation with the Environment Agency.

A number of key conclusions were found. Increased severity and frequency of storms will lead to more flash flooding and soil erosion. Hotter, drier summers will lead to intense heat waves and more frequent periods of drought.

Many species within the Lake District will be pushed out of the National Park as the Lake District's climate envelope changes and there is phenological disruption (i.e. changes to periodic events in biological life cycles such as bud burst and hibernation). New species may move into the National Park which could be important for the resilience of native species from elsewhere in the UK, however it could also mean invasive plants and animals move in and dominate, as well as a greater variety and incidence of pests and diseases (State of the Park Report 2018).

In the context of a changing environment agriculture and forestry will change in the Lake District as increased biological productivity and an extended growing season means it will become possible to grow different products.

Ecosystem services that the natural environment provides will also be impacted. Higher temperatures and drought will affect the carbon sequestration potential of peatland and woodland. Increased wildfires will become more frequent restricting access to the natural environment for the benefit of people's health and well-being. River and lake levels will be the subject to extreme variability – with alternating periods of too much and too little water impacting on the National Park's ability to continue as a critical regional provider of drinking water. This coupled with increased algal blooms will disrupt recreational pursuits the Lake District is associated with, as well as impacting the economy that has built up around this (e.g. cancellation of events such as the Great North Swim).

When the content of this research was analysed in the context of the short (2030s), medium (2050s) and long term (2070s) time frames a general trend can be seen (Figure 2). In the short to medium term environmental changes will be driven principally by precipitation leading more flooding of grasslands, higher river flows, and more Storm Desmond like events as an example. However in the long term environmental changes will be driven principally by temperature where

there will be greater incidences of wildfires, peat desiccation and erosion, and more frequent long duration droughts.

The table compiling the results of the literature review can be seen in Appendix D, and list of full references seen in Appendix A.

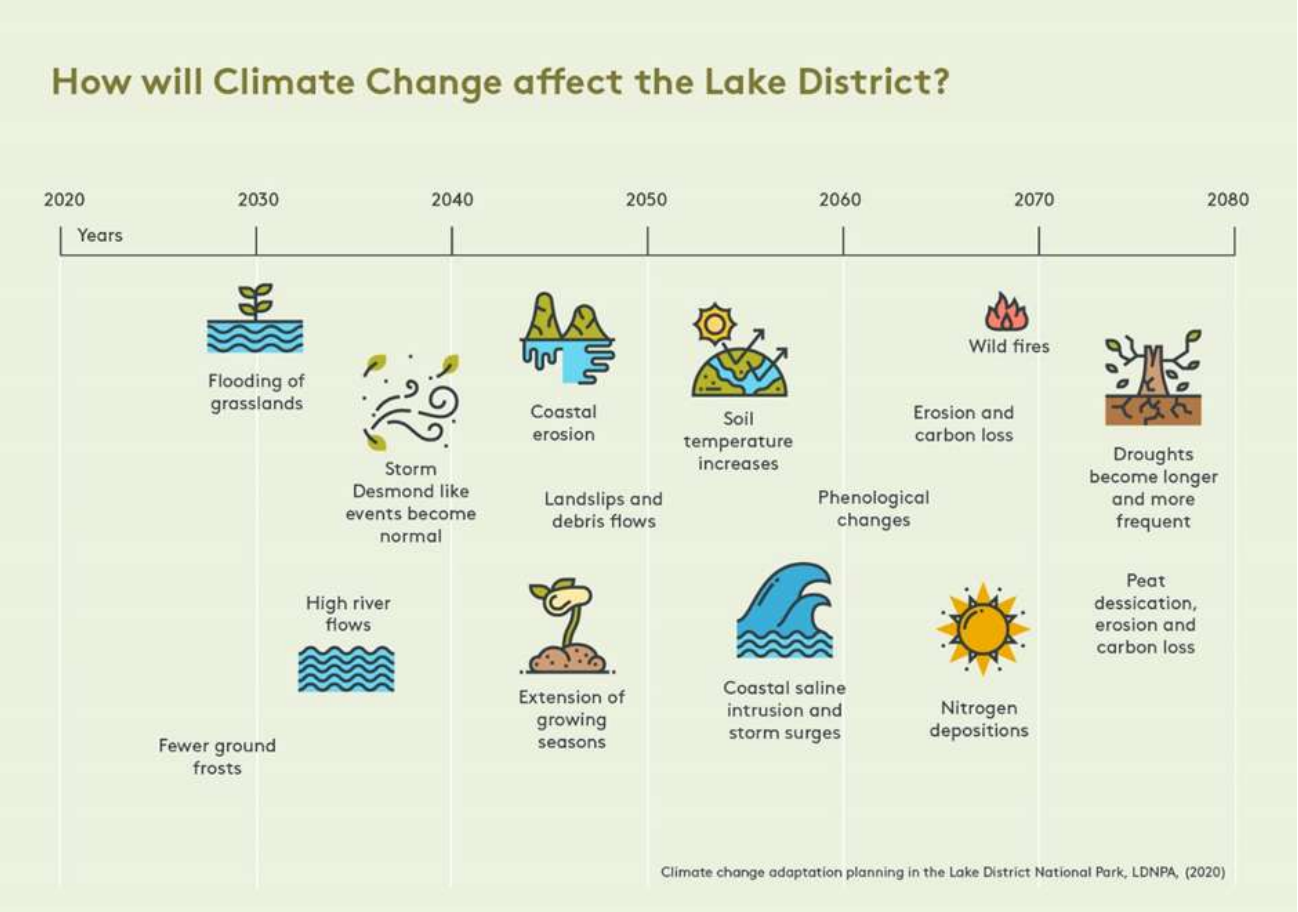

Figure 2: Expected environmental change in the LDNPA across the short, medium and long term

2.3 Gather Evidence: Assets and Services in the National Park

After putting together a picture of how climate change will influence the Lake District both climatically and environmentally (in a worst case emissions scenario) the next step in setting the context for the risk assessment was to determine how to define the National Park's key assets and services for this assessment. To do this we used already agreed measures of value in the National Pak which included;

- The Special Qualities of the National Park arranged across the four elements of the Lake District National Park Vision; Spectacular Landscape (Wildlife and Cultural Heritage), Vibrant Communities, Prosperous Economy, and World Class Visitor Experience (Lake District National Park Authority, 2006)
- Attributes of Outstanding Universal Value of the Lake District Wold Heritage Site (The English Lake District World Heritage Site)
- Ecosystem Services: Supporting, Provisioning, Regulating and Cultural Services (Millennium Ecosystem Assessment)

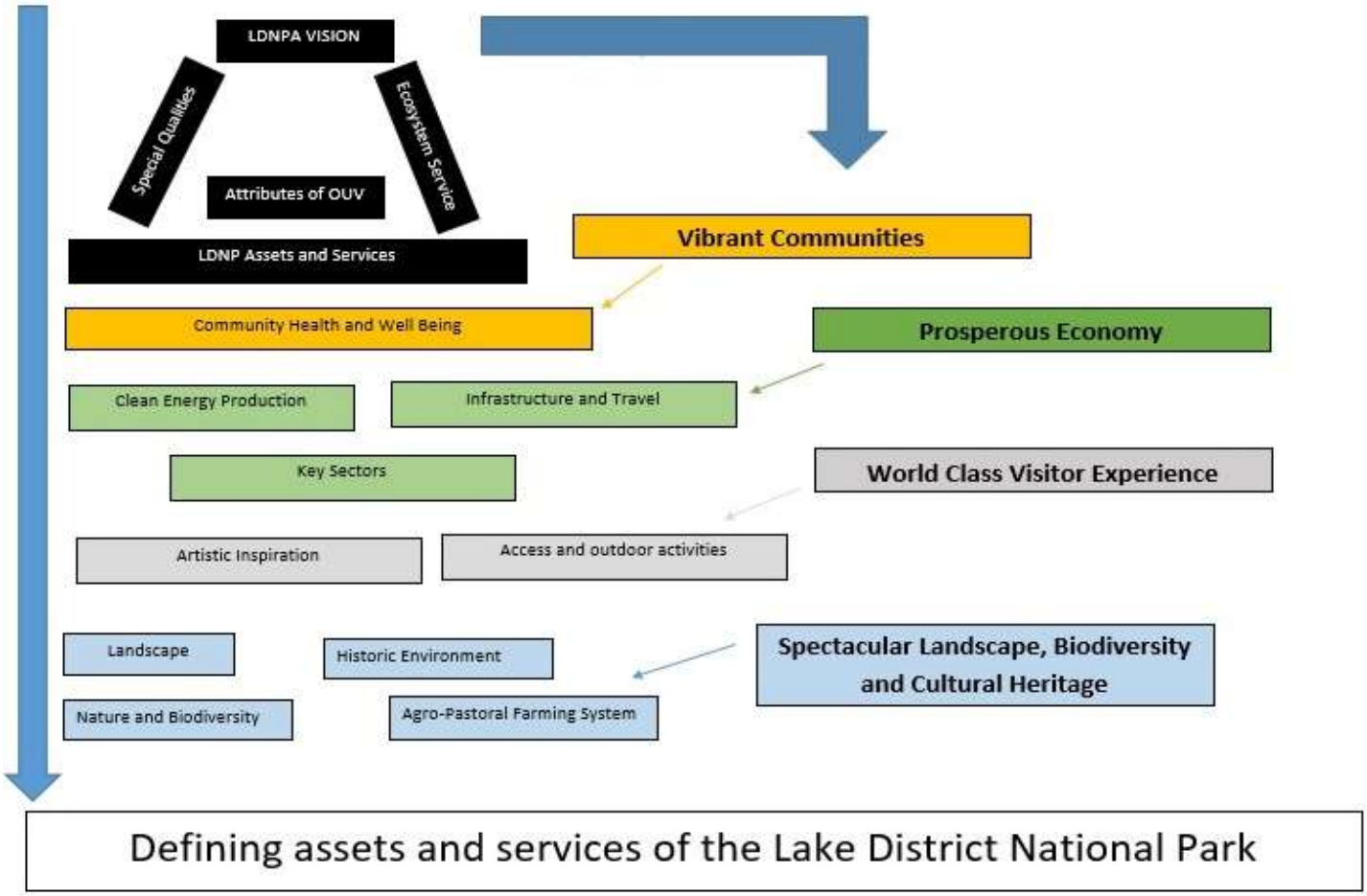

Figure 3: Defining the assets and services of the Lake District National Park

From these three aspects a number of different assets and services were determined and categorised according to the four elements of the Lake District National Park Vision (conceptualised in figure 3). However it was found that these assets and services were quite broad and therefore difficult to achieve an accurate risk assessment of the effects of climate change. For example the Lake District High Fells Special Area of Conservation (SAC) was one asset that was identified in the National Park, but this is very broad covering many different habitats and species each of which will have a differing response to climate change. In order to make the risk assessments meaningful, assets and services were broken up into several discrete units, or "indicators", that would act as the criteria against which the of the risk assessment would be undertaken so for example arctic alpines were defined as an indicator of the High Fells. The following sections will now detail the assets and services for each part of the Lake District National Park Vision, and the indicators used in the risk assessment.

2.3.1 Spectacular Landscape: (Wildlife and Cultural Heritage)

Landscape as well as the indicators that were used as part of the risk assessment. The left hand column of the table (asset groups) categorises assets and services into broader groups. This is because certain assets and services can be grouped according to a particular theme (e.g. Nature and Biodiversity within Spectacular Landscape) and distinguished from other groups which are related to another theme (e.g. Historic Environment). Within Spectacular Landscape 4 asset groups containing 15 assets and services were identified. From these 15 assets and services 25 indicators were taken forward into the risk assessment.

As can be seen from Table 2 an asset or service can have multiple different indicators and this reflects how different assets and services can have various important components. For example there are three different indicators used in the risk assessment for the Built Heritage asset

(Historic bridges, vernacular buildings, vernacular landscape features), two indicators used to risk assess the ecosystem service Carbon Storage (Peatlands, Woodland Carbon Cycle), and just one for High Fells (Arctic Alpines). The number of indicators used reflects the availability of resource and time to complete the risk assessment rather than the amount of significant components an asset contains. There are certainly many more important components that make up the high fells than just arctic alpine plants.

Assets Groups	Assets and Services	Indicator
Landscape	Areas of Distinctive Character	Area 22 Borrowdale
	Ecosystem Functioning	Wildlife Composition (Dragonflies and Butterflies)
Nature and Biodiversity	High Fells	Arctic Alpines
	Lakes	Cold Water Fish
	Tarns	Wetland Habitats
	Rivers	Aquatic Macro-Invertebrates
	Carbon Storage	Peatlands, Woodland Carbon Cycle
	Local and Regional Water Supply	Water Quantity and Quality
	Trees and Woodlands	Ancient Semi-Natural Woodland, Multi-Purpose Forests
Historic Environment	Built Heritage	Historic bridges, vernacular buildings, vernacular landscape features
	Archaeological sites and historic landscapes	Floodplain archaeological sites, woodland archaeology, upland mining and quarrying sites, high fells archaeology, coastal historical assets
	Designed Landscapes	Parkland Trees and Plants
Agro-Pastoral Farming System	Native Livestock Breeds	Herdwick Sheep
	Agricultural Grasslands	Soil Health, Upland Hay Meadows
	Common Land	Active Commons

Table 2: Assets/Services and Indicators used in the risk assessment for Spectacular Landscape.

2.3.2 Vibrant Communities

Within Vibrant Communities the risk assessment looked at three broad areas; Community functioning, Households, and Infrastructure (Table 3). Community functioning is the ability of a community to be independent and sustainably provide each of its member's access to the services they require to lead safe and fulfilling lives. It is the aggregative effect of multiple components (or assets). Resilience is one component and was the focus of the risk assessment.

Asset Groups	Assets and Services	Indicator
Community functioning	Resilience	High resilience towns and villages
		Low resilience towns and villages
Households	Housing	Housing and flood risk
		Housing and coastal flood risk
		Living and working conditions
		Households on private water supplies
Infrastructure	Mobility	Transport Networks
	Social spaces	Community Buildings
	Utilities	Public water supply, Digital Networks

Table 3: Assets/Services and Indicators used in the risk assessment for Vibrant Communities

Resilience refers to the ability of communities to reduce exposure, prepare for, cope with, recover better from, adapt and transform to shocks and stresses. Two representative towns in the Lake District were created to act as indicators in the risk assessment. Both were given different characteristics that made them more or less resilient. The results for each indicator could then be extrapolated to communities in the Lake District by looking how the characteristics of the representative towns were shared or not shared by real life towns and villages in the Lake District.

The second group of assets in this risk assessment for Vibrant Communities was households. For households the asset that was examined was the physical housing stock and a number of different indicators were examined in determining the impacts of climate change. Flood risk to both coastal and in-land housing stock was assessed, in addition to the effects extreme temperatures (hot and cold) on the living and working conditions of houses as well as the impact changes in precipitation could have on households on private water supplies.

Finally the impacts of climate change on key infrastructure associated with community mobility, social spaces, and utilities were assessed. The indicator used for mobility was transport networks such as roads. Social spaces, that are not only important for developing cohesion and cooperation (e.g. allowing meeting spaces and establishment of committees) but also for health and well-being, were looked at by assessing the impacts of climate change on community buildings such as churches and town halls. Public utilities were examined through the impacts of climate change on the Public Water Supply and Digital Networks such as mobile phone and broadband.

2.3.3 Prosperous Economy

Prosperous Economy was assessed around three broad areas; the impacts of climate change on key sectors within the economy, on infrastructure and travel, and on workforce and employment (Table 4).

	Assets and Services	Indicator
	Agriculture	Farm Businesses
	Hospitality and Tourism	Visitor Accommodation, Beaches, Retail,
	Digital and creative	Digital Infrastructure (Broadband to premises / mobile phone)
Infrastructure and Travel	Asset Groups	Roads
	Key Sectors	Public Ferries, Launches and Cruises
Workforce and employment	Green Economy	Microgeneration of renewables in the Lake District
	Labour Productivity	Working conditions

Table 4: Assets/Services and Indicators used in the risk assessment for Prosperous Economy.

Agriculture and Hospitality and Tourism are the two biggest industries within the National Park and therefore are appropriate assets to include in the risk assessment when looking at key sectors. The digital and creative sector was included in order to recognise the burgeoning importance of this industry in the Lake District which has been emphasised even more so during the Covid-19 pandemic and the large number of people working from home.

From the perspective of infrastructure and travel, both land based travel and water based travel have been included, in order to assess the impacts of climate change on the economy. This is because due to the nature of the Lake District having numerous large water bodies, many businesses would be isolated and separate from their consumer market and workforce if it wasn't for the use of boats, ferries and cruises transporting goods and people. Therefore in the risk assessment an indicator looking at the impact of climate change on water based transport was included in addition to the road network.

There are indicators used in the risk assessment that appear multiple times in different sections. This is due to the fact that some assets are important to multiple sectors. For example the indicator looking at the impact of climate change on the road network is included both here in the Prosperous Economy as well as in Vibrant Communities. This because access and mobility is both important for the health and well-being of communities (particularly isolated ones in the Lake District) and for businesses and industry to be able to function.

Workforce and employment is also key to a Prosperous Economy and was the final aspect examined in the risk assessment. Two assets were risk assessed; labour productivity, the ability of the workforce to meet the objectives and expectations in their respective roles; and the "Green Economy", jobs and industries associated with decoupling the economy from increasing greenhouse gas emissions. The effect of climate change on labour productivity was assessed by looking at how climate change would influence conditions within a working place by looking at variables such as extreme heat and cold. The effect of climate change on the green economy was assessed by how it would impact on the viability and take-up of micro-generation renewable projects in the Lake District.

2.3.4 World Class Visitor Experience

Assets related to access as well as the physical and cultural experience visitors enjoy when visiting the National Park were included in the risk assessment for World Class Visitor Experience (Table 5).

Asset Groups	Assets and Services	Indicator
Access	Open access land, footpaths and trails Transport services and infrastructure Places to stay	Footpaths and rights of way Land and water based transport networks (roads, boating activities) Visitor accommodation
Physical Experience	Health and Well-being	Recreational Activities Green space and mental health
Cultural Experience	Lake District World Heritage Site Amenity value of the Lake District Historic Environment	Global Value of the World Heritage Site Landscape character

Table 5: Assets/Services and Indicators used in the risk assessment for World Class Visitor Experience

To understand the impact of climate change on access, the indicators used in the risk assessment covered how people get to and move around the National Park (road networks, ferry and boat services), where people stay when they get there (campsites and hotels), and the different ways the National Park's attractions are enjoyed (footpaths and Rights of Way).

The benefits that the Lake District provides people's health and well-being is considered a key asset of the National Park and is nationally significant. A large part of how people attain these benefits is through some sort of physical experience of the National Park. To understand the impact of climate change on this, recreational activities within the National Park (e.g. mountain biking, open water swimming, and rock climbing) as well as the availability of green spaces were included as indicators in the risk assessment.

A large draw of the Lake District National Park to visitors is the opportunity to come and experience first-hand its rich cultural and historic heritage. The Lake District landscape has inspired a number of cultural movements over the last 400 years and its landscape is a product of cultural traditions that span centuries. It was for these reasons that the Lake District was awarded World Heritage Site status in 2017. As such one of the indicators used within the risk assessment related to assets on the cultural experience of the National Park. This indicatorexplores how climate change impacts within the National Park could affect the global value of the World Heritage Site. To compliment this an indicator on the effect of climate change on landscape character was also included as a way of measuring its impact on the amenity value of the Lake District.

2.4 Risk Assessment: Methodology

The aim of the risk assessment is to quantify the level of vulnerability/opportunity that assets and services of the National Park will experience in the short, medium and long term with climate change given the climatic and environmental circumstance outlined above. In order to determine the significance of climate change consequences on assets and services, expertise from local partners and stakeholders was sought and fed into the risk assessment framework that has been adapted specifically for purposes of CCAR (Appendix C).

2.4.1 Climate Vulnerability Index

The risk assessment framework used in the Climate Change Adaptation Reporting for the Lake District National Park is based on the Climate Vulnerability Index (CVI) that was developed for assessing climate change impacts on World Heritage Sites. The CVI was chosen because it enables more nuance to be uncovered which may mediate the level of vulnerability or opportunity that a particular asset or service experiences. For example the risk assessment does not only look at the significance of climate change effects on an asset or service, but it also considers its adaptive capacity i.e. its ability to respond to these effects - giving a truer reflection of the vulnerability or opportunity that an asset or service experiences.

Figure 4 has been taken from the Orkney World Heritage Site CVI report and conceptualises CVI (Historic Environment Scotland). For the purposes of this report the CVI has been modified and adapted in numerous ways. Vulnerability has been amended so the CVI is able to measure assets and services of the National Park not just the attributes of OUV for the World Heritage Site. In addition the CVI originally only measured vulnerability to climate impacts.

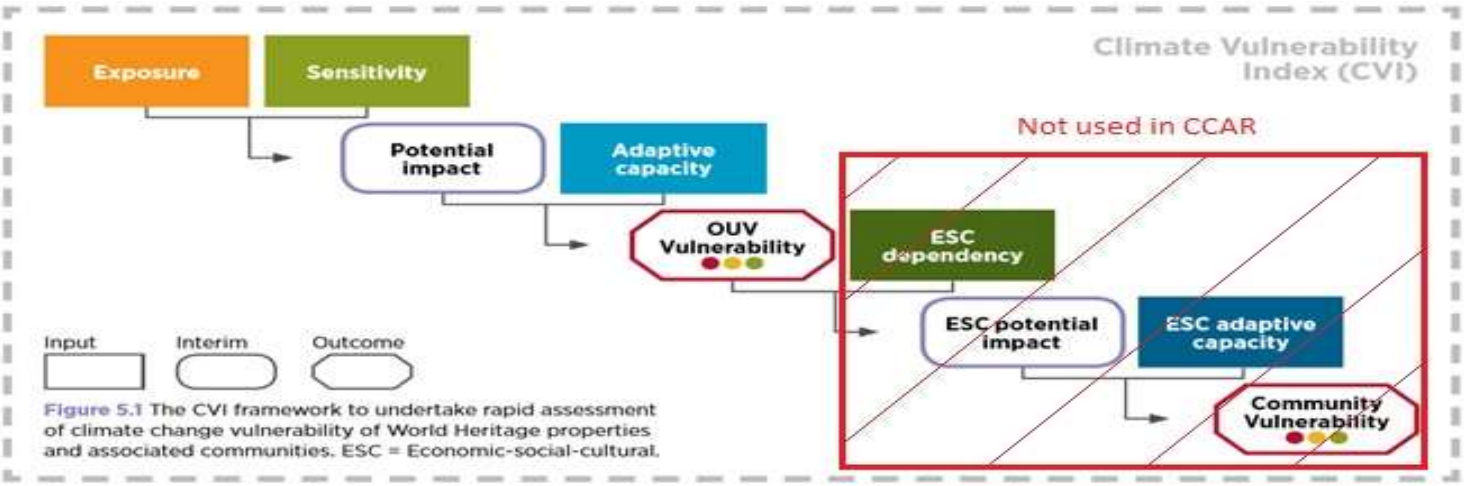

Figure 4: Modified Climate Vulnerability Index (Historic Environment Scotland). The red hashed area was not used in this report.

For this report the opportunities climate change brings to certain assets and services is included in the CVI. The CVI developed for World Heritage Sites also compares climate vulnerability of the World Heritage Site against community vulnerability (people who depend on the World Heritage Site). For this climate change adaptation risk assessment (CCAR) it wasn't necessary to treat community separately in the risk assessment (right hand portion of figure) because community was seen as an asset itself. Therefore it was treated alongside other assets and services when measuring vulnerability/opportunity (left hand portion of the framework). And finally a number of definitions as well as the scope of various parameters have changed to best reflect the context

that CCAR is being undertaken in. For further information and full procedures on the risk assessment please see Appendix C.

2.4.2 Indicators

As mentioned in 1.7 the assets and services that were identified for the Lake District National Park are much too broad to undertake an accurate risk assessment of. When thinking about the impacts of climate change if the asset/service that is being considered is broad, there is likely to be characteristics that will respond differently to climate change. The risk assessment would just amalgamate these differing responses into one outcome which would not be representative. Instead assets and services were broken down into smaller homogenous units that limited the variability in response to climate change. It was these smaller units, or indicators as they have been termed, that became the subjects of the risk assessment. For the full list of indicators used in the risk assessment see 1.7 above.

However before the indicators could go through the risk assessment process they had to be defined in order to fix the scope of what was actually being assessed, and what was not being assessed in terms of climate change impacts. The indicator definition was very important at informing what the risk assessment looked at. A definition example is given below for an indicator in the Vibrant Community section of the risk assessment looking at households on private water supplies.

“Boreholes for water extraction are necessary in those locations where mains water is not a practical option and where the geology and hydrology permits. Boreholes of various depths pump the water from the aquifer through a vertical pipe. Groundwater drought can be exacerbated by high demand for water during unusually hot or particularly dry summers. Groundwater droughts are marked by lower than average water levels in aquifers, borehole and wells, and by reduced flows to groundwater-fed rivers and wetlands. Depletion of these aquifers can make the remaining water more saline. Regular drought conditions may deplete groundwater storage to an extent where a water supply cannot be guaranteed through traditional means.

Due to the rural nature of the Lake District there are a large number of properties in the National Park that depend on their own private water supplies. This isn’t just the situation for discrete isolated farms but also for clusters of properties making up communities in entire valleys (e.g. Winster Valley). Therefore this indicator assesses the effect climate change could have on private water supplies in the Lake District National Park”.

2.4.3 Collecting the data

The following evidence sources were used to complete the risk assessments for each indicator;

- National evidence
- Peer reviewed research
- Available local research
- National/local expertise
- Lake District National Park Partnership

In the first instance relevant local and national expertise was used to complete risk assessments where available. This was done by providing them with questionnaires (Appendix D) designed to capture all the quantitative (scoring) and qualitative (justifying narrative and links to supporting evidence) information that is asked for in the risk assessment. The questionnaires, once complete, were collected and the information transferred to the risk assessment template (Appendix C). This produced a final vulnerability or opportunity score for that indicator (the risk assessment template

includes the scoring matrixes that the questionnaires don't) after which the results were sent back to the contributor to ensure that they corresponded with their intentions in the questionnaire. The reason questionnaires were sent to contributors rather than the risk assessment template was because it was decided through trialling the template with internal members of staff it was deemed too complex to complete by anyone else other than the author of this report. A full list of contributors can been seen in Appendix B.

In the event expertise didn't either exist for a particular indicator or was not available to complete questionnaires, risk assessments were completed by the author using the best available evidence which included locally produced reports, national publications or peer reviewed research literature. In most cases relevant expert and professional opinion was able to be consulted to sense check the thought process and outputs. However to be transparent about the evidence base each risk assessment was based on, risk assessments were scored against the following three tiered confidence system;

- Low confidence: Based on internal non-professional judgement either from the authors and or colleagues within the National Park Authority in the absence of available evidence or expertise.

- Medium confidence: Based on large published evidence base which could include peer reviewed literature, government agency publications, or partner organisation research. Or based on the judgement of professional expertise without support from a deep research literature field.

- High confidence: Based on consultation with professional expertise and corroborated with links to published research.

In terms of the scoring metric used in the risk assessments, a 5 point scale was used both for assets/services the assessment deemed vulnerable to climate change as well as those that may experience opportunity with climate change. This scale is shown below:

Vulnerability	Low	Moderate	High	Very High	Extreme
Opportunity	Low	Moderate	High	Very High	Fantastic

2.5 Action Planning: Interpreting the results of the risk assessment

Approximately 40 separate indicators representing a wide variety of assets and services covering each of the 4 key areas of the Vision were included in the risk assessment. The degree of granularity contained within the outputs of the risk assessment provided a number of ways this information could be developed to inform the Partnership Management Plan. For example key messages for climate action on adaptation could be developed at many different scales, from cold water fish (using the outputs of individual indicators) to the entire ecosystems of lakes and rivers (by combing the outputs of a number of related indicators). It was decided that in order to maximise the effectiveness of how this work on climate change adaptation planning was integrated into the Partnership Management Plan, the results of the risk assessments would be interpreted according to the Partnership Management Plan's "key challenges". Key challenges are challenges within the National Park that have uncertainty, pressures or urgent action required within them that if not addressed pose a threat to achieving the Lake District National Park Vision in 2030. Five key challenges were identified for the next Plan and they include;

- Future of Farming and Forestry, Nature Recovery and Climate change
- Vibrant Communities and Prosperous Economy
- Sustainable Travel
- Climate Action and Net Zero
- Lake District for Everyone

For each of the key challenges in the new Plan there will be a number of strategic and tactical objectives which when delivered aim to put the National Park in a position to overcome them. The impacts of climate change will effect each and every aspect of the National Park including the five challenge areas. Therefore by analysing the results of climate change risk assessment in the context of these different challenge areas key messages can be developed that will inform and steer the formulation of these objectives and ensure that they are “climate resilient” and have the best opportunity to succeed. Given the importance of understanding the impact of climate change on the Lake District World Heritage Site, key messages from the risk assessment were also developed around this too.

It is understood that by only interpreting the results of the risk assessments and drawing conclusions for the key challenge areas and World Heritage Site risks not communicating the impacts of climate change on other aspects of the National Park that are not covered by these areas. It is hoped that anyone wanting to explore how other areas are impacted by climate change will use the raw data that was generated in the risk assessments to generate their own conclusions and interpretations. Indeed within the results section of this report the results for all of the indicators assessed in the risk assessment are presented.

3 Results

In total 41 separate risk assessments were undertaken in this report to appraise what the impact of climate change will be on assets and services in the National Park over the short, medium and long term. Each risk assessment was based on “indicators”, a discrete unit of an asset/service that is an important and or critical component of it.

This report now describes the results all the risk assessments that were undertaken and is broken down according to each part of the Vision. Pages 38-48 contain a series of tables that lists all the results generated by the risk assessment.

3.1 Spectacular Landscape (Wildlife and Cultural Heritage)

For Spectacular Landscape four assets and services were examined in the risk assessment; Nature and Biodiversity, Agro-Pastoral Farming system, Ecosystem Services, and Historic Environment.

Nature and Biodiversity

Arctic alpines and cold water fish species (Whitefish *Coregonus lavaretus*, Vendace *Coregonus albula* and Arctic Char *Salvelinus alpinus*) exist in the Lake District at the extreme edge of their distribution boundary. They are found more abundantly at either more northerly latitudes or regions with higher altitudes (e.g. The European Alps), where temperatures remain low for all or part of the year. Based on the emission scenario used in this report it was found both arctic alpines and cold water fish in the Lake District are extremely vulnerable to the scale of warming projected in the long term with climate change and are likely to become extinct in the Lake District due to a lack of suitable habitat space. Even in the short term the risk for both is high due to non-climate related pressures (land management, water industry, and urban development) that have the potential to act in combination with climate change.

Cold water fish were examined in the risk assessment by looking at the effect of climate change on processes associated with river and lake ecosystems, and what this would mean with respect to these species' biological requirements. It showed that many different hydro-ecological processes would be significantly affected by climate change such as lower dissolved oxygen levels, disruption to the thermocline and stratification, variable water levels and flushing times, increased sedimentation, and increased INNS. The implication of this is that the impacts of climate change are felt across an entire habitat space, not just localised to particular species (albeit with varying degrees of vulnerability between species). For example within rivers and lakes in the Lake District there are a number of different species that occupy the same habitat space as cold water fish, and many are likely to be impacted by climate change in some way.

The need to think about the significance of climate change beyond single species but on wider habitats was underlined in the risk assessment looking at **butterfly and dragonfly species at their northern and southern range limits**. The results of this assessment showed that climate change will alter the Lake District's "climate envelope", in turn changing how habitats are expressed in the National Park; leading to habitat space for some species decreasing (southern limit species such as Mountain Ringlet), while increasing for others (northern limit species such as Duke of Burgundy butterflies). The degree to which a species is affected negatively or positively affected by this depends on whether it is a specialist (specific ecological needs) or a generalist (non-specific ecological needs). The point being that climate change will impact on entire ecosystems, and although particular species within ecosystems will be affected disproportionately more than others (Cold Water Fish, Arctic Alpines), all species will be influenced in some way.

In addition the risk assessment for southern and northern limit species also showed that if interventions on climate change adaptation are to be successful they should ensure habitat permeability with the landscapes outside of the National Park (e.g. to facilitate species dispersal) as well as ensuring that sympathetic and strategic land management practices exist within it (e.g. to remove non-climate related pressures on species and ensure the expression of habitats favourable to new species moving into the National Park).

Woodlands and forests are another significant habitat type in the Lake District National Park. They account for almost 13% of its area, with 64% being comprised of broadleaved species and 36% conifer (State of the Park Report 2018). To understand the impact of climate change on the different types of woodland in the National Park, the risk assessment looked at both **ancient semi-natural woodlands, and also multi-purpose forests** - forests that cannot be classed as ancient semi-natural woodland and whose management is commercially underpinned to deliver a range of natural capital provisions (e.g. timber). The risk assessment results showed that ancient semi-natural woodland are likely to be relatively resilient to climate change in the short to medium term with little change in the distribution of the main species. However as these woodlands are adapted to a cool wet climate, a transition to much warmer drier summer conditions with greater disease and pest exposure in the long term with climate change is likely to make these woodlands highly vulnerable to composition and character change, with the potential for the loss of species. For multi-purpose forests the risk assessment found both increasingly levels of opportunity and vulnerability with climate change. The extension of the growing season, warmer temperatures and higher CO2 concentration in the atmosphere could increase productivity and tree growth for timber production. However although multipurpose forests are somewhat resilient to climate change they will experience some vulnerability. High intensity storm events could disrupt management which could be significant as soon as the short term, as well as increasing threats from INNS in the long term.

Agro-Pastoral Farming System

Herdwick sheep are a key part of the agro-pastoral farming system in the Lake District National Park due to their ability to be hefted to the land as well as their unique physical adaptations that allow them to live in the Lake District's cold, wet climate and make use of nutritionally poor vegetation. The risk assessment found that in terms of direct impacts from climate change, Herdwick sheep are relatively resilient in the short, medium and long term. An extended growing season, warmer average temperatures, and increased CO2 concentration will increase biological productivity leading to more nutritionally rich grazing vegetation. The assessment did stress though that there could be an elevated pest and disease threat due to increasingly milder winters, and this concern should be taken seriously when thinking about the future of the breed due to the majority of Herdwick genetic diversity being confined to the Lake District. However the main threat Herdwick sheep face from climate change could be through indirect effects; namely changes to farmers and land manager behaviour. The move to a much milder climate with better growing conditions would widen the narrow habitat niche Herdwick sheep have been able to occupy relatively exclusively. This would potentially make other less "hardy" breeds of sheep become suited to the Lake District landscape. Farmers and land managers would have greater flexibility in choosing other breeds of sheep that are much more productive per hectare of land (e.g. lowland breeds). A move away from Herdwicks as the dominant breed in the National Park would have serious implications for the Agro-Pastoral Farming system.

Another crucial component of the agro-pastoral farming system in the Lake District is the **health of its soils**. Without healthy soils the benefits climate change could have for agriculture in the National Park such as increased productivity are lost. It was outlined in the risk assessment that a legacy of historic land management (overgrazing, peat extraction and drainage, recreational pressures) in the Lake District has meant that there are areas of the National Park where soils (which could be peatland, grassland and woodland soils) have been compromised to some extent and as a consequence are vulnerable to damage and erosion from high intensity rain and prolonged periods of drought. As it is likely the Lake District will experience more frequent storms of increasing intensity in the short term with climate change, the risk assessment scored soil health as being highly vulnerable in the short to medium term. In the long term soil health is found to be less vulnerable in order to reflect the burgeoning recognition by policy makers (2020 Agriculture Bill) and land managers (ELMS) currently over the importance of soil health. However in its scoring the risk assessment has also assumed wide-spread implementation of interventions on-the-ground that promote soil health will follow immediately over the next few years. This is because soils take time to recover and it will require interventions now in order to realise greater resilience to climate change in the longer term.

The risk assessment also looked at the effects of climate change on **active commons**. The use of common land in the Lake District is a huge part of the agro-pastoral farming system in the Lake District where hefted flocks graze without physical boundaries. When looking specifically at the impact of climate change directly on active commons, assuming continued management, the risk assessment found active commons to be relatively resilient to climate change on the whole. Functions such as the conservation of semi-natural habitats would continue (albeit with a slightly different composition of plants species), and the production of native breeds of livestock would be assisted by enhanced productivity from an extended growing season and warmer climate. Climate change does have the potential to damage the physical infrastructure associated with access (e.g. storm events washing away tracks and bridges), but with support (ELMS) for repair and maintenance these should remain temporary shocks. However this is all dependent on a scenario where a satisfactory agricultural support scheme is created to replace Common Agricultural Policy (CAP) payments. The risk assessment stressed that a situation where the new agricultural support

scheme is not satisfactory, the level of vulnerability is much higher. This is because it would not only magnify the vulnerability active commons experience from impacts associated with climate change (e.g. no financial support to recover from storm damage), but also potentially stop active management of commons all together. An inadequate agricultural support scheme post CAP could greatly diminish the number of active commoners by making farming economically unviable. Without management of common land climate change would be left to completely alter the characteristics of these landscape spaces removing all the functions and services (open access land, biodiversity of semi-natural habitats, agricultural produce) active commons once delivered. Therefore the agro-pastoral farming system is not just important for the generation of agricultural products, but also for the conservation of particular expressions of landscape.

Another example are **upland hay meadows**. Upland hay meadows are habitats of high biodiversity value attributable to extensive agricultural management (winter grazing-spring exclusion-July Mowing- after-math grazing). The risk assessment found that most species of upland hay meadows should be relatively resilient to climate change with the exception of a few sensitive species (e.g. Wood Cranesbill *Geranium Sylvaticum* requires lower temperatures for vernalisation) which are vulnerable to being replaced by more southerly distributed species (currently) as the climate warms. The reason why the risk assessment results show high vulnerability to climate change is the strong in-combination effect that future changes in land management could have. As mentioned the long term financial security of land managers and farmers who are responsible essentially for creating these habitats is very uncertain. As with active commons if the agricultural support system that replaces CAP payments is not satisfactory, habitats such as upland hay meadows potentially could be lost through either agricultural intensification or land abandonment. Whatever scale this plays out over the impact of climate change in the absence of strategic and sympathetic land management would accelerate these processes.

Ecosystem Services

Carbon storage is a major ecosystem service within the Lake District National Park with woodlands and peatlands being two of the biggest carbon stores. The risk assessment looked at both of these habitats and appraised what the impact of climate change would be on them remaining as carbon stores.

With regard to **woodlands** the risk assessment found that although climate change would increase carbon emissions from some parts of the carbon cycle (e.g. warmer temperatures leading to increased organic matter decomposition in the soil), an extended growing season, higher average temperatures and increased CO_2 concentration in the atmosphere would increase net primary productivity of woodlands. This means that not only is it likely that woodlands in the National Park would remain a carbon sink, climate change would increase the amount of carbon that is stored within them. This is reflected in the low vulnerability scores for the short and medium term in the risk assessment, with a slightly more elevated level of vulnerability in the long term. This could mean a potential for extended periods of drought and water stress as well as an increase in soil respiration rates.

The ability of **peatlands** within the National Park to remain as a carbon store on the other hand was found to be highly vulnerable to climate change. In a pristine state peatlands have a number of adaptations (e.g. change to drought tolerant plant species in times of drought) that would make them resilient to the climate change projected for the National Park. However as was shown in the risk assessment many of the National Park's peatlands are in a degraded state due to a legacy of damaging land management regimes (e.g. peat cutting, drainage and overstocking). Bare peat is

vulnerable to both water erosion and desiccation from extended periods of hot dry weather. Since it is predicted that climate change is going lead to more frequent intense storm events (starting in the short term) which will combine with much hotter drier summer periods in the medium to long term, explains why peatlands in the risk assessment were found to be moderately vulnerable in the short term, with the level of vulnerability greatly increasing in the long term. This underlines the importance of peatland restoration work in the National Park if peatlands are to remain as stores and not sources of carbon in the face of climate change.

The Lake District National Park is a significant **water supply** source which is of local and regional importance - providing drinking water to around 4 million people in the north west of England. The risk assessment looked at the impact of climate change on both water quality and water quantity at public water supply assets in the National Park. Water quality in the Lake District is highly vulnerable to climate change impacts. High intensity rainfall has the potential to wash soil and nutrients from land into water bodies which is exacerbated by the steep sided topography that surrounds many of the public water supply assets in the National Park (e.g. Thirlmere). In addition rising temperatures were shown in the risk assessment to interact with an increasing nutrient load of water bodies to increase the frequency and scale of algal blooms further deteriorating water quality. Within the results of the risk assessment for water quality the highest level of vulnerability was found to be in the medium term (high vulnerability) with the short and long term scored as being moderately vulnerable. The reason the level of vulnerability of water quality is not high considering the risk factors with climate change just mentioned is because there is commitment by United Utilities (locally responsible water and waste water provider) to resource and invest in a number of interventions (e.g. sustainable land management, blending and treatment technologies) over the short, medium and long term to build resilience and mitigate somewhat this level of risk. This was also the case for water quantity. An increased frequency and duration of droughts in the long term with climate change means that is highly likely that most public water supply assets by 2080 will have suffered disruption due to low water levels, and without mitigation would have consequences for end users. However United Utilities have invested and resourced a number of measures (e.g. drought plans, monitoring of water levels, demand reduction, leakage reduction and efficiency improvements) to mitigate the scale of this impact. This is why the level of vulnerability within the risk assessment is restricted to a moderate impact and not higher.

The National Park not only manages water so as to make it available for human consumption but its rivers, lakes, woodlands, peatlands and vegetation also work at a landscape scale to store it and prevent communities both within and outside of the National Park boundary suffering from **flooding (i.e. Flood Management)**. The risk assessment looked at what effect impacts from climate change would have on the ability of the Lake District landscape to go on offering this service by taking one catchment within the Lake District (Kentmere) and appraising the risk of flooding to a downstream community (Kendal). It was found that increasing frequency of storms and periods of higher rainfall intensity that will occur over the short, medium and long term will make communities in the Lake District highly vulnerable to flooding, and this vulnerability is relevant as soon as the short term. The risk assessment showed that it wasn't just the fact that the volume of rain that will fall in a short period will increase, it will also interact with a number of human created features in the landscape that will exacerbate this risk (e.g. land management practices, urban development on floodplains, artificial manipulation of river courses, expansion of impermeable surfaces). However investment in natural interventions at a landscape scale (e.g. sustainable land management practices, natural flood management interventions) combined with more hard engineering solutions (e.g. SUDS) associated the flood mitigation schemes that remove or ameliorate these features have the potential to lower the level of vulnerability communities will

experience with climate change – provided action happens as soon as possible and is matched with suitable ambition.

Historic Environment

The risk assessment assessed the impact of climate change on **coastal, floodplain and high fells archaeology** in the National Park. The assessment found that coastal archaeology and floodplain archaeology were particularly vulnerable to climate change. With respect to coastal archaeology, historic assets were vulnerable to damage and loss from sea level rise in the long term, with also the potential for impact in the short to medium term through engineering works that will be undertaken as part of coastal management strategies (e.g. construction of sea defences). Due to the lack of survey information and full understanding of what archaeology exists along the National Park's coast, the scale of this impact is unknown.

In terms of **floodplain archaeology**, although historical assets will be vulnerable to erosive damage from higher and more voluminous river flows, a more pressing and potentially damaging impact is related to work that is being done currently within the National Park to try and build resilience to climate change. River restoration work and watercourse realignment schemes that are designed to deliver natural flood management benefits have the potential to destroy the historic environment. In many cases within the Lake District a river channel has historically been modified and is itself of archaeological or historical interest and significance in its own right. Indeed historic field systems and their waterways are recognised within the list of components that combine to create the Lake District's OUV within the World Heritage Site. Climate adaptation and mitigation works to rivers therefore have the ability to damage and destroy these historical assets.

In the short to medium term **archaeology found on the high fells** is likely to be the least vulnerable to climate change. Although in the long term high fells archaeology will be vulnerable to damage from increased periods of hotter and drier weather from climate change, which leads to greater desiccation and erosion of peat, with increased footfall from visitors to the National Park (the result of a warming climate making the Lake District a more desirable holiday destination globally) having the potential to exacerbate this. There is a risk that scaling up of climate action interventions such as tree and scrub planting could damage archaeology assets in the high fells if care is not given to the choice of planting sites. This is a risk that has relevance today and needs to be adopted into thinking by stakeholders and partners working in the Lake District delivering climate action projects.

The rich historical and cultural heritage of the Lake District can be visibly seen in the **vernacular architecture** that is ubiquitous in the landscape which includes historic bridges, farmhouses, cottages and barns, civic/religious buildings, as well as features associated with the agro-pastoral farming system such as sheepfolds, bields and stone walls. They provide a view of how local people used local materials and traditional techniques to build the infrastructure that would allow them to successfully live and work in the Lake District's environment, and contribute greatly to its distinctive character. The risk assessment found that all features of vernacular architecture in the National Park are highly vulnerable to the impacts of climate change with a significant risk in the short term, and an even greater risk in the long term. Flooding and the erosive force of overland flows associated with intense storm events were found to be the reasons for this vulnerability where infrastructure can be washed away, and in the case of buildings lead to damp conditions that instigate decay. However what also elevates vulnerability the risk assessments showed is the inappropriate or unsatisfactory maintenance and repair of vernacular architecture that is currently being seen in the National Park. A move to modern materials and building styles, away from the original design,not only undermines the point of vernacular architecture in the first place (impacting

on landscape character), but the techniques being used (e.g. non-breathable mortars and renders, replacing timber windows with sealed uPVC units). Making them less equipped to deal with the Lake District environment (cold, damp and wet) which will be exacerbated in the long term with climate change. In addition, a lack of funding and support for the upkeep of traditional techniques also elevates this vulnerability. This is because there is an incentive to use convenient modern options to replace vernacular features that are either lost or damaged with climate change (farmers opting for fencing rather than maintaining stone walls that have a significant labour cost).

The risk assessment found that **historic upland mining and quarrying sites** also to be highly vulnerable to increased flooding and erosive damage caused by more violent overland flows, a result of more frequent and intense storm events related to climate change. These sites are inextricably linked to water and the use of water for power. Leats and waterways run through sites, and have the potential to seriously damage industrial remains due to the fact they were not designed to have the capacity to deal with the increased volumes of rainfall that are predicted to occur with climate change e.g. the damage done to Myers Head Lead Mine near Hartsop after Storm Desmond. Similar to vernacular architecture, historic mining and quarrying sites are made more vulnerable to climate because there is currently little resource available to ensure the adequate maintenance and repair of sites following damage, or investment in interventions on the ground that could mitigate the worst impacts.

The final aspect of the historic environment the risk assessment examined was the impact of climate change on the **trees and plants associated with the Lake District's designed landscapes**. Designed landscapes are the result of a series of deliberate management actions that codify someone's vision of landscape. In the Lake District they are inspired by agro-pastoralism as well as artistic/literary movements such as romanticism and picturesque in the late 18th century. The selection and positioning of particular tree and plant species are a significant component. A warming climate over the short, medium and long term will change what species can and cannot grow in the National Park and introduce new pest and diseases. Therefore in the long term designed landscapes are highly vulnerable to climate change as it may become impossible to have the same vision of landscape that was originally intended if certain species can no longer be viably maintained. Although tree and plant species can be substituted for other species to give a similar effect, there are limits on the extent designed landscapes can change and adapt before losing their integrity and authenticity of what was originally envisaged. There is also vulnerability in the short to medium term if interventions on climate action such as tree and scrub planting are not planned sympathetically with designed landscapes in mind; with the restoration of Grizedale Beck and designed views of Dollywagon Pike a current example.

3.2 Vibrant Communities

For Vibrant Communities three assets and services were examined in the risk assessment; community functioning, households, and infrastructure.

Community Functioning

Community functioning is the capacity of a community to remain independent, be economically prosperous, and provide all of its residents and visitors the minimum number of services that ensure they are able to achieve good emotional and physical health. To examine what effect climate change will have on community functioning in the National Park the risk assessment looked at its impact on **community resilience** - *"the ability of communities to reduce exposure, prepare for, cope with, recover better from, adapt and transform as needed to, the direct and indirect effects of climate where these effects can both be shocks and stresses"* (Twigger-Ross et al, 2015). There are a number of different characteristics (see risk assessment for full list) a

community can possess that will increase or decrease resilience. In the risk assessment the effects of climate change on a high resilience community (i.e. possessed many characteristics of resilience) and a low resilience community (i.e. possessed few characteristics of resilience) were contrasted. To avoid stigmatisation rather than select two real life communities, two “model” communities (Fairbridge and Cairnthwaite) that did not exist but had been given traits and features characteristic of towns and villages in the Lake District were created. The results for each could then be extrapolated to communities in the Lake District by looking at how characteristics of the representative towns were shared or not shared by real life towns and villages. The first point to make from the risk assessments is that since all communities in the Lake District share some of the characteristics (e.g. situated in steep sided valleys or next to rivers prone to flooding) with the representative communities they will all experience negative impacts from climate change over the short, medium and long term to some degree. In the short term it is likely an increasing number of communities in the National Park will suffer similar damage and disruption that was experienced by Glenridding after Storm Desmond in 2015. In the medium to long term in addition to a greater frequency of intense storms, communities across the Lake District will have to endure the consequences of much hotter drier summers such as intense heat waves and long duration droughts (some communities in the National Park are on private water supplies) which have the potential to deteriorate living and working conditions (e.g. health complications). However what the risk assessments showed was that the level of vulnerability to these impacts is mediated by which attributes a town or village possesses that increase or decrease community resilience - with communities that are considered “highly resilient” demonstrating a much lower level of vulnerability to climate change over the short, medium and long term compared to communities considered to have “low resilience”. A number of attributes that lower community resilience and thus increase vulnerability include;

- Low community spirit with little intra-community engagement
- A high proportion of second home owners
- No formulised emergency planning
- An unbalanced age structure dominate by people of retirement age
- A high number of vulnerable people (e.g. people on low incomes)
- Poor infrastructure, communication and transport links
- Exposure to physical environment (e.g. situated in steep sided valleys, properties on private water supplies)

As can be seen there is difference between the attributes in terms of what a community can do to either acquire or ameliorate them, and the risk assessment showed that depending on which attribute a community did or didn’t possess affected its adaptive capacity. For example some attributes have an element of permanence about them that is difficult to change. An isolated rural community at the bottom of a steep sided valley will always be vulnerable to increased landslips and overland water flows to some extent despite whatever work and intervention (sustainable land management practices, Natural Flood Management measures) is done in the catchment to mitigate risk. However some attributes can be addressed relatively easily. For example the formulation of an emergency town plan was found in the risk assessment to greatly reduce a communities vulnerability to the impacts associated with climate change. Provided a community is willing to engage and participate, an emergency town plan is relatively straight forward to put together and once agreed a community has the knowledge of what to do before, during and after climate change impacts to keep disruption to an minimum. Considering this, the risk assessment results are therefore very useful in determining which real life communities in the National Park are more vulnerable to climate change than others by seeing which communities exhibit attributes that

lower resilience. Understanding why communities are vulnerable to climate change will inform what actions/interventions must be done to build resilience.

Households

As well as looking at the impact of climate change on communities at a collective scale the risk assessment also looked at how individual households would experience climate change by appraising how it would affect both the living and working conditions of properties across the National Park as well as how their vulnerability to flooding would change.

The results showed that with respect to **living and working conditions** households within the National Park are moderately vulnerable to climate change. Living and working conditions can be significantly affected by environmental conditions, where excess cold, intense heat, as well as damp conditions from periods of wet weather can have impacts on both emotional and physical health. The National Park has a high percentage number of residents being over the age of 65, and a number of its housing stock are “hard to treat” homes in rural areas which fail to meet energy efficiency standards, and each year there is an excess number of winter deaths related to cold weather. However climate change is projected to lead to milder winters overall and thus shouldn’t drive an overall increase in number of deaths related to cold. However in addition to a general trend of increasingly warmer, wetter winters and hotter drier summers, climate change is also expected to trigger extreme weather variability which could be manifested by periods of extreme cold weather (such as the “Beast from the East” in 2018). Therefore it cannot be said for certain that climate change won’t contribute to an increase in number of deaths due to excess cold and for this reason, in the short term to medium term at least is why vulnerability to climate change has not been scored lower than moderate. However in the long term it is expected that climate change will drive more frequent instances of hotter, drier weather; particularly in the summer time which could have a number of impacts on households in the National Park. Periods of intense heat can be uncomfortable and make it difficult for people to hold their concentration –stifling labour productivity e.g. people working at home or in offices. Extreme heat can also lead to a variety of heat stress conditions such as heat stroke, which can put a number of vulnerable groups at a higher risk of mortality. More education is needed about how to keep homes both warmer and cooler through low carbon solutions (e.g. taking advantage vernacular building features or relatively simple measures such as the use of blinds to keep the sun out during the day).

The risk assessment also looked at how the **flood risk to households** in the National Park would change with climate change, such as the potential impact from higher river flows, ground water flooding, and high lake levels caused by more frequent intense storm events, as well as the potential for sea level rise, coastal erosion and increased severity of tidal surges to inundate and damage households situated along the coast.

For **coastal households** the results showed that it was likely that they would be impacted by climate change in the short, medium and long term and in some cases the effects may mean that particular households may need to abandon their properties and move further inland. Despite this the vulnerability score for coastal households in the risk assessment remained at a moderate level. This is because the impact and consequences of sea level rise are recognised as a threat by local authorities and is being prepared for. The North West Shoreline Management Plan (SMP2) covers the coastline from Great Orme in North Wales to the Scottish Border, thus including the National Park’s coastline. It incorporates projections of sea level rise into long term plans for coastal defences. The Cumbria Coastal Strategy builds on this and assesses the existing condition of land and flood defences along the Cumbria coast line (including the National Park) and identifies potential future interventions.

Its key objectives are:

- to evaluate the risk of flooding and erosion along the Cumbrian coastline
- identify properties and infrastructure at risk
- identify and evaluate potential long-term solutions
- form a robust and objective evidence base
- to provide a framework for future infrastructure and development

Adaptation strategies including building and enhancing coastal protection structures, such as dykes or sea walls, as well as deploying coastal warning systems. However the success of this planning on lowering the risk of climate change to coastal households is completely dependent on the resource and funding available in the future to implement it.

The risk assessment found that the vulnerability of **inland households** to flood risk from climate change was greater than for coastal households. Vulnerability in short term was high, which increased to very high in the long term. This is because inland flooding in the National Park occurs much more frequently and is much more difficult to predict which area will be worst affected. Due to the National Park's mountainous topography flood risk is highly localised, concentrated to households that are located in high risk areas such as those that sit in functional floodplains, close to water courses and or located at the bottom of steep sided valleys. The National Park has a history of damaging flood events with the most recent being those associated with Storm Desmond in 2015. Because of this there is a lot of work and action to help raise awareness and build resilience with communities to flood risk, as well as interventions (Natural Flood Management, Sustainable Land Management practices) in catchments to mitigate the scale of flooding when it does occur. However for this to be effective in reducing vulnerability of inland households, more work is needed, especially in delivering catchment interventions at a landscape scale in order to lead to meaningful flood attenuation.

Infrastructure

Having robust, adequate infrastructure is crucial for communities to remain independent and viable. The risk assessment examined the impact of climate change on a number of different types of infrastructure important to communities in the National Park.

It was found that the **transport network** in the National Park is highly vulnerable to climate change, and this is across the short, medium and long term. **Land based transport infrastructure** such as roads, bridges and railways will be vulnerable in the short term to medium term to climate events related to precipitation, in addition to temperature related events in the long term. Storms events will not only mean flooding and windblown trees will make roads and rail in the National Park impassable for temporary periods, but it could also lead to intense erosive overland water flows that result in road closures due to permanent damage that requires repair e.g. bridges and roads becoming structurally unsound. Intense heat waves in the long term also have the same capacity to disrupt the land transport network. Periods of intense heat can melt tarmacked surfaces as well as buckle railway lines, making them unsafe to be travelled on.

The large number of lakes and rivers in the National Park means **water based transport** is very important to communities as well. Like land based transport the risk assessment found that public ferries, launches and cruises operating in the National Park were highly vulnerable to climate change across the short, medium and long term. More frequent intense storms in the short to medium term have the potential to damage jetties/piers and vessels or supporting infrastructure such as pier houses, ticket offices, marinas, moorings toilets, car parks, and maintenance

facilities. In the long term in addition to more frequent, intense storms, hotter drier weather in the summer time could lead to more frequent droughts. Low water levels could mean jetties and piers become inaccessible and some routes becoming impossible to navigate due to shallow water.

A large proportion of communities in the National Park are isolated (some only have one route in and out due to topography, with diversions taking routes that follow narrow roads and high passes) and depend on operating land and water based transport services to access essential services and maintain social bonds. A loss of just one of these services for a period of time could result in a community in the National Park double its travel time to the nearest hospital or lead to food shortages with local shops not able to resupply.

Utilities are also a key component of infrastructure that communities in the National Park need to have access to if they are to remain independent and prosperous. The impact of climate change on the **public water supply** in the National Park has already been mentioned in section 3.1 looking at ecosystem services. It was found that across both water quality and water quantity climate vulnerability was scored at a moderate level, due to the amount of measures and interventions the local water services provider has either undertaken or has planned to mitigate against the worst effects. However there are also a number of communities in the National Park (e.g. Winster Valley) that don't have access to the public supply and instead rely on their private supplies through the use of boreholes. The risk assessment found that **private water supplies** are vulnerable to extended droughts that lower aquifer water levels beyond the capability for extraction. In the medium to long term, climate change is likely make this risk more acute as the frequency and severity of droughts increase. It is poorly understood what the risk of climate change is for private water supplies – how many people are affected, which parts of the National Park are at risk, and the level of drought that would be problematic. The results of the risk assessment scored vulnerability as moderate, with the caveat that vulnerability could be higher or lower and more research was needed.

The other public utility that the risk assessment looked at was **digital infrastructure**. Reliable broadband and mobile signal is crucial for any modern community to function – and has been a revolutionary development in bringing greater connectivity to remote and isolated communities in the National Park. The results showed that over the short, medium and long term there is low vulnerability to climate change. Broadband lines are generally underground and mobile phone masts are not likely to be located in areas of flood risk. Therefore digital infrastructure is relatively insulated from climate change impacts. In fact, investment in developing digital infrastructure further in the National Park will help alleviate other vulnerabilities this risk assessment has identified for communities from climate change.

The final component of infrastructure important to communities that the risk assessment examined was **community buildings**. Community buildings are social spaces that are not only important for developing cohesion and cooperation (e.g. allowing meeting spaces and establishment of committees) but also for health and well-being. Examples can include churches and town halls. The assessment found community buildings to be of low vulnerability across the short, medium and long term. On the face of it this is an interesting finding when you compare these results with the results for household flood risk which was found to be highly vulnerable to climate change. It is clear that community buildings will be vulnerable to flooding as well. However the difference in the risk assessment between these two Vibrant Communities indicators was that community buildings were considered to have much more effective Adaptive Capacity. For example the "Village Hall Improvement Grant Scheme" provides funding to help make buildings "fit for purpose", which includes adapting to climate change. Communities can access funding of up to £75,000 towards refurbishment and alterations of buildings to make them more resilient. The fact that there are

fewer community buildings than households at risk of flooding (meaning funding can go further), commitment to action from the curators/those responsible, as well as support from volunteer organisations (ACT) to access funding for climate change adaptations, helps mitigate the risk of community buildings being adversely affected by climate change. This is important, because like digital infrastructure, having places where communities can come together to plan and organise will be important for mitigating other aspects of vulnerability to climate change communities face – such as being able to prepare and deliver (when needed) an emergency town plan that can help maintain community functioning in the event of an impact from climate change.

3.3 Prosperous Economy

For Prosperous Economy three assets and services were examined in the risk assessment; Key Sectors, Workforce and Employment, and Infrastructure and Travel.

Key Sectors

Agriculture, and Hospitality and Tourism are the two biggest industries within the National Park and therefore are appropriate assets to include in the risk assessment when looking at key sectors.

With regard to **agriculture** the risk assessment looked at the impact of climate change on farm businesses in the National Park. This was different in scope to the indicators assessed as part of the agro-pastoral farming system asset under Spectacular Landscape. Rather than look at the direct impact of climate change on different physical constituent parts of farming (soils, livestock, semi-natural habitats, Common Land), this assessment focused specifically on economics (which is informed by the agro-pastoral farming system assessments), and the ability to operate as profitable sustainable businesses. The results found that climate change has the potential to have a mixed impact on farm businesses, bringing both vulnerabilities and opportunities. On the one hand farm businesses are extremely vulnerable to climate change, with an increasing risk over the short, medium and long term. An increased frequency of storms has the ability to damage physical infrastructure that farm businesses rely on to either attend to livestock or transport them to market. Periods of intense storms could also mean farm businesses incur greater periodic costs due to over wintering livestock for extended periods, and having to provide supplementary feed. In addition, in order to remain profitable, farm businesses in the National Park in many cases have multiple diversified income streams other than the rearing and selling of livestock e.g. converting unused barns into holiday cottages and fields into campsites. These additional income streams can be equal to or more important to the farm business than livestock production. The flooding of campsites during storms, and the severance of local, regional and national transport routes which stop visitors reaching the National Park has the potential to disrupt this aspect of farm businesses. Many farm businesses in the National Park are extremely isolated and for this reason many are not connected to mains water supply, but have their own private borehole. In the medium to long term high temperatures and extended periods of dry weather and droughts could mean that farm businesses experience water shortages. This would disrupt all aspects of farm business from animal husbandry through to providing visitor accommodation. However on their own these impacts do not explain the extreme vulnerability farm businesses may experience with climate change. It is the multiplying effect significant non-climate related factors have on exacerbating the impacts of climate change that leads to there being an extreme risk. As mentioned in the risk assessment for the agro-pastoral farming system (most notably Active Commons) many farms in the National Park are dependent on agricultural support payments (received from CAP). Without this funding most farm businesses in the National Park become unprofitable (unless supplemented by significant diversified income streams). The UK government has pledged to replace CAP payments with a domestically funded scheme after leaving the EU. However it is likely this support

will not be in excess of what was received under CAP, and could for many farm businesses be a lot less if they fail to offer adequate public benefits. In this scenario farm businesses would have fewer resources with which to invest in climate change adaptation. Capacity to adapt to climate change is also eroded further by the aging demographic of farm business owners in the National Park and a lack of new entrants. Climate change will require farm businesses to adapt and be flexible in order to respond to a changing environmental context. Generally speaking it will be harder for an older demographic to adapt by learning new skills or taking different approaches.

The risk assessment did find that there are potential opportunities for farm businesses with climate change. Increased average annual temperatures, milder winters, extended growing season, increasing productivity with more palatable vegetation for livestock that will result on the whole with climate change, will increase the variety of products farm businesses can offer. However in order to take advantage of these opportunities it will require the restructuring of farm businesses. To do this farm business owners will need new and specific skills. At the current time with uncertainty around public sector funding for agriculture it is unsure what mechanisms will be in place to provide this training. This explains why the risk assessment only scored the potential opportunities climate change may have for farm businesses as low.

To understand the impact of climate change on the **Hospitality and Tourism sector** the risk assessment looked at a number of its different aspects which included **visitor accommodation**, **retail**, and **digital infrastructure**.

Similar to farm businesses the risk assessment found that **visitor accommodation** would likely experience both vulnerability as well opportunity with climate change. By looking at caravan and campsites specifically (a major form of visitor accommodation in the Lake District), in terms of vulnerability the risk was found to be moderate in the short term, rising to high in the long term. In the short to medium term caravan and campsites are vulnerable to flooding and damage from intense storms, particularly those sites that are situated close to water courses. In the long term, as mentioned for farm businesses, frequent severe droughts potentially could reduce the availability of clean drinking water and disrupt sanitation services. To balance the negative impacts of climate change on visitor accommodation, there is potential for climate change to bring about a number of opportunities for those offering caravan and camping facilities. This risk assessment found that although the level of opportunity was scored as low in the short term, as the National Park moves to a warmer climate, there are increased opportunities. If the climate change projections used in this report come to pass it is very likely that vacationing and holiday behaviour will change drastically. Traditional summer holiday destinations in Europe such as Spain and Southern France will become much too hot. The Lake District on the other hand would become an even more attractive holiday destination for both domestic and international visitors which business owners within the National Park could capitalise on.

These opportunities were also shown in the risk assessment to be shared by the **retail** component of the hospitality and tourism sector. Shops, cafes, restaurants would all benefit with more visitors coming to the National Park. However these benefits can only be realised if also the vulnerabilities that the risk assessment found that exist with climate change are addressed too. Although the risk assessment found the vulnerability in the short term is low, it increases to a moderate level in the medium to long term. The short to medium risk of greater flooding from the increased frequency of storm events is mitigated somewhat for the retail sector. Most town centres and premises are not in areas of flood risk which offers some protection. In addition there have been a number of schemes implemented already designed to build resilience into retailing. An example being the Keswick flood defence work which has been delivered to defend premises which include retail premises. However what arguably has not received as much planning and explains the moderate

vulnerability score in the medium to long term is how town centres and the retailing sector in the National Park will respond to periods of intense heat waves. Exposed areas with little shade could lead to uncomfortable conditions within towns and villages for consumers, and at worst lead to potential health complications such as heat stroke, particularly for vulnerable people such as children and the elderly. Exploration of how this could be mitigated against should be undertaken and there are ways this could be done that wouldn't detract from the historic character of towns and villages in the National Park (e.g. awnings, blinds, covered seating areas and trees).

The final component the risk assessment looked at that has relevance to the hospitality and tourism sector is **digital infrastructure**. As mentioned in section 3.2 the risk assessment found that digital infrastructure is relatively resilient to climate change impacts. Means of digital communication is now the dominant method people use to choose and make reservations at accommodation providers and places to eat. Therefore in order for the local economy in the National Park to benefit from the opportunities already mentioned for the hospitality and tourism sector from climate change, it is a positive that the ability to access broadband and 3g+ mobile network services will in general not be affected.

Workforce and employment

Local people having access to gainful employment and also the ability to be productive in these roles are key to a prosperous economy. To assess the impact of climate change on workforce and employment the risk assessment looked at how **working conditions** and the ability to be productive would be affected. The risk assessment also examined how the labour market would change by looking at the scale of opportunity for the "**Green Economy**" with employment in delivering micro-generation renewables.

The impact of climate change on **working conditions** has already been examined from the point of view of Vibrant Communities. It should be noted that this assessment only considers the working conditions of those occupations that are based indoors. There are also many roles and jobs within the National Park that are outdoor based and clearly these roles will also be affected by climate change (if not more so). However the Covid-19 pandemic has seen a large shift to home working, with National Park residents who would otherwise travel to offices outside of the National Park remaining at home. This is likely to become the norm in the coming years and therefore it is important to consider how climate change will impact on people's ability to be productive at home. As already mentioned the level of vulnerability of working conditions to climate change was found to be moderate across the short, medium and long term. The risk to productivity comes from climate change creating an environment within the home that is uncomfortable and disrupts people's ability to maintain concentration – either because the temperature is either too hot or too cold. In the future climate change has the potential to bring periods of extreme weather such as severe cold snaps, and particularly in the long term, extended periods of hot, dry weather. A large number of homes in the National Park are hard to heat, with some homes also difficult to keep cool in heat waves, this this could mean many people working at home could be exposed to these conditions, and work productivity suffer as a result.

Action on climate change, both mitigation and adaptation, is starting to be taken more seriously at each level of society, with the UK government declaring a climate emergency in 2019. There are increasing calls for a "green recovery" following the Covid-19 pandemic, with increased investment and resource to support decoupling economic growth from an increase in carbon emissions. A big part of this will have to be greater use of renewable energy. The risk assessment looked at the level of opportunity that climate change may have in supporting the growth of the **green economy** by appraising its influence on the expansion of **micro-generation renewables** in the National

Park. It was found that in the short term the level of opportunity directly associated with climate change was low, however in the medium to long term this would increase to a high level of opportunity. There is already considerable opportunity in the National Park for energy production from hydropower due to the amount of rivers and streams that can be used to install micro-hydroelectric plants. The only constraint is protected designations within the National Park, and the resource and inclination to install them. Therefore the part of climate change that will see increased volumes of rainfall in certain parts of the year will not likely make any difference to the level of opportunity for hydropower in the National Park. However the projections for climate change used in this report also show that by the 2070s the climate in the National Park will be a lot hotter and could see a 5^{o}C degree increase in average temperatures between June and July. With this in mind there could be an increasing opportunity for energy production from solar energy due to more sunny days with increased sunlight intensity than there is currently. Provided there is both local and national government support, the increasing opportunity over the medium to long term should benefit the National Park's economy by creating an industry of new jobs in the development and installation of renewable energy technologies.

Infrastructure and Travel

A functioning **transport network** (e.g. roads, rail, ferry/cruise services) is critical in allowing the movement of goods, people and skills which is important to every sector of the economy (e.g. agriculture, service industry, hospitality and tourism). The impact of climate change on both the land (roads and rail) and water (ferry/cruise services) transport network has already been discussed above for Vibrant Communities. As mentioned it was found that all transport infrastructure (both land and water) is highly vulnerable to climate change over the short, medium and long term. Although most transport infrastructure is under the responsibility of statutory authorities, some of it is owned by private businesses and when damage occurs from climate change insurance will only cover a like for like replacement. However the impacts of climate change are projected to get worse and require an increasing scale of adaptation and enhancement to ensure resilience. As the risk assessment found a significant degree of risk to the transport network in the short term, investment is required now to ensure disruption is kept to a minimum. Yet this may not be possible as businesses deal with a likely post-pandemic recession.

3.4 World Class Visitor Experience

For World Class Visitor Experience 3 assets and services were examined in the risk assessment; Access, Physical Experience and Cultural Experience.

Access

The National Park receives approximately 19 million visitors each year and for people to be able to come an enjoy it Access is critically important. In order to assess the impact of climate change on Access, the risk assessment examined its impact on **public footpaths and rights of way**, **places to stay**, as well as **transport services and infrastructure**.

In terms of **public footpaths and rights of way** the risk assessment found that there was a moderate level of vulnerability in the short term, rising to high vulnerability in the long term. Climate change was found to have a number of different impacts on public footpaths and rights of way which included;

- Erosion through more intense rainfall and flooding and surface flow as well as intense hotter drier summers leading to windblown erosion
- Wind Blown damage to path infrastructure that could occur with more intense storms

- Flooding/Waterlogging leading to wider paths and damage to walls and fences as walkers take detours. Threat to loss of ecologically sensitive areas and landscape aesthetics.
- At higher altitudes greater freeze/thaw events causing path surface to deteriorate rapidly.
- Reduced snow cover with milder winters may remove the winter insulation that binds the soil and vegetation making upland paths more susceptible to erosion.
- Wildfires may become more frequent in the summer which would lead paths needing to close more frequently for health and safety reasons.

It is expected that in the short term those climate change impacts related to precipitation will have most significance, while in the medium to long term they will combine with climate change impacts related to high temperatures such as wildfires and windblown erosion to have even greater effect. The cumulative effect of different climate change impacts over the short, medium and long term explains why there is an increasing level of vulnerability. A lot of work has been done in the National Park to improve path infrastructure to try and make it more resilient to climate change – instigated in the wake of the damage done by Storm Desmond in 2015. However these upgrades only cover a fraction of the National Park that will be affected by climate change. Concern was expressed in the risk assessment over the commitment for funding and resource to extend the scale of the upgrades across the entirety of the National Park. In addition it was even felt that the upgrades that have already been undertaken maybe offset by increased visitor numbers and greater erosion from footfall, as summers become warmer and drier and more people holiday in the Lake District. Being able to enjoy the landscape through walking and hiking is one of the mains attractions that draw visitors to the National Park and climate change has the potential to disrupt this, which will have consequences for both the visitor experience and the local economy.

Another key component of Access to the National Park is having a **place to stay** once visitors get there. The impact of climate change on places to stay has already been discussed in Prosperous Economy looking at Visitor Accommodation, specifically caravan and camp sites. As mentioned the risk assessment found that there will be both vulnerabilities and opportunities with climate change, which increases over the short, medium and long term. Putting the results of this risk assessment in the context of the World Class Visitor Experience element of the Vision, only the vulnerabilities of climate change are relevant though. The opportunities of climate change that had significance under Prosperous Economy such as a move to warmer climate increasing the number of domestic and international holiday visitors, actually have the potential to negatively impact World Class Visitor Experience, and exacerbate vulnerabilities. If there is less capacity within the Lake District to deal with an increased volume of visitors because there is less visitor accommodation available due to climate change related impacts (e.g. caravan and camp sites closed due to flooding or the damage from past flooding), further pressure will be put on the fewer sites that are left open. If this results in accommodation providers not being able to provide all the services visitors require to have a safe, enjoyable stay in the it will complicate the ability of the National Park to be an attractive visitor destination that is internationally respected.

The final component of providing Access to the National Park that was examined in the risk assessment was **Transport Services and Infrastructure**. The topography of the National Park is mountainous, interspersed with large bodies of water making the majority of the landscape remote and hard to get to. Therefore for visitors to be able to fully enjoy everything the National Park has to offer, it is crucial that the transport network is kept open and operating. The impact of climate change on Transport Services and Infrastructure has already been examined above under Vibrant Communities and Prosperous Economy by looking at both the water and land based transport network. As mentioned it was found that all transport infrastructure (both land and water) is highly vulnerable to climate change over the short, medium and long term. This will have significant consequences in terms of being able to maintain a world class visitor experience. Disruption to

ferry/cruise services potentially could lead to thousands of people a year missing out on quintessential “Lakes experiences” such as cruises on Lake Windermere and Ullswater. The Scafell massif popular with fell walkers, not least because it contains England’s highest mountain, is situated in the heart of the National Park and access routes to it most popular walks are particularly isolated. Damage to these access routes from climate change impacts could mean these key attractions become inaccessible.

Physical Experience

A major attraction of the National Park are the number of ways the landscape can be experienced physically; such as through swimming, hiking, running, cycling and climbing. The ability to undertake these activities not only has great benefits to physical health, but combined with being out in the natural environment can also have a profoundly positive effect on emotional health and mental wellbeing. By providing these services to the general public the National Park is of significant local, regional and national importance, and to evaluate how the impact of climate change will influence the ability of the National Park to continue to provide these services, the risk assessment looked at its impact on both **Recreational Activities**, as well as **access to “Green Spaces”**.

With respect to **recreational activities** in the National Park, the risk assessment found that there is likely to be a moderate level of vulnerability to climate change in the short term, which rises to a high level of vulnerability in the medium to long term. In the short term, footpaths and trails used for mountain biking, fell running and hiking are vulnerable to water erosion from a greater frequency of intense storms. As mentioned for Access above, the significant investment in upgrading paths and trails in the National Park following the damage from Storm Desmond may offset these impacts to some degree. However without further investment this will likely not keep pace with an increasing magnitude of impact in the medium to long term. In addition in the long term extended periods of hot, dry weather have the potential to lead to greater windblown erosion of paths, and the outbreak of fires could mean that visitors are prevented from accessing certain areas. In terms of water based recreational activities, there is vulnerability in particular from the effect that periods of hot dry weather can have on increasing the chance that algal blooms will result in rivers and lakes becoming temporarily hazardous to health. Although there is risk of this in the short term, it becomes a much more significant threat in the medium to long term where increased temperatures become the dominant driver of environmental change. The consequences of these impacts could mean that a large proportion of visitors whose primary reason for using the Lake District National Park is for physical activity start to use other parts of the UK whose landscape offer similar opportunities (e.g. mountainous areas of Wales and Scotland). This would have ramifications for the local economy. In addition to the loss of visitors to other parts of the UK, the cancellation of sporting events in the National Park due to climate change impacts would also adversely affect the local economy. There are already examples of this having occurred in the National Park. In 2010 the Great North Swim was cancelled due to health fears over an outbreak of blue-green algae. Cancellation of events like this would lead to the loss of significant sums of money as the hospitality sector (hotels, shops, restaurants) miss out on increased trade.

In terms of the ability to **access “green spaces”**, and through this the capacity of the National Park to offer people mental health benefits, the risk assessment found in the short term vulnerability to climate change should be low. Although access to some parts of the landscape may be interrupted more frequently due to an increase in more intense storms, this should only be temporary and last as long as the climate change related event. The significant investment in climate proofing trail and path infrastructure post storm Desmond should mean that extensive repairs that lead to restricted access for prolonged periods are avoided. The actual physical

experience that people have in the National Park's landscape is likely to remain the same in the short term. However the risk assessment found that in the medium to long term the level of vulnerability to climate change was very high. Although there has been investment to upgrade existing trail and path infrastructure, continuing upgrades will be needed to keep pace with increasingly severe impacts and it is unknown at this time whether commitment to make this investment will transpire. In addition in the medium to long term, periods of hotter drier weather will also lead to greater incidence of wildfires that will have a similar effect to the damage done by intense storms in leading to restrictions on which parts of the National Park can be assessed. A factor that will also have a significant effect in the long term in increasing the vulnerability of not being able to acquire mental health benefits from the National Park, is the impact climate change will have on changing landscape composition. Increased average temperatures will lead to a change in composition of plant and animal species, loss of iconic species, increase invasive non-native species and a greater variety and incidence of pest and diseases. This could move the National Park's "green spaces" away from subjective ideals, and rather than be sources of uplifting emotional benefit, they could become representations of decay and degradation that could trigger stress and anxiety for some people.

Cultural Experience

In addition to enjoying the benefits the natural landscape has to offer, a large draw for visitors to the National Park is its rich **cultural heritage** which includes its historic environment. Over the centuries the National Park has been the subject and inspiration for various literary and artistic movements. From poets and writers such as William Wordsworth and Beatrix Potter, to artists such as JMW Turner; all of whom have taken inspiration from the National Park's distinctive character which is a product of a harsh, isolated environment requiring local people to develop unique traditions, occupations and ways of life as a response. Visitors from all over the world come to the National Park to see where these literary/artistic figures lived and worked, and the landscapes and local communities which gave them inspiration. To assess what climate change will mean for the National Park's cultural heritage the risk assessment looked at its impact on the **Lake District World Heritage Site (WHS) designation,** as well as on distinctive character areas.

For the WHS designation the effect of climate change on each of its themes were examined; continuity of traditional agro-pastoralism (Theme 1), discovery and appreciation of a rich cultural landscape (Theme 2), and a model for protecting cultural landscape (Theme 3). The risk assessment found that in the short term the WHS scored as high vulnerability to climate change, but in the medium to long term this reduced to moderate vulnerability. In the short term the impacts of climate change were found to be largely confined to theme 1, where damage to physical infrastructure such as bridges, stone walls, and barns will disrupt land managers ability to carry out daily functions. In the medium to long term the agro-pastoral farming system will start to benefit from an extended growing season and increased productivity. However this has the potential to change land management practices (e.g. choosing less traditional breeds of livestock) which has negative implications for theme 1 of the WHS designation. In addition theme 2 will also be impacted by landscape aesthetics and character change, as species composition changes in response to an extended growing season and warmer temperatures. The biggest threat that the risk assessment found that is relevant to all themes (1, 2 and 3) of the WHS designation was the in-combination effect climate change would have with none-climate related factors. Farmers and land managers within the National Park are heavily dependent on economic support to remain viable businesses and its removal without a satisfactory substitute would be a disaster for farming in the National Park and WHS designation. For example the National Trust with its "landlord flocks" and 90 farms are important to sustaining the Herdwick Breed. However changes in farming economics due to subsidy changes could lead to increasing pressure to remove landlord flocks to

allow tenant farmers to make their farms viable. Without the compulsion of the landlord flock the survival of native breeds in the National Park (themes 1 of the WHS) would be under threat. The other major issue that is exerting pressure on the WHS designation, and could have an in-combination effect with climate change is an indirect consequence of climate change. It refers to the climate change adaptation and mitigation interventions (e.g. Natural Flood Management & increased tree planting) which although help the landscape respond to climate change can significantly impact on the cultural heritage of the National Park. Unsympathetic climate action can undermine the WHS designation by moving the National Park in a direction that is away from what it is trying to protect (e.g. river restoration works of historic water channels and afforestation in designed landscapes). This is an issue that is of current significance and explains why the vulnerability to climate change in the short term is higher than in the medium to long term. In the medium to long term it is hoped that the work currently underway by Lake District National Park Authority to establish agreement across all partners and organisations undertaking climate adaptation and mitigation works to take due consideration of WHS designation status (e.g. use of Heritage Impact Assessments) will have had its desired effect. The consequences for the National Park if the WHS designation remains vulnerable to climate change could mean that the National Park's World Class Visitor Experience is damaged. If climate change instigates changes to landscape character or to the agro-pastoral farming system, visitors arriving to the National Park may be disappointed to have a "Lake District Experience" that doesn't meet their expectations. At its worst climate change could mean a loss of WHS status if it is deemed the extent climate change has changed relevant features of the National Park means it can no longer represent the original WHS inscription definition. In either case as the WHS designation has become one of the reasons why a number of international visitors now choose to visit the National Park there could be some knock-on effect on the local economy.

Although briefly mentioned within the risk assessment on the WHS designation, the impacts of climate change on **landscape character** was also examined. To assess landscape character the risk assessment used one specific example of landscape character in the National Park, Area 22: Borrowdale Area of Distinctive Character. This area was chosen as it is iconic part of the National Park, representing and demonstrating many features that uniquely distinguish the English Lake District. The assessment found that in the short term landscape character was of low vulnerability to climate change, but the risk increased dramatically in the medium to long term to very high and extreme vulnerability respectively. In the short term there would be impacts such as flood and storm damage to historic stone walls and bridges, however these impacts would only be temporary changes to the National Park's aesthetics as they can be repaired and rebuilt provided the resources and motivation exist. However, in the medium to long term higher average temperatures with climate change will lead to a permanent change in the ecological conditions of the National Park that would see plant and animals species change as well as increased colonisation of none native invasive species. Once these changes occur there is nothing that can be done to rectify them, and would lead to a dramatic change in the character and aesthetics of the landscape. Although the risk assessment looked specifically at Area 22: Borrowdale Area of Distinctive Character, these results can be extrapolated to every distinctive character area of the National Park. As mentioned above landscape character is a significant component of the WHS designation and the consequences of climate change on it has ramifications for the WHS designation (e.g. the experience of the Lake District National Park not meeting visitors pre-conceived expectations) and benefits it brings to the local economy. It should be noted that the level of vulnerability for the WHS designation was scored lower than for landscape character in the risk assessments in the long term. However although landscape character is an important component of the attributes of OUV for the WHS, there also many other important components that make up the designation that might not be as badly affected as landscape character.

Result Tables

Spectacular Landscape (Wildlife and Cultural Heritage)

Table 7: Risk assessment results for Nature and Biodiversity asset (Spectacular Landscape)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Nature and Biodiversity	Arctic Alpines	Short	Possible	Likely	High	Moderate	Restricted	Medium Probability	High	High	Low	High	Moderate
		Medium	Likely	Very Likely	Very High	Very High	Extensive	High Probability	Very High *	Very High	None	Very High	Moderate
		Long	Very Likely	Very Likely*	Very High*	Very High	Very Widespread	High Probability	Very High *	Extreme	None	Extreme	Moderate
	Butterflies and Dragonflies (Northern range limit species	Short	Likely	Occasional	Likely	Moderate (+)	Restricted(+)	Unknown	Moderate (+)	High (+)	Moderate	Moderate	Moderate
		Medium	Very Likely	Frequent	Very Likely*	Moderate (+)	Localised (+)	Unknown	Moderate (+)	High (+)	Moderate	Moderate	Moderate
		Long	Very Likely	Impacting most years	Very Likely*	High (+)	Localised (+)	Unknown	High (+)	Very High (+)	Moderate	High	Moderate
	Butterflies and Dragonflies (Southern range limit species)	Short	Possible	Intermittent	Possible	Low (-)	Restricted (-)	Low Probability (-)	Low (-)	Moderate (-)	Moderate	Low	Moderate
		Medium	Likely	Frequent	Very Likely	Moderate (-)	Extensive (-)	Medium Probability (-)	High (-)	Very High (-)	Low	Very High	Moderate
		Long	Very Likely	Impacting most years	Very Likely*	Very High (-)	Very Widespread (-)	Medium Probability (-)	Very High (-)	Extreme (-)	None	Extreme	Moderate
	Cold Water Fish	Short	Likely	Frequent	Very Likely	Moderate	Localised	High Probability	Very High	Very High	Low	Very High	Moderate
		Medium	Very Likely	Impacting Most Years	Very Likely*	Very High	Extensive	High Probability	Extreme	Very High*	None	Extreme	Moderate
		Long	Very Likely	Impacting Most Years	Very Likely*	Very High	Very Widespread	High Probability	Extreme	Very High*	None	Extreme	Moderate
	Ancient Semi-Natural Woodland	Short	Possible	Occasional	Possible	Low (-)	Localised	Unknown	Very Low	Low (-)	Moderate	Low Vulnerability	High
		Medium	Likely	Frequent	Very High	Low (-)	Localised	Unknown	Low	Moderate (-)	Moderate	Low Vulnerability	High
		Long	Very Likely	Impacting most years	Very High*	Moderate (-)	Extensive	Unknown	High	Very High (-)	Low	Very High Vulnerability	High
	Multi-Purpose Forests	Short	Possible	Occasional	Possible	Low (+/-)	Very Widespread (+/-)	Unknown	Moderate (+/-)	Moderate (+/-)	Moderate	Low Vulnerability / Moderate Opportunity	High

													rtunity	
		Medium	Likely	Frequent	Very Likely*	Moderate (+/-)	Very Widespread (+/-)	Unknown	High (+/-)	Very High (+/-)	High	Moderate Vulnerability	Very High Opportunity	High
		Long	Very Likely	Impacting most years	Very Likely*	Moderate(+/-)	Very Widespread (+/-)	Unknown	High (+/-)	Very High (+/-)	High	Moderate Vulnerability	Very High Opportunity	High
* = Means score went above the category level. This is accounted for in final scores with an extra category added.														

Table 8: Risk assessment results for Agro-Pastoral Farming system asset (Spectacular Landscape)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity	Spatial Scale (Modifier)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects	Modified Sensitivity	Effect	Adaptive Capacity	Vulnerability	Confidence
Agro-Pastoral Farming System	Herdwick Sheep	Short	Unlikely	Intermittent	Unlikely	Very low (-)	N/A	Very unlikely (-)	Very Low (-)	Low (-)	High	Low	Low
		Medium	Possible	Occasional	Possible	Low (-)	N/A	Low probability (-)	Low (-)	Moderate (-)	Moderate	Low	Low
		Long	Likely	Occasional	Likely	Low (-)	N/A	Medium probability (-)	Moderate (-)	High (-)	Moderate	Moderate	Low
	Soil Health	Short	Likely	Occasional	Likely	Low	Localised	Low probability	High	High	None	High	Moderate
		Medium	Very likely	Frequent	Very Likely*	Moderate	Extensive	Medium probability	Very High	Very High	Low	Very High	Moderate
		Long	Very likely	Impacting most years	Very Likely*	High	Extensive	High probability	Very High	Very High	Moderate	Moderate	Moderate
	Upland hay meadows	Short	Possible	Intermittent	Possible	Very Low	Restricted	Low Probability	Very Low	Low	Moderate	Low	Moderate
		Medium	Likely	Frequent	Very Likely	Low	Restricted	Medium Probability	Moderate	High	Low	High	Moderate
		Long	Likely	Impacting	Very Likely	Moderate	Restricted	High Probability	High	Very High	None	Very High	Moderate
	Active Commons	Short	Possible	Occasional	Possible	Low	Localised	Very Unlikely	High (-)	High	High	Low (-)	Moderate
								Satisfactory ELMS*					
								High Probability	Low (-)	Moderate	None	High (-)	Moderate
								Unsatisfactory ELMS*					
		Medium	Possible	Frequent	Likely	Low	Localised	Low Probability	High (-)	High	Moderate	Moderate (-)	Moderate

								Satisfactory ELMS*					
								High Probability	Moderate (-)	High	None	High (-)	Moderate
								Unsatisfactory ELMS*					
		Long	Likely	Frequent	Very Likely	Low	Extensive	Low Probability	High (-)	High	Low	High (-)	Moderate
								Satisfactory ELMS*					
								High Probability	Moderate (-)	High	None	High (-)	Moderate
								Unsatisfactory ELMS*					

* = Means score went above the category level. This is accounted for in final scores with an extra category added.
*=Two scenarios for ELMS have been scored for Compounding effects as well as adaptive capacity. This is to recognise the importance of ELMS in influencing the resilience of Active Commons.

Table 9: Risk assessment results for Ecosystem services asset (Spectacular Landscape)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity	Spatial Scale (Modifier)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects	Modified Sensitivity	Effect	Adaptive Capacity	Vulnerability	Confidence
Ecosystem Services	Peatlands (Carbon Storage)	Short	Possible	Occasional	Possible	Moderate	Extensive	High Probability	Very High (-)	High (-)	Moderate	Moderate	Moderate
		Medium	Likely	Frequent	Very Likely	High	Extensive	High Probability	Very High (-)	Very High (-)	Low	Very High	Moderate
		Long	Very Likely	Impacting most years	Very Likely*	Very High	Extensive	High Probability	Extreme (-)	Extreme (-)	None	Extreme	Moderate
	Carbon Storage of Woodlands	Short	Unlikely	Intermittent	Unlikely	Very Low (-)	Restricted (-)	Low probability (-)	Very Low (-)	Low	Low	Low	High
		Medium	Unlikely	Occasional	Unlikely	Very Low (-)	Localised (-)	Low probability (-)	Low (-)	Low	Low	Low	High
		Long	Possible	Frequent	Likely	Very Low (-)	Localised (-)	Low probability (-)	Low (-)	Moderate	Low	Moderate	High
	Public Water Supply – Water Quality	Short	Very likely	Frequent	Extreme	Moderate (-)	Localised	High Probability	Very high (-)	Very high (-)	Moderate	Moderate	High
		Medium	Very likely	Occasional	Extreme	High (-)	Localised	High Probability	Extreme (-)	Extreme (-)	Moderate	High	High
		Long	Possible	Occasional	Possible	High (-)	Localised	High Probability	Extreme (-)	High (-)	Moderate	Moderate	High
	Public Water Supply – Water Quantity	Short	Very likely	Occasional	Very likely	Moderate (-)	NA	High probability	High	Very High (-)	High	Moderate	High
		Medium	Very likely	Occasional	Very likely	Moderate (-)	NA	High probability	High	Very High (-)	High	Moderate	High
		Long	Very likely	Frequent	Extreme	High (-)	NA	High probability	Very high	Very High (-)	High	Moderate	High

	Kendal Flood Risk	Short	Likely	Occasional	Likely	High (-)	Localised	Medium Probability	Very High (-)	Very High (-)	Low	Very High	High
		Medium	Likely	Occasional	Likely	High (-)	Localised	Medium Probability	Very High (-)	Very High (-)	Low	Very High	High
		Long	Likely	Occasional	Likely	High (-)	Localised	Medium Probability	Very High (-)	Very High (-)	Low	Very High	High
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 10: Risk assessment results for Historic Environment asset (Spectacular Landscape)													
Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity	Spatial Scale (Modifier)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects	Modified Sensitivity	Effect	Adaptive Capacity	Vulnerability	Confidence
Historic Environment	Archaeology on the High Fells	Short	Unlikely	Occasional	Unlikely	Very Low	Restricted	Low Probability	Very Low	Low	None	Low	High
		Medium	Possible	Occasional	Possible	Low	Localised	Medium Probability	Moderate	Moderate	None	Moderate	High
		Long	Possible	Frequent	Likely	Moderate	Localised	Medium Probability	High	High	None	High	High
	Archaeology in the floodplain	Short	Unlikely	Occasional	Unlikely	Moderate	Restricted	Medium Probability	High	Moderate	None	Moderate	High
		Medium	Possible	Occasional	Possible	Moderate	Localised	Medium Probability	High	High	None	High	High
		Long	Possible	Frequent	Likely	High	Localised	High Probability	Extreme	Very High	None	Very High	High
	Designed Landscapes – Trees and Plants	Short	Unlikely	Intermittent	Unlikely	Low	Restricted	Medium Probability	Moderate	Moderate	Low	Moderate	High
		Medium	Possible	Occasion	Likely	Moderate	Localised	High Probability	Very High	Very High	Low	Very High	High
		Long	Likely	Frequent	Very likely	High	Extensive	High Probability	Very High	Very High	Low	Very High	High
	Vernacular Landscape Features	Short	Possible	Occasional	Possible	Moderate (-)	Localised	High probability	Very high	High (-)	None	High	High
		Medium	Likely	Frequent	Very Likely	High (-)	Extensive	High probability	Very High*	Very high (-)	None	Very High	High
		Long	Very Likely	Impacting	Very Likely*	High (-)	Extensive	High probability	Very High*	Extreme (-)	None	Extreme	High
	Vernacular Bridges	Short	Possible	Impacting most years	Likely	High (-)	Extensive	Medium Probability	Very High*	Very high (-)	None	Very high	High
		Medium	Likely	Impacting most years	Very Likely	Very High (-)	Very Widespread	Medium Probability	Very High*	Very high (-)	None	Very high	High
		Long	Very Likely	Impacting most years	Very Likely*	Very High (-)	Very Widespread	High Probability	Very High*	Extreme (-)	None	Extreme	High

	Vernacular Buildings	Short	Unlikely	Impacting most years	Possible	Moderate (-)	Localised	High probability	Very high	High (-)	None	High	High
		Medium	Possible	Impacting most years	Likely	High (-)	Extensive	High probability	Extreme (-)	Very high (-)	None	Very High	High
		Long	Likely	Impacting most years	Very Likely	High (-)	Very widespread	High probability	Extreme (-)	Very high (-)	None	Very High	High
	Historic Quarrying / Mining sites	Short	Possible	Occasional	Very Likely	Moderate (-)	Localised (-)	High Probability (-)	Very High (-)	High (-)	None	High	Moderate
		Medium	Likely	Frequent	Very Likely*	High (-)	Localised (-)	High Probability (-)	Very High* (-)	Very high (-)	None	Very High	Moderate
		Long	Very Likely	Impacting Most Years	Very Likely*	Very High (-)	Extensive (-)	High Probability (-)	Very High* (-)	Extreme (-)	None	Extreme	Moderate
	Historical Coastal Assets	Short	Unlikely	Occasional	Unlikely	Low (-)	Localised	Low Probability	Moderate	Moderate	None	Moderate	Moderate
		Medium	Unlikely	Occasional	Unlikely	Moderate (-)	Extensive	Low Probability	High	Moderate	None	Moderate	Moderate
		Long	Possible	Frequent	Likely	High (-)	Very Widespread	Medium Probability	Very High	Very High	None	Very High	Moderate
	Woodland Archaeology	Short	Unlikely	Intermittent	Unlikely	Very Low	Restricted	Medium Probability	Low	Low	None	Low	Moderate
		Medium	Unlikely	Occasional	Unlikely	Very Low	Localised	Medium Probability	Low	Low	None	Low	Moderate
		Long	Possible	Occasional	Possible	Low	Localised	Medium Probability	Moderate	Moderate	None	Moderate	Moderate

Vibrant Community

Table 11: Risk assessment results for Community Functioning asset (Vibrant Community)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Community Functioning	High resilience towns and villages	Short	Likely	Occasional	Likely	High (-)	Very widespread (-)	Medium probability (-)	Extreme (-)	Very high (-)	Low	Very High	Moderate
		Medium	Very likely	Frequent	Extreme	Very High (-)	Very Widespread (-)	Medium probability (-)	Extreme (-)	Extreme (-)	Low	Very High	Moderate
		Long	Very likely	Frequent	Extreme	Very High (-)	Very Widespread (-)	Medium probability	Extreme	Extreme	None	Extreme	Moderate
	Low resilienc	Short	Likely	Occasional	Likely	Moderate	Restricted	Unlikely	Moderate	High (-)	High	Low	Moderate

	e towns and villages	Medium	Very Likely	Frequent	Extreme	High	Localised	Medium Probability	Very High	Very High (-)	Moderate	Moderate	Moderate
		Long	Very Likely	Frequent	Extreme	High	Localised	High Probability	Extreme	Extreme (-)	Moderate	High	Moderate
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 12: Risk assessment results for Households asset (Vibrant Community)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Households	Households at risk from flooding (except sea)	Short	Likely	Occasional	Likely	Moderate (-)	Localised (-)	Medium probability (-)	High (-)	High (-)	Low	High	Low
		Medium	Very Likely	Occasional	Very Likely	High (-)	Localised (-)	Medium probability (-)	Very High (-)	Very High (-)	Low	Very High	Low
		Long	Very Likely	Occasional	Very Likely	High (-)	Localised (-)	Medium probability (-)	Very High (-)	Very High (-)	Low	Very High	Low
	Households at risk of coastal flooding	Short	Likely	Occasional	Likely	Moderate	Localised	Unknown	Moderate (-)	High (-)	Moderate	Moderate	Low
		Medium	Likely	Occasional	Likely	Moderate	Localised	Unknown	Moderate (-)	High (-)	Moderate	Moderate	Low
		Long	Likely	Occasional	Likely	Moderate	Localised	Unknown	Moderate (-)	High (-)	Moderate	Moderate	Low
	Living and Working Conditions	Short	Possible	Occasional	Possible	Low (-)	Localised	Very unlikely/Unknown (-)	Low (-)	Moderate (-)	Low	Moderate	Low
		Medium	Possible	Occasional	Possible	Low (-)	Localised	Very unlikely/Unknown (-)	Low (-)	Moderate (-)	Low	Moderate	Low
		Long	Possible	Occasional	Possible	Low (-)	Localised	Very unlikely/Unknown (-)	Low (-)	Moderate (-)	Low	Moderate	Low
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 13: Risk assessment results for Infrastructure asset (Vibrant Community)													
Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Infrastructure	Land-based transport	Short	Very likely	Impacting most years	Extreme	Moderate (-)	Localised	Medium Probability	High (-)	Very High	Low	Very High	Low
		Medium	Very likely	Impacting most years	Extreme	High (-)	Extensive	High Probability	Extreme (-)	Extreme	Low	Very High	Low
		Long	Very likely	Impacting most years	Extreme	Very High (-)	Very Widespread	High Probability	Extreme (-)	Extreme	Low	Very High	Low
	Water Based Transport	Short	Very Likely	Occasional	Very Likely (-)	Moderate (-)	Localised	Low Probability	High (-)	Very High (-)	Low	Very High	Low
		Medium	Very Likely	Frequent	Extreme (-)	High (-)	Extensive	Low Probability	Very High (-)	Very High (-)	Low	Very High	Low
		Long	Very Likely	Impacting most years	Extreme (-)	Very High (-)	Very Widespread	Medium Probability	Extreme(-)	Extreme (-)	Low	Very High	Low
	Digital Infrastructure	Short	Very Unlikely	Intermittent	Very unlikely	Very low	Restricted	Very unlikely	Very Low (-)	Low (-)	Low	Low	Low
		Medium	Very Unlikely	Occasional	Very unlikely	Low	Restricted	Very unlikely	Low (-)	Low (-)	Low	Low	Low
		Long	Unlikely	Occasional	Unlikely	Low	Localised	Very unlikely	Low (-)	Low (-)	Low	Low	Low
	Community Buildings	Short	Possible	Occasional	Possible	Low (-)	Localised (-)	Low Probability (-)	Moderate (-)	Moderate (-)	Moderate	Low	Low
		Medium	Possible	Occasional	Possible	Low (-)	Localised (-)	Low Probability (-)	Moderate (-)	Moderate (-)	Moderate	Low	Low
		Long	Possible	Occasional	Possible	Low (-)	Localised (-)	Low Probability (-)	Moderate (-)	Moderate (-)	Moderate	Low	Low
	Private Water Supplies	Short	Unlikely	Occasional	Unlikely	Low (-)	Localised (-)	Low Probability (-)	Low Probability (-)	Moderate	None	Moderate	Low
		Medium	Unlikely	Occasional	Unlikely	Low (-)	Localised (-)	Low Probability (-)	Moderate (-)	Moderate	None	Moderate	Low
		Long	Possible	Occasional	Possible	Low (-)	Localised (-)	Low Probability (-)	Low Probability (-)	Moderate	None	Moderate	Low
	Public Water Supply	See Ecosystem services under water quality and water quantity											
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Prosperous Economy

Table 14: Risk assessment results for Key Sectors (Prosperous Economy)																								
Asset	Indicator	Time Frame	Exposure		Temporal scale (Modifier)	Modified Exposure		Sensitivity (+/-)		Spatial Scale (Modifier) (+/-)		Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)		Modified Sensitivity (+/-)		Effect (+/-)		Adaptive Capacity		**Vulnerability** / Opportunity		**Confidence**
Key Sectors	Agriculture - Farm Businesses	Short	Likely (-)	Possible (+)	Occasional (+/-)	Possible	Likely	Moderate (-)	Low (+)	Restricted (-)	Restricted (+)	High probability (-)	Unknown (-)	High (-)	Low (+)	High (-)	Moderate (+)	Low (-)	None (+)	High	Low	Low
		Medium	Very likely (-)	Likely (+)	Frequent (+/-)	Very likely	Very Likely*	High (-)	Moderate (+)	Extensive (-)	Localised (+)	Medium probability (-)	Unknown (-)	Extreme (-)	Moderate (+)	Extreme (-)	High (+)	None (-)	None (+)	Extreme	Low	Low
		Long	Very likely (-)	Very likely (+)	Impacting most years (+/-)	Very likely*	Very Likely*	Very High (-)	Moderate (-)	Very Widespread (-)	Localised (+)	Medium probability (-)	Unknown (-)	Extreme (-)	Moderate (+)	Extreme (-)	High (+)	None (-)	None (+)	Extreme	Low	Low
	Hospitality and Tourism – Visitor Accommodation	Short	Possible		Intermittent	Possible		Low (-)	Low (+)	Restricted (-)	Localsied (+)	Low Probability	Low Probability	Low (-)	Moderate (+)	Moderate (-)	Moderate (+)	Low (+/-)		Moderate	Low	Low
		Medium	Likely		Occasional	Likely		Low (-)	Moderate (+)	Restricted (-)	Extensive (+)	Medium Probability	Medium Probability	Moderate (-)	Very High (+)	High (-)	Very High (+)	Low (+/-)		High	Moderate	Low
		Long	Likely		Occasional	Likely		Low (-)	High (+)	Restricted (-)	Extensive (+)	Medium Probability	Medium Probability	Moderate (-)	Fantastic (+)	High (-)	Very High (+)	Low (+/-)		High	Moderate	Low
	Hospitality and Tourism - Retail	Short	Very unlikely		Occasional	Very unlikely		Very Low (-)	Low (+)	Restricted (-)	Restricted (+)	Low Probability (-)	Low Probability (+)	Low (-)	Very Low (+)	Low (-)	Low (+)	Low		Low	Low	Low
		Medium	Unlikely		Frequent	Possible		Low (-)	Moderate (+)	Localised (-)	Localised (+)	Medium Probability (-)	Medium Probability (+)	Moderate (-)	Moderate (+)	Moderate (-)	High (+)	Low		Moderate	Moderate	Low
		Long	Unlikely		Impacting Most years	Possible		Low (-)	Moderate (+)	Localised (-)	Localised (+)	Medium Probability (-)	Medium Probability (+)	Moderate (-)	Moderate (+)	Moderate (-)	High (+)	Low		Moderate	Moderate	Low
	Hospitality and	Short	Very Unlikely		Intermittent	Very unlikely		Very low		Restricted		Very unlikely		Very Low (-)		Low (-)		Low		Low		Low

	Tourism – Digital Infrastructure	Medium	Very Unlikely	Occasional	Very unlikely	Low	Restricted	Very unlikely	Low (-)	Low (-)	Low	Low	Low
		Long	Unlikely	Occasional	Unlikely	Low	Localised	Very unlikely	Low (-)	Low (-)	Low	Low	Low
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 15: Risk assessment results for Workforce and employment asset (Prosperous Economy)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Workforce and employment	Working Conditions	Short	Possible	Occasional	Possible	Low (-)	Localised	Very unlikely/Unknown (-)	Low (-)	Moderate (-)	Low	Moderate	Low
		Medium	Possible	Occasional	Possible	Low (-)	Localised	Very unlikely/Unknown (-)	Low (-)	Moderate (-)	Low	Moderate	Low
		Long	Possible	Occasional	Possible	Low (-)	Localised	Very unlikely/Unknown (-)	Low (-)	Moderate (-)	Low	Moderate	Low
	Micro-generation renewables	Short	Possible	Frequent	Likely	Low	Localised	Medium Probability	Moderate	Moderate	Low	Low	Low
		Medium	Likely	Frequent	Very Likely	High	Extensive	Medium Probability	Very High*	Very High	Low	Moderate	Low
		Long	Very Likely	Impacting most years	Very Likely*	Very High	Extensive	Medium Probability	Very High*	Fantastic	Low	High	Low
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 16: Risk assessment results for Infrastructure and Travel asset (Prosperous Economy)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Infrastructure and Travel	Land-based transport	See Infrastructure under Vibrant Community Assets											

	Water Based Transport	See Infrastructure under Vibrant Community Assets
* = Means score went above the category level. This is accounted for in final scores with an extra category added.		

World Class Visitor Experience

Table 17: Risk assessment results for Access asset (World Class Visitor Experience)

Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Access	Footpaths and rights of way	Short	Very Likely	Occasional	Very Likely	Moderate	Localised	Medium	Very High	Very High	High	Moderate	Moderate
		Medium	Very Likely	Frequent	Very Likely (Level 5)*	High	Extensive	Medium	Very High*	Extreme	Low	High	Moderate
		Long	Very Likely	Frequent	Very Likely (Level 5)*	High	Extensive	High	Very High*	Extreme	Low	High	Moderate
	Places to stay	See Visitor Accommodation under Prosperous Economy											
	Transport services and infrastructure	See Land based and water based transport networks under Vibrant Communities											
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 18: Risk assessment results for Cultural Experience asset (World Class Visitor Experience)													
Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Cultural Experience	Lake District World Heritage Site	Short	Very likely	Occasional	Very Likely	Low (-)	Restricted	High Probability (-)	Moderate (-)	High (-)	Low	High	Low
		Medium	Very likely	Frequent	Extreme	High (-)	Localised	Medium Probability (-)	Very High (-)	Very High (-)	Moderate	Moderate	Low
		Long	Very likely	Impacting most years	Extreme	High (-)	Extensive	Unknown	Very High (-)	Very High (-)	Moderate	Moderate	Low
	Landscape Character	Short	Likely	Occasional	Likely	Low (-)	Localised	Medium probability	Moderate	High	High	Low	Low
		Medium	Likely	Frequent	Very likely	High (-)	Extensive	Medium probability	Very High*	Very High	Low	Very high	Low
		Long	Very Likely	Impacting most years	Very likely*	Very High (-)	Very widespread	Medium probability	Very High*	Extreme	None	Extreme	Low
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

Table 19: Risk assessment results for Physical Experience asset (World Class Visitor Experience)													
Asset	Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
Physical Experience	Recreational Experience	Short	Possible	Intermittent	Possible	Very Low	Localised	Medium probability	Low	Moderate (-)	Low	Moderate	Low
		Medium	Likely	Occasional	Likely	Low	Localised	Medium probability	Moderate	High (-)	None	High	Low
		Long	Likely	Occasional	Likely	Moderate	Localised	Medium probability	High	High (-)	None	High	Low
	Green spaces and mental health	Short	Likely	Occasional	Likely	Low (-)	Restricted	Low probability	Low	Moderate (-)	Moderate	Low	Low
		Medium	Likely	Frequent	Very Likely	Moderate (-)	Localised	Medium probability	High	Very High (-)	Low	Very high	Low
		Long	Likely	Frequent	Very Likely	High (-)	Extensive	High probability	Very High	Very High (-)	Low	Very High	Low
* = Means score went above the category level. This is accounted for in final scores with an extra category added.													

4 What does climate change mean for the strategic challenges of the Lake District National Park Partnership's Plan

At the start of this report it was stated that there are three parts to Climate Change Adaptation Reporting; Gather Evidence, Risk Assessment, and Action Planning. Using the latest evidence and projections this report has shown what climate change and resultant environmental change could mean for the National Park in the short, medium and long term. It has identified a range of assets and services considered of value in the National Park; and has presented the results of the risk assessments that have analysed the level of vulnerability and or opportunity assets and services would experience in the short, medium and long term if exposed to the projected climate and environmental change in the National Park. The purpose of the final part of the process, Action Planning, is to detail how those areas of vulnerability and or opportunity in the National Park can be either made more resilient, or be appropriately equipped to take advantage of the opportunities climate change will offer. Although the scope of this report only goes as far as the first two parts of this process, the results that have been presented should provide an evidence base and steer for those means that can coordinate resource and plan and initiate interventions that deliver action on climate change.

One of those means is the Lake District National Park Partnership's Plan (LDNPP). The LDNPP is the core mechanism that the National Park Authority and its partners use to deliver the Vision. It is a key strategic document that identifies issues, risks and threats to the National Park's Special Qualities and Outstanding Universal Value of the WHS, and within its strategies, actions, and research framework provide an appropriate response to address or mitigate these. The impact of climate change, as this report has shown, will influence each and every area within the scope of the LDNPP and reaffirms the necessity of integrating the results of this report within the new iteration of LDNPP for 2020-2025.

To assist with this integration this report has looked across all of the risk assessments in the context of the five Strategic Challenges identified in the new plan for the National Park (see 1.10), as well as the World Heritage Site Designation, and developed a number of key messages. This was done in collaboration with the lead authors for each of the strategic challenges who have then used the key messages for objective setting in the LDNPP.

This report now presents the key messages for each challenge area, and represents a synthesis of results for all relevant risk assessments.

4.1 Strategic Challenge: Future of Farming and Forestry, Climate Change and Nature Recovery

To explain the strategic challenge around the Future of Farming, Climate Change and Nature Recovery, the following excerpt has been taken from the Partnership's Plan Strategic Challenge document.

"The Lake District's natural and cultural assets and good farming and forestry, deliver a range of benefits to people, including high quality food, wood products, wildlife, drinking water, water flow management, carbon storage, access and recreation, health and wellbeing, distinctive and beautiful landscapes, and a sense of place. To secure a sustainable future for the Lake District, its people and economy, visitors and wider society an integrated approach to change for farming and forestry, nature recovery, Net Zero greenhouse gas emissions and adaptation to climate change is essential. Key to managing the Lake District National Park's special qualities and World Heritage attributes of outstanding universal value is to ensure that:

- *our traditional hill livestock farming system sustains its authenticity*

- *farming and forestry adapt to new challenges and opportunities*
- *our habitats and species urgently recover*
- *Farming, forestry and nature, working together, reduce Greenhouse Gas emissions and store more carbon*
- *Farming, forestry and nature become more resilient to the impacts of Climate Change and help mitigate the impacts of Climate Change"*

From looking across each of the risk assessments that has relevance to this strategic challenge the following key messages were synthesised with respect to the vulnerabilities and opportunities this strategic challenge will face in the short, medium and long term.

Future of farming and forestry key messages

- An extended growing season and warmer temperatures offer opportunity to increase productivity and diversify products in the long term.

- More focus is needed on improving soil health and making soil more resilient to extreme weather events (e.g. intense rainfall) so that these benefits can be realised.

- Traditional model of farming in the Lake District is potentially vulnerable to change as a warming climate provides farmers with more options (e.g. other livestock breeds).

- Action/working within the farming sector is central to climate change adaptation, and ensuring all aspects of the National Park are resilient to climate change.

- Functions of Active Commoning (e.g. cultivation of semi natural habitats, production of native breed livestock) are relatively resilient to the direct impacts of climate change – although aesthetics would change which may have a cultural impact. However this is predicated on continued agricultural management of the Commons going forward, which will depend on the amount of the agricultural support farms and land managers receive once the UK leaves the Common Agricultural Policy.

- There is a significant in-combination effect between the financial viability of agricultural businesses and climate change. An unsatisfactory outcome of ELMS (forthcoming domestic agricultural support scheme) in terms of its coverage (the amount of farmers/land managers eligible) as well as the extent of support (£S paid) will exacerbate vulnerability to climate change impacts and negate the ability to take advantage of its opportunities.

- Farming in the Lake District is vulnerable from secondary effects of climate change impacts at larger geographic scales (e.g. changing global land use patterns - supply and demand).

- Landscape monitoring (i.e. species abundance, representation, composition and phenological processes) of the National Park will be key to ensure effective continued management of Farming and Forestry as the climatic and environmental context changes. It will play a key role in maximising productivity as well as identifying threats and stressors (e.g. Invasive Non Native Species) and thus be important in informing remedial action.

Nature Recovery key messages

- Cold adapted species at the edge of their climatic space in the National Park will be pushed out in the long term.

- Resilience of the natural environment to climate change requires adoption of interventions at a landscape scale.

- Ensure habitat permeability and connectivity with landscapes outside of the National Park so that more southerly distributed species (currently) can colonise as the environment becomes more favourable.

- We have chosen a small number of indicators. Cold water fish have come out as highly vulnerable – this is likely to be indicative of wider scale risk to lakes.

- Non-climate related pressures on the natural environment exert strong in-combination effect with climate change. For example, water quality pressures. Targeted interventions could lead to quick wins.

- Threat of pests and diseases and non native invasive species will become even more acute in the future.

- Should this influence priorities for nature recovery networks?

Climate change key messages (public benefits from landscape)

- Climate change has the potential to increase the National Park's carbon emissions (e.g. through soil erosion, decomposition of organic matter) and reduce its carbon storage capacity.

- Actions on climate change adaptation (e.g. tree planting, regenerative grazing, peatland restoration) can minimise the negative consequences of climate change (e.g. flooding) while increasing carbon storage and limiting emissions. A clear link between adaptation and mitigation, but as seen below care is needed on how this interacts with the cultural landscape.

- To successfully and effectively build resilience to climate change action cannot be piecemeal. It requires systemic change at a landscape scale, with widespread coordinated adoption of interventions e.g. natural flood management.

- Actions on climate change adaptation requires foresight. Planning needs to be done with a view to how the future will be, not how the present is (e.g. tree planting with species of more southerly provenances) to make the best long term solutions.

- Actions to buffer resilience to certain assets may increase vulnerability in others e.g. peatland restoration and afforestation and the historic nvironment and cultural heritage. Actions need to be measured and have carefully considered other interests in their planning and formulation (e.g. consultation with, and use of published guidelines from relevant responsible bodies).

- The National Park is not an island. Action on climate change adaption within the National Park is critically important to features outside of the National Park (e.g. reducing flood risk to towns and villages, ensuring landscape connectivity and permitting new species to colonise the National Park)

4.2 Strategic Challenge: Sustainable Transport

To explain the strategic challenge around Sustainable Transport the following excerpt has been taken from Partnership's Plan Strategic Challenge document.

"Covid-19 has had a devastating effect on the community and economy of the Lake District, and the immediate priority is one of recovery. To support vibrant communities, action is needed to encourage the return of customers to businesses, and we must accept that visitors and communities will for some time be nervous about travelling by public transport and lift-sharing, so the private car is likely to be the travel mode that most visitors choose in the short term. One of the few positive experiences of the Covid-19 lockdown was that more people have enjoyed cycling and walking more, and many people discovered, or rediscovered the health and wellbeing benefits of cycling, walking and horse riding on quiet roads and the air quality and quality of life improvements where traffic is reduced. The Partnership now has a unique opportunity to work together to ensure some of these benefits can continue to be experienced through a 'green recovery', attracting new visitors to the Lake District to undertake quiet and healthy recreation".

From looking across each of the risk assessments that has relevance to this strategic challenge, the following key messages were synthesised with respect to the vulnerabilities and opportunities this strategic challenge will face in the short, medium and long term.

Sustainable Transport key messages

- The ability to deliver sustainable transport in the Lake District National Park is highly vulnerable to the impacts from climate change.
- Although impacts such as increased temperatures from climate change will be of significance, particularly in the long term, events related to increased precipitation (both volume and intensity) will have the strongest impact in the Lake District.
- The impacts of climate change on sustainable transport are already being seen with key infrastructure being affected such as roads and bridges (e.g. Storm Desmond).
- Impacts on key infrastructure will become more frequent and at an increasingly larger scale over the next 50 years.
- Roads and bridges (which includes historic landscape features in the National Park) will be vulnerable to damage from both one off events and repeated exposure (e.g. high intensity rainfall events); piers and jetties may become inaccessible due to extreme variations in water levels disrupting water transport routes
- Unpredictable weather patterns could mean that campsites and overflow carparks on grass fields could become flooded and unable to be used at busy times of the year. This could generate greater anti-social behaviour such as non-regulated parking and fly camping which would impact on natural, historic and cultural environment, and also lead to tensions with the local community. It could also incentivise tarmacking of these areas which would exacerbate flood risk further.
- Interventions to build resilience into transport infrastructure exist but are costly.
- This could lead to delays in repair and long term disruption that extend way beyond climate impacts which for transport will relate to one-off temporary events rather than systemic change brought by climate change.

- Repair of some transport infrastructure falls on the private sector (Lake Cruise Operators). Although important, investment in upgrading infrastructure to make it climate resilient may not be possible in the short term as businesses deal with the post-pandemic recession.

- The impacts of climate change on transport will be localised to susceptible areas. For example single roads located in steep narrow valley or floodplains, or cruise and ferry operations on lakes where there other pressures (water extraction) exacerbating climate impacts e.g. drought.

- The scale of consequence is also highly localised with isolated communities that rely on limited transport links at risk of being cut off.

- This could mean the distance people travel increases within the Lake District either because community residents have to use alternative routes to access essential resources such as hospitals, supermarkets, or similarly visitors will travel more if remote "honey pot" sites are affected.

- Digital infrastructure (e.g. broadband, wireless and mobile network technology) will be largely unaffected by climate change impacts. Increasingly more effective and efficient digital connectivity may offset some of the impacts above as more residents with the Lake District work from home and travel less.

- In addition the ability to work from hotels, holiday cottages and B&Bs could mean more multi-day trips to the Lake District than single day trips. This could make it easier to encourage the greater use of public transport to the Lake District rather than cars.

- However the impacts of climate change on the transport network outside of the National Park (e.g. disruption to major rail networks) could mean more people arrive by car

- Encouraging even greater participation in low carbon activities such as mountain biking, open water swimming, fell running, hiking and canoeing will be key to delivering a model for sustainable transport in the Lake District. However increased frequency of algal blooms in rivers and lakes, greater water erosion of trails and rights of way, and outbreak of wildfires may limit how frequently people can participate in these "green" activities which may lead people to choose to travel further to enjoy these activities, or choose alternative less carbon friendly ways of enjoying the Lake District.

4.3 Strategic Challenge: Vibrant Community and Prosperous Economy

To explain the strategic challenge around Vibrant Community and Prosperous Economy the following excerpt has been taken from the Partnership's Plan Strategic Challenge document.

"Lake District's rural communities face a number of challenges. Whilst high visitor numbers can benefit communities, such as introducing some more public transport options to an area which would not otherwise be available and creating significant local jobs, the popularity of the Lake District can adversely impact on communities. It creates pockets of ***acute pressure for local housing*** *for example, pushing prices up significantly. In some communities, the lack of homes in permanent occupancy is affecting the viability of local services such as schools and GP surgeries.*

Many local people are being forced to move to another part of the county or further afield due to the lack of suitable, affordable housing and the consequent ***changing age structure*** *of the population presents a risk to the long term future of rural communities in the Lake District.*

*For communities and the economy to prosper, people of working age need to be able to easily access **suitable employment**, including professional and skilled roles. There is an urgent need to attract labour to Cumbria. As well as building a strong visitor economy, we need to enable a diverse range of business opportunities including working from home, and access to superfast broadband and good mobile phone coverage is fundamental to achieving this. Community and businesses will also need to adapt to the changing climate and be effective in reducing greenhouse gas emissions".*

From looking across each of the risk assessments that has relevance to this strategic challenge, the following key messages were synthesised with respect to the vulnerabilities and opportunities this strategic challenge will face in the short, medium and long term.

Community key messages

- Climate change will affect communities differently within the Lake District depending on their characteristics. Those communities that have multiple transport links, a balanced age structure, a vibrant community spirit, and active volunteer sector trained how to deal with community disruption (flood events related to climate change) are more resilient to climate change than those that don't.

- Vulnerable populations (elderly, disabled) will be disproportionately affected by climate change impacts. They are not likely to be able to respond effectively to storm events and flooding in the short to medium term, and suffer the most from the health implications of periods of intense summer heat waves. Without members of the community that are able to respond and who are willing to support vulnerable populations, this risk is exacerbated.

- Road networks and ferry and lake cruise routes are vulnerable to damage and disruption from climate change. Communities are at risk of being cut off from essential services such as hospitals, supermarkets, and doctor surgeries. This risk is particularly emphasised for the many isolated communities in the Lake District.

- Existing properties in the Lake District that are located in a functional floodplain or within a high flood risk area need to be appraised as to whether they can be adapted to become flood resilient. There is limited provision for new housing in the Lake District so it is essential that efforts are focused on making existing housing stock fit for purpose and climate resilient.

- A large number of properties in the National Park do not perform to the highest energy efficiency standards and will cost more to heat. In the context of climate change this will have implications for living conditions and public health due to complications associated with excess cold, dampness and extreme heat.

- In addition many community buildings (churches, town halls) also fall into this category. If they are not invested in and made more climate resilient there is a high risk that they may fall into disuse. For rural communities (isolated one in particular) this has implications for community spirit (and thus resilience) as these buildings are key hubs which communities can come together and organise.

- There is an increasing risk to coastal communities in the National Park from sea erosion and flooding and this is recognised with a number of plans and strategies in place to mitigate this risk as much as possible.

- Extended periods of limited rainfall in the summer in recent years has flagged up a potential vulnerability of households on private water supplies in the National Park. Since hotter, drier summers in the long term will become more significant and the fact there are a number of communities in the Lake District on private water supplies, more research is needed into the scale of the impact and what can be done.

Economy

- Loss of key infrastructure associated with land and water based transport routes from damaging climate change effects (e.g. road and bridge closures, low water levels and access to piers and jetties) has the potential to cut off supply lines and sever businesses from their customers.

- There will be both positive and negative effects in the agricultural sector from climate change.

- Positive effects include a longer growing season, and increased biological productivity (e.g. more palatable grasses) increasing the options available to farmers. This will include greater diversity of agricultural options for farmers (e.g. ability to rear more productive breeds of lowland sheep) as well as enable them to provide more public benefits (e.g. woodland creation).

- However to take advantage of new opportunities farmers require training to understand how to recognise these opportunities and restructure their businesses in a changing climate. This remains a gap.

- Without interventions the negative impacts from climate change on farm businesses outweigh the positive effects. Farm businesses are highly vulnerable to climate change and this risk increases over the short, medium to long term. Intense storms will damage farm infrastructure limiting productivity and disrupt diversified income streams; milder winters and hotter summers will increase the disease risk to livestock as well as potentially reducing fertility due to water stress.

- This has the potential to increase emotional stress within the farming community affecting physical and mental health. Support should be made available to help farmers/land managers prepare and adapt farms to make them more climate resilient in the first instance, as well as providing assistance after damage and disruption from climate change has taken place.

- Uncertain agricultural support schemes, aging demographics, and a changing global economy will all act in combination with climate change to elevate the vulnerability of farm businesses in the Lake District.

- Inefficient housing stock that is not resilient to the impacts of climate change could mean that the resultant difficult living and working conditions could stifle labour productivity if more people are working from home.

- Digital infrastructure will largely be unaffected by climate change. It should be expanded as it will help support the economy, help meet net zero targets, and make communities and their businesses (particularly isolated ones) more resilient to the impacts of climate change.

- On balance climate change will bring benefits to the visitor economy in the National Park. A warmer climate overall in the Lake District will likely see more people vacationing here rather than traditional places currently such as Southern Europe. However planning needs to be put in place to ensure that infrastructure is adequate to deal with increased visitor pressure and that it is well equipped to deal with both one off and long term climate shocks.

- Climate change will generate new jobs in the green economy with great opportunities for the Lake District to become a national leader in delivering micro-renewable energy projects, land management that works for nature and agriculture, sustainable tourism and transport.

4.4 Strategic Challenge: Lake District for Everyone

To explain the strategic challenge around Lake District for Everyone, the following excerpt has been taken from Partnership's Plan Strategic Challenge document.

"National Parks contain the most beautiful, spectacular and dramatic areas of countryside in England. They are landscapes of national importance and their designation gives them the highest status for the conservation of landscape and scenic beauty. They also contain fantastic opportunities for recreation, and millions of visitors enjoy these health and wellbeing benefits and their special qualities every year.

The Government recently commissioned the Landscapes Review Final Report 2019 (Glover Review) which highlighted these places as national assets supported in part through state funding and therefore are available for everyone to enjoy. However the report highlighted "Most visits are made by the same (better off, less diverse) people repeatedly, and those who miss out are the older, the young – especially adolescents – and those from lower socio-economic groups and black, Asian and minority ethnic communities". This is therefore a key challenge identified by the Government which the Partnership should be seeking to address by responding to the proposals outlined in the Landscapes Review Final Report considering both residents and visitors (whom may be Cumbrian day trippers, north west/east regional visitors, national visitors, and international visitors)".

From looking across each of the risk assessments that has relevance to this strategic challenge, the following key messages were synthesised with respect to the vulnerabilities and opportunities this strategic challenge will face in the short, medium and long term.

Lake District for Everyone key messages

- The wealth of opportunities in the Lake District for outdoor pursuits is an asset the National Park can use to attract a greater proportion of younger visitors. However climate change has the potential to diminish availability of these opportunities. Warmer temperatures will increase algal blooms of rivers and lakes and lead to more outbreaks of wildfire and increased rainfall intensity could lead to further water erosion of trails and rights of way – limiting or temporarily disrupting activities in the Lake District such as wild swimming, mountain biking, hiking and rock climbing.

- Climate change will lead to much more extreme weather. This may mean higher grade, or more specialist equipment is needed more often to enjoy the Lake District landscape. This equipment can be expensive and discourage low income groups from visiting the National Park (using landscape more focused into narrower seasons – which may exacerbate erosion, congestion).

- Climate change will generate new jobs in the green economy with great opportunities for the Lake District to become national leaders in delivering micro-renewable energy projects and sustainable retrofitting of existing buildings. In the future new skills will be required to meet this need and provide a way for greater parts of society to involve themselves with the National Park.

- A warmer climate with climate change will make the National Park a much more popular holiday destination for people for all parts of society, both nationally and internationally. This could put strain on the relationship between visitors and local communities if visitors are not sympathetic, or understand local customs and traditions (e.g. following the Countryside Code).

- In addition if there are more visitors it will lead to much more waste in the National Park (e.g. food waste). Thought needs to be put into how the National Park processes this waste – move to a circular economy?

- As average temperatures in the United Kingdom become warmer over the next 50 years, pest and diseases as well as non native invasive species, currently confined to more southern limits, will have greater ability to spread and establish themselves in the Lake District National Park. Increased number of new visitors into the National Park have the potential to exacerbate this risk.

- Climate change will make the natural environment in the Lake District much more sensitive to disruption. An increase in the number of visitors to the National Park that don't have the knowledge or awareness of how to sympathetically enjoy the landscape can lead to acceleration of negative processes associated with climate change.

- Roads and rail networks will be impacted by greater frequency of high intensity storm events and in the medium to long term from severe heat waves. Water based cruise and ferry routes will be disrupted by variable water levels with both periods of too much and too little water. The cost of repair, as well as upgrades to make transport more climate resilient could be passed on to transport users which may make travel to the Lake District more expensive influencing who can come and enjoy the Lake District.

- Action to adapt and build resilience to climate change requires interventions at a landscape scale. In some instances this requires a lot of physical labour such as large scale tree planting. This could provide volunteer opportunities for groups who don't usually visit the National Park to get involved. This could be done through either outreach to schools in deprived areas, or through corporate social responsibility initiatives.

4.5 Strategic Challenge: Climate Action

To explain the strategic challenge around Climate Action – Achieving Net Zero the following excerpt has been taken from Partnership's Plan Strategic Challenge document.

"Globally and nationally our response to addressing climate change has not been adequate. In the Lake District we have developed and reported on a carbon budget for more than 10 years which has enabled us to track carbon savings we have made through habitat restoration, greener land management practices, and sustainable travel initiative etc. However despite these savings, each year we have consistently failed to meet the carbon savings targets that we have set. The cost of

our inaction has meant we are already experiencing and have to respond to the impacts of climate change (damage brought by Storm Desmond). It is urgent we start delivering against the climate targets we set ourselves if we are to limit the extent and severity of future impacts in the long term. The impact of restrictions imposed in response to the Covid-19 pandemic has created large scale economic impact on society bringing much hardship to businesses and people. However this year's annual emissions are expected to be down by 6-8%, close to the target of 7.6% that is required every year between 2020 to 2030 to keep global warming below 1.5c. It is important that as we move away from the rescue phase and into the recovery phase of covid-19 pandemic that we ensuring the green fiscal recovery packages we deliver are aimed to help support a decoupling of economic growth from GHG emissions".

From looking across each of the risk assessments that has relevance to this strategic challenge, the following key messages were synthesised with respect to the vulnerabilities and opportunities this strategic challenge will face in the short, medium and long term.

Climate Action key messages

- To successfully and effectively build resilience to climate change action cannot be piecemeal. It requires systemic change at a landscape scale, with widespread coordinated adoption of interventions e.g. natural flood management

- Actions on climate change adaptation requires foresight. Planning needs to be done with a view to how the future will be, not how the present is (e.g. tree planting with species of more southerly provenances) to make the best long term solutions

- Actions to buffer resilience to certain assets may increase vulnerability in others. Actions need to be measured and considerate - balanced with competing interests with a view to all timescales and risks

- Therefore climate action should address areas of conflict within the National Park head on and be a result of compromise and agreement in order to get sustainable outcomes.

- The National Park is seeing the impacts of climate change already, with further impacts in the short term (the next 10-20 years) largely being "baked in", regardless of the success of the global mitigation effort.

- Therefore climate action is relevant today and work is needed now across partners and sectors in the National Park to put together plans for projects that are ready to go and "shovel ready", and can successfully deliver benefits in the next 10-20 years.

- Climate change adaption within the National Park is critically important to features outside it. There needs to be coordinated action to ensure interventions within the National Park meet the needs of those sites that sit outside it (flood risk to towns and villages, ensuring landscape connectivity and permitting new species to colonise the National Park).

- As both public and private assets will be impacted by climate change a large commitment for investment from both the public and private sectors in the National Park is required.

- A knock on effect of this investment will mean a creation of jobs and support for stimulating a green economic revolution.

- Climate action will require interventions in every sector. Monitoring will be required to ensure there is a consistent level of ambition is being delivered across sectors.

- There are many non-climate related pressures within the National Park that exert a strong in-combination effect with climate change (e.g. high visitor numbers, water abstraction, development, land management practices). In some cases actions to address these pressures may be more effective than addressing the direct impacts of climate change.

4.6 World Heritage Site

The World Heritage Site designation is not listed as a separate Strategic Challenge in the 2020-2025 Partnership's Plan. However due to the importance of the World Heritage Site designation to the National Park, as well as it being a requirement from ICOMOS (International Council which governs Word Heritage Sites) to provide a climate change impact risk assessment on World Heritage Sites, it was felt important that the results of this report should be considered from a dedicated World Heritage perspective. It will be noticed that an indicator included in the cultural experience asset under world class visitor experience did specifically look at the impacts of climate change on the World Heritage Site. This section now builds on the results of this indicator by looking across the results in all risk assessments included in this report, and where there is relevance to the World Heritage Site, synthesise a number of key messages with respect to the vulnerabilities and opportunities the World Heritage Site designation will face in the short, medium and long term with climate change.

World Heritage Site key messages

- Adaptation and mitigation interventions (tree planting and fencing, natural flood management schemes) although help our landscape respond to climate change, if not done in a sympathetic way can significantly impact on landscape character/aesthetics, historic environment (e.g. re-meandering and loss of historic water channels through NFM), as well as functioning of the agro-pastoral farming system (e.g. fencing leading to a reduction in stock and effect on the "hefted" flocks).

- However these interventions are necessary to address the climate crisis and will need to increase in scale and number going forward. This makes it critically important that there is a shared understanding of the integrity of the WHS, and that Heritage Impact Assessments are routinely and consistently carried out by partners undertaking climate change adaptation or mitigation interventions.

- Landscape aesthetics and character will also change naturally with climate change. It is out of anyone's control - other than the success of the global mitigation effort which will determine the extent of this change. The composition species of plants, insects, and trees etc. will become different as the climate becomes more favourable to some and less favourable to others.

- This has implications for the Lake District's designed landscapes where a series of deliberate management actions have codified someone's vision of landscape. Climate change also may bring new pests and diseases to the Lake District or exacerbate those already there (*Phytophthora ramorum* at Tarn Hows). Although tree and plant species can be substituted if climate change no longer allows for them, there are limits on the extent designed landscapes can change and adapt before losing their integrity and authenticity of what was originally envisaged.

- There are communities in the Lake District that are isolated, have ageing populations, have a large number of second home owners, have weak support networks and characteristics that make them more vulnerable to climate change. The impact of climate change on weakening community resilience would have a knock-on effect on WHS.

- Local industries are key attributes of OUV for the Lake District National Park which are inextricably linked to the communities they have developed within and serve. A weakening of local communities with climate change will also impact the continuation of these local industries and threaten this aspect of the World Heritage Site OUV.

- The ethos of World Heritage Site is to put local community at its heart. If climate change leads to a break up of local communities it would fundamentally undermine the purpose of the World Heritage Site.

- The vibrancy of farm businesses in the Lake District is central to the integrity of WHS. Farm businesses will experience both positive and negative effects from climate change. Climate change on the whole will make farming much more productive, increasing the options available to farmers. Although there will be periods of temporary costs associated with damaging climate events (intense storms, periods of prolonged drought) that can affect the ability of farms to operate and the quality of the products they produce.

- Native Breed cattle are relatively unaffected by the impact of climate change. There will be an increased risk of pest and disease outbreaks and this should be taken lightly considering the delicate genetic diversity of Herdwicks. However the risks are hard to scale and largely unknown. On balance, a warmer climate, milder winters, and increased availability of nutritious vegetation will be positive for native breeds.

- What essentially would be a more favourable climate in the long term for rearing livestock, may widen the niche native breeds such as Herdwicks have been able to successfully occupy in the Lake District. This could lead to less traditional breeds not associated with the WHS but more economically productive being used more in the Lake District.

- In the short to medium term agricultural support post “Brexit”, ageing demographics and lack of new entrants, as well as the future of global land use are more pressing concerns to the vibrancy of farm businesses in the Lake District than climate change.

- This is also the reason the future of active Commons is in doubt, another key feature of the WHS. Climate change will have a relatively low impact on active Commons albeit with some temporary disruption to access e.g. Storm Damage to access routes. Active Commoning relies on a vibrant agricultural sector and the future agricultural support that is agreed post- CAP (Common Agricultural Policy) will determine the future of active Commoning in the Lake District.

- The Lake District’s historic environment such as its coastal, upland and lowland archaeology, remains of historic upland quarry and mining sites, and vernacular landscape features/buildings are a key component of the WHS. All of these assets are vulnerable to climate change impacts and if lost cannot be replaced. In the short term, flooding and erosion from intense storms threaten historic quarry and mining sites, damaging lowland archaeology with vernacular landscape features such as stone walls at risk of being

washed away. In the medium to long term, peat desiccation and erosion threaten to destroy archaeology on the high fells and sea level rise and erosion could mean the loss of important historical features along the National Park's coast line.

5 Report Limitations

When interpreting the results and key messages of this report it is important that they are put in the context of its limitations.

Context setting - Emissions Scenario

As stated in the methodology section the climate projections (different meteorological variables) for the Lake District National Park are based upon data modelling using RCP 8.5. RCP 8.5 represents a high end no-policy baseline scenario. It doesn't represent **the** "business as usual scenario" but **a** "business as usual scenario", where more than 90% of the other no-policy baseline scenarios in the literature result in lower emissions. In other words, it is a worst case scenario. Therefore the level of vulnerability and or opportunity of assets and services in the National Park were assessed in the risk assessment in an unlikely context. It is most probable that the level of vulnerability and opportunity that assets and services in the National Park will experience with climate change will be significantly lower than what is presented in the results of this report. There are a number of lower emission scenarios that could have been used for this report for comparison. However by introducing a range of emissions scenarios would have led to several vulnerabilities and opportunity scores for each asset and service assessed in the risk assessment. This would have meant that this report would have had a level of complexity and depth that would not have not been able to be resourced. To aid simplicity and clarity of the results, one emission scenario was chosen instead. A "worst case scenario" was selected because the other lower emission scenarios are based on "expected" global policy interventions to mitigate further GHG emissions, which if successful and fully delivered, will only have influence over the level of global warming in the medium to long term as some level of climate change is "locked in" and unavoidable. Due to the uncertainty over whether these global policy interventions get delivered is why a cautious approach was taken using an unmitigated worst case emissions scenario.

Context setting - Environmental change

To determine the level of vulnerability and or opportunity of assets and services in the National Park to climate change, not only were climate projections (e.g. summer and winter rainfall) used to guide the risk assessments, but also information on how it is thought the environment in the National Park would change as a result of climate change. To provide this information, which included giving an indication over the timeframe different environmental changes would have significance, a literature review was undertaken of peer reviewed literature. The literature review was then provided to the Environment Agency to verify its applicability to the National Park. However there are a number of limitations of this literature review which may question its veracity when applied to the National Park. Most, if not all, of the literature included in the review was based in research contexts outside of the Lake District National Park due to the lack of locally specific examples. Although effort was made to include only similar research contexts (e.g. northern hemisphere and similar latitudes) there may be inaccuracy in extrapolating to the National Park. In addition most research reviewed used outdated climate change projections in their analysis (UKCP09) due to the most recent projections only having been released relatively recently (UKCP18).

Inconsistency of data and expertise

A total of 41 separate risk assessments were intended to be completed for the National Park Authorities' contribution to Climate Change Adaptation Reporting. In the process of completing the risk assessments it was found that there was inconsistency in the amount and quality of data as well as expertise that was available for each asset and service examined. Those assets and services which were well researched and thus had a lot of available data to draw upon, as well as available professional expertise that could either add to or verify it, are likely to have much more reliable and accurate results than those assets and services where this was not the case. As presented in section 2.4.3, to be transparent about this limitation a confidence rating system (low, medium, high) was included to show which results have less research and professional verification behind them.

In addition in some areas a lack of available expertise has meant that some intended risk assessments that were detailed in the Methodology section were unable to be completed. The breadth of assets and services examined in this report has meant it was crucial to draw upon the wide range of expertise in the Lake District National Park Partnership and beyond to achieve coherent results. In some less complex areas, an unavailability of professional expertise (as well as a lack of available research) meant the National Park Authority could complete the risk assessments internally by providing a low confidence indication. However for some more complex areas this was not possible and specialist expertise was necessary. The pressures that the global pandemic has put on partners and organisations who would normally be able to offer resources to assist, has meant the scope of this report has had to narrow in some areas. The potential risk of this is that the level of vulnerability and or opportunity experienced by certain assets and services maybe not be as accurate as it otherwise would be as it is based on less available information.

6 Appendices

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6.2 Appendix B: Contributors

- Action with Communities Cumbria
- Butterfly Conservation
- Centre of Ecology and Hydrology
- Cumbria County Council
- Cumbria CVS
- Cumbria Wildlife Trust
- Environment Agency
- Federation of Cumbria Commoners
- Forestry England
- Foundation for Common Land
- Friends of the Lake District
- Lake District National Park Authority
- National Farmers Union
- The Farmer Network
- The National Trust
- United Utilities
- University of Cumbria
- University of Lancaster

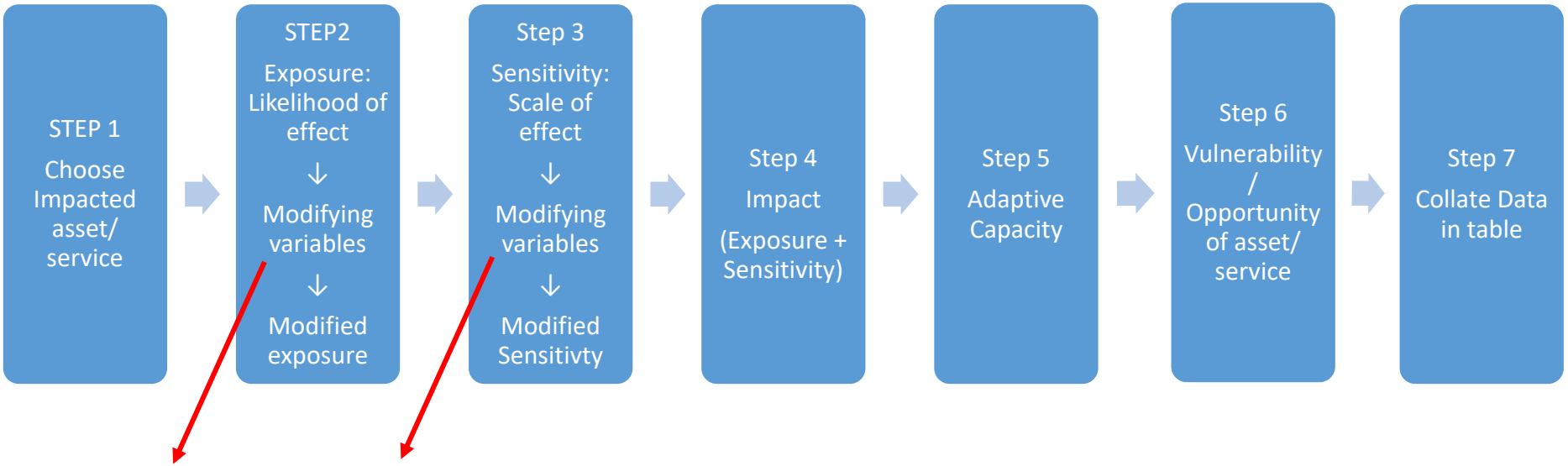
Appendix C: Risk Assessment Methodology

Adapting the Climate Vulnerability Index

Vulnerability/Opportunity of assets is found by looking at exposure and sensitivity (along with modifier variables), qualified against adaptive capacity.

Done for both short (2030s), medium (2050s) and long term (2070s)

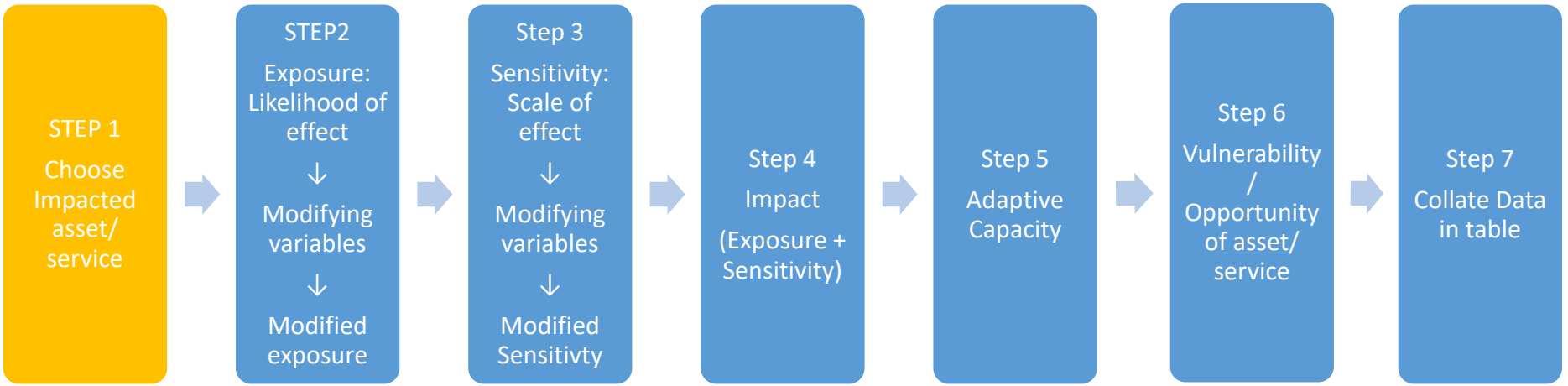
*Remember impact can be positive or negative



How Modifier variables influence Exposure / Sensitivity scores.

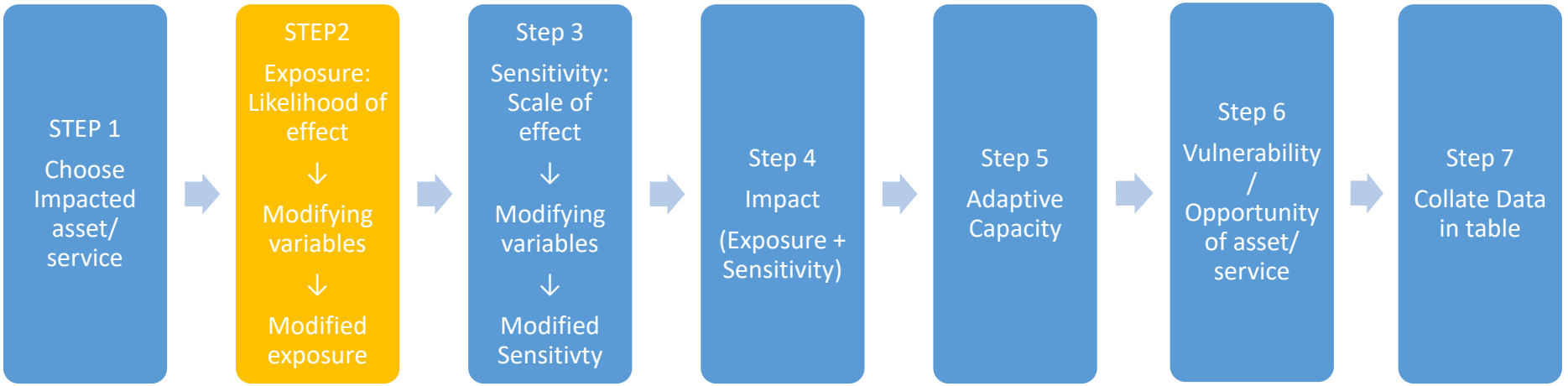
For every level above 0 for a modifier variable, add .5 of a level to Exposure/Sensitivity.

E.g. if sensitivity score is level 2 (low) and modifying variables are level 1 for spatial scale (localised) and level 1 for compounding factor (low probability) add .5 for spatial scale, and add .5 for compounding factor which means sensitivity score is elevated by 1 level (.5 + .5 = 1 level) to Level 3 moderate.



Step 1: Impacted asset/service and effect

Asset > Indicator	Defining the indicator
Evidence Source:	



Step 2: Determining Exposure using modifier variables

Likelihood that the capacity of _____ will be affected by climate change.

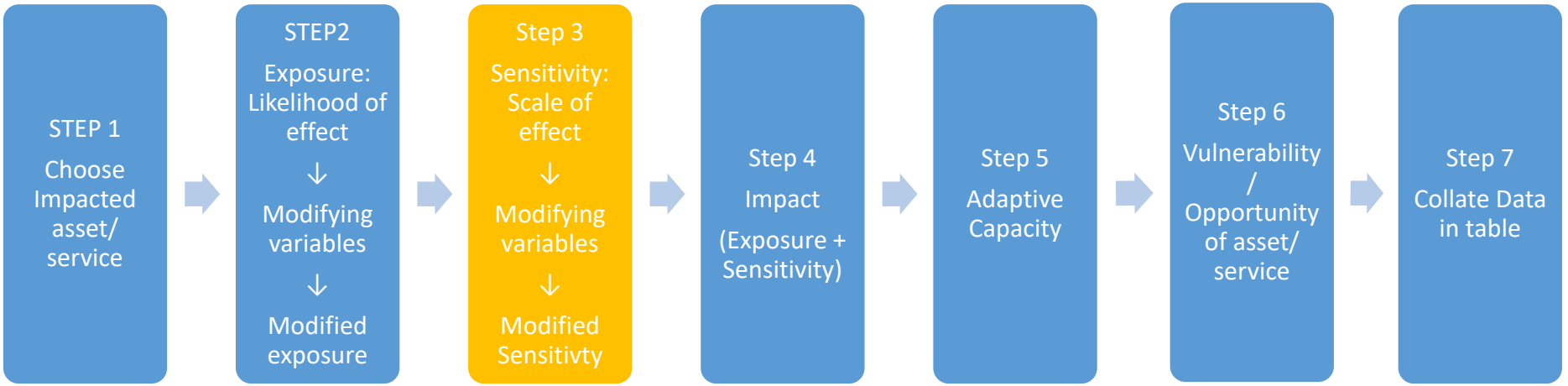
Scoring metric: Based on categorical levels for exposure, based on IPCC definitions

Exposure %based on IPCC		Level 1	Level 2	Level 3	Level 4	Level 5
Indicator	**Timeframe**	Very unlikely (<10%)	Unlikely (10-33%)	Possible (34-66%)	Likely (67-90%)	Very Likely (>90%)
	Short term					
	Medium term					
	Long term					

Modifier variables

Temporal scale: How frequently _____be influenced by the effects of climate change?

Temporal scale: The frequency of event exposure		Level 0	Level 1	Level 2	Level 3
Indicator	**Timeframe**	Intermittent (<1 event/decade)	Occasional (1-5 events/decade)	Frequent (5-10 events/decade)	Impacting most years
	Short term				
	Medium term				
	Long term				
Explanatory Notes					
Base Exposure Score	**Timeframe**	**Modified Exposure**			
	Short				
	Medium				
	Long				
Level 5* means that the score has exceeded the maximum level by one or more extra levels.					



STEP 3 Sensitivity: The degree to which a system is affected, either adversely or beneficially by climate related stimuli**.** Scoring metric: Can be a negative (impact) or positive (opportunity)

Sensitivity	Level 1: Very Low	Level 2: Low	Level 3: Moderate	Level 4: High	Level 5: Very High
Negative Effect (-)	Slight negative impact but effects not yet measurable. All components of asset/service remain essentially intact.	Some components affected or disrupted but impact is generally superficial. Overall condition remains unaffected by climate change.	A number of the assets/services' components disrupted or affected. Overall condition is in decline and caused in part by climate change.	Significant number of components affected/disrupted/lost. Overall condition is in decline and principally driven by climate change.	Potential for complete loss of asset/service and or with irreversible damage to overall condition caused by climate change.
Positive Effect (+)	Slight positive response to climate change but effects not yet measurable. Value and importance of asset/services remains unchanged.	Positive change driven by climate change is starting to have a measurable effect. However Value and or significance of asset/service remains unchanged.	Positive change from climate change is starting to increase value and or significance of asset/service.	Value of asset/ service has increased due to positive change brought by climate change.	The positive effects of climate change have enhanced the value and or significance of asset/service by a tremendous degree.
Short					
Medium					
Long					
Explanatory notes					

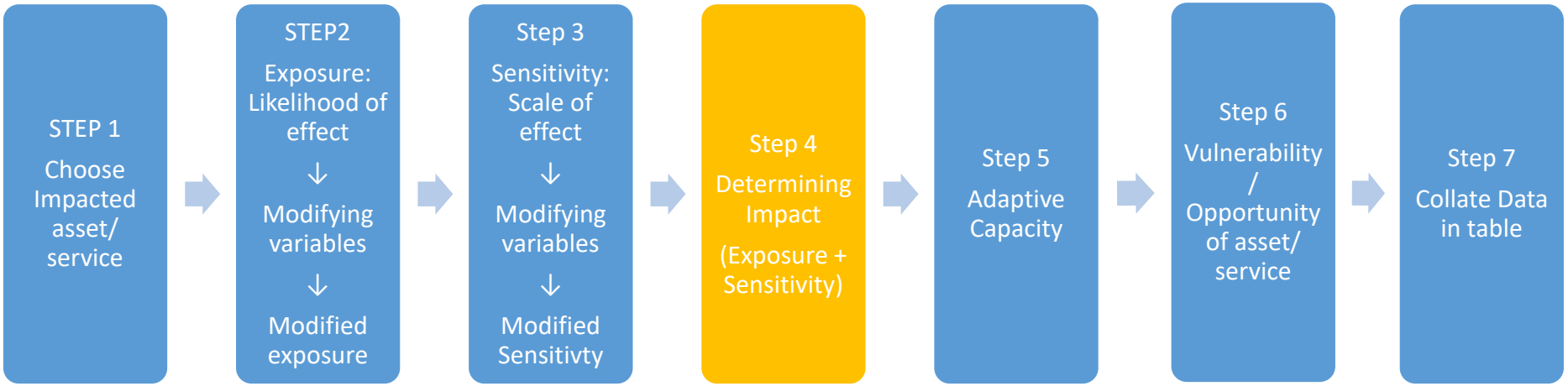
Modifier variables

Spatial scale: Extent (%) of assets and services that will be affected by negative/positive effect

Compounding/synergising factors: Is the negative/positive effect going to compound/synergise with non-climate stressors, and or will the impacts have secondary effects on other assets and services.

Modifier Variable: Spatial Scale	**Level 0** Restricted (<10%)	**Level 1** Localised (11-50%)	**Level 2** Extensive (51-90%)	**Level 3** Very widespread (91-100%)
Short				
Medium				
Long				
Explanatory Notes				
Modifier Variable: Compounding/ Synergising effects of non climate related factors	Very unlikely/unknown	Low probability	Medium probability	High probability
Short				
Medium				
Long				
Explanatory Notes				

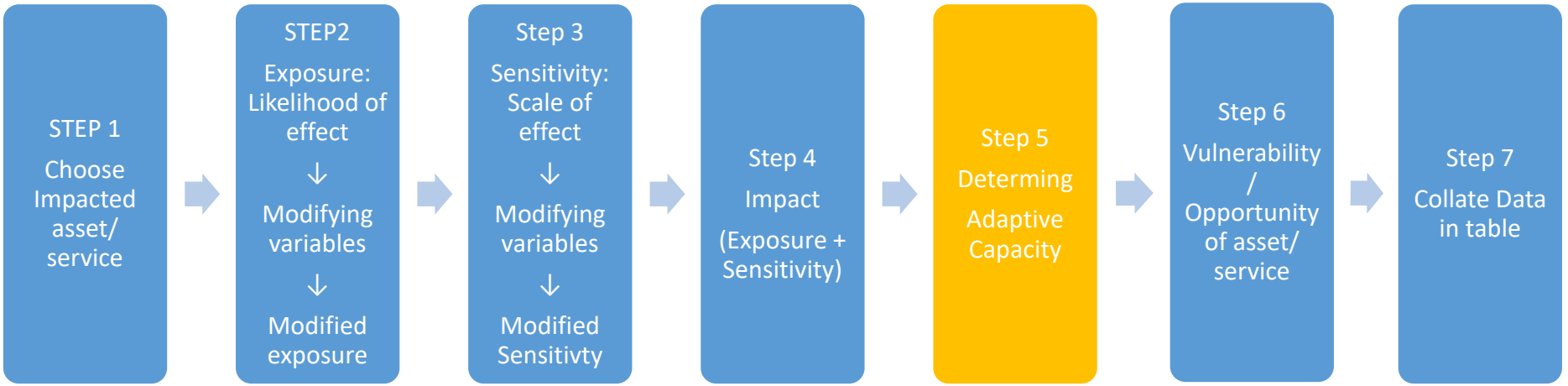
Base Sensitivity Score	**Timeframe**	**Modified Sensitivity**	
	Short		
	Medium		
	Long		
Level 5* means that the score has exceeded the maximum level by one or more extra levels.			



STEP 4 Determining Effect (+/-) using matrix

Modified Exposure	**Modified Sensitivity**					
	Level 1 (Very Low) (+/-)	**Level 2 (Low)** (+/-)	**Level 3 (Moderate)** (+/-)	**Level 4 (High)** (+/-)	**Level 5 (Very High)** (+/-)	**Level 5* (Extreme/Fantastic)**
Level 1 (Very unlikely)	Low (+/-)	Low (+/-)	Low (+/-)	Low (+/-)	Low (+/-)	Low (+/-)
Level 2 (Unlikely)	Low (+/-)	Low (+/-)	Moderate (+/-)	Moderate (+/-)	Moderate (+/-)	Moderate (+/-)
Level 3 (Possible)	Low (+/-)	Moderate (+/-)	Moderate (+/-)	High (+/-)	High (+/-)	High (+/-)
Level 4 (Likely)	Low (+/-)	Moder*ate* (+/-)	High (+/-)	High (+/-)	Very High (+/-)	Very High (+/-)
Level 5 (Very Likely)	Low (+/-)	Moderate (+/-)	High (+/-)	Very High (+/-)	Very High (+/-)	Very High (+/-)
Level 5* (Extreme/Fantastic)	Low (+/-)	Moderate (+/-)	High (+/-)	Very High (+/-)	Very High (+/-)	Extreme/Fantastic (+/-)

Indicator	**Time Frame**	**Modified Exposure**	**Modified Sensitivity**	**Effect**
	Short Term			
	Medium Term			
	Long Term			



Step 5 Adaptive Capacity

Definition: The potential, capability or ability of an asset or service to adjust to climate change, to moderate potential damage, to take advantage of opportunities, or respond to the consequences.

In this framework, adaptive capacity is considered in terms of:

1) Current action / resource to build resilience that is planned/allocated*
2) Internal capacity of asset/services to respond (e.g. modify behaviour, or activate contingencies in order to respond to climate variability*
3) The effectiveness of 1 and 2 to address the impact being considered

*1 and 2 only contribute to the overall adaptive capacity if they are assessed to be effective in addressing the relevant impact i.e. scores level 2 or above.

Adaptive Capacity

	Level 1 (None)	Level 2 (Low)	Level 3 (Moderate)	Level 4 (High)
Current Action/Resource	No action / resource either underway or planned	Low level of action/resource underway or planned	Moderate level of action/resource underway or planned	High level of action/resource currently underway or planned.
Short				
Medium				
Long				
Explanatory Notes				
Capacity to adapt behaviour/activate contingencies	No capacity to adapt or activate contingencies	Low capacity to adapt or activate contingencies	Moderate capacity to adapt behaviour or activate contingencies	High Capacity to adapt behaviour or activate contingencies
Short				
Medium				
Long				
Explanatory Notes				
Effectiveness	Very Low / Negligible	Low Level of effectiveness	Moderate level of effectiveness	High level of effectiveness
Short				
Medium				
Long				
Explanatory Notes				

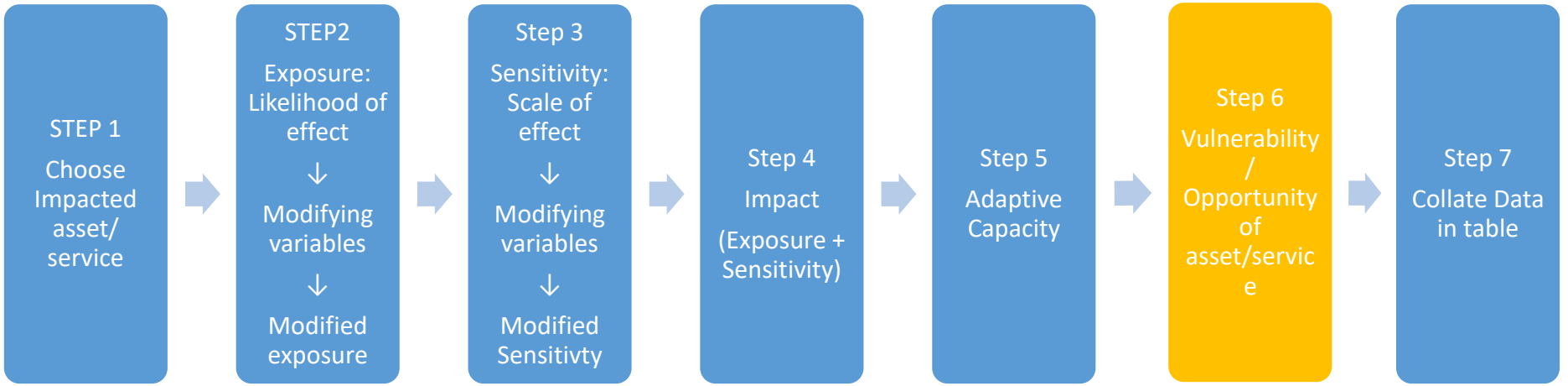
Adaptive Capacity Scoring Matrixes and Scores

Matrix: Combined output of current action / Resource and capacity to adapt behaviour/activate contingency	**Current Action / Resource**			
Capacity to adapt behaviour/activate contingency	**Level 1 (None)**	**Level 2 (Low)**	**Level 3 (Moderate)**	**Level 4 (High)**
Level 1 (None)	None	Low	Low	Low
Level 2 (Low)	Low	Low	Low	Moderate
Level 3 (Moderate)	Low	Moderate	Moderate	High
Level 4 (High)	Low	Moderate	High	High

Adaptive Capacity of		**None**	**Low**	**Moderate**	**High**
	Short				
	Medium				
	Long				

Matrix: Qualifying against effectiveness	**Combined score of capacity to adapt behaviour/activate contingency and current action/resource**			
Effectiveness of adaptive capability	**Level 1 (None)**	**Level 2 (Low)**	**Level 3 (Moderate)**	**Level 4 (High)**
Level 1 (Very low / negligible)	None	None	None	None
Level 2 (Low)	None	Low	Low	Moderate
Level 3 (Moderate)	None	Low	Moderate	Moderate
Level 4 (High)	None	Moderate	High	High

Final Adaptive Capacity of	**Adaptive Capacity**	**None**	**Low**	**Moderate**	**High**
	Short				
	Medium				
	Long				



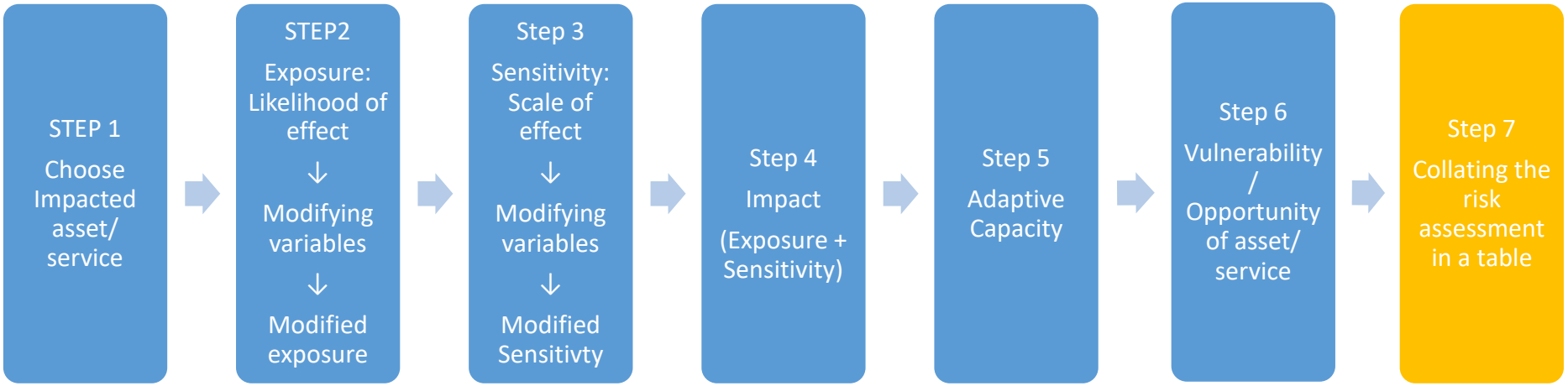
Step 6: Determining Vulnerability or Opportunity

Vulnerability	Low	Moderate	High	Very High	Extreme
Opportunity	Low	Moderate	High	Very High	Fantastic

Potential Effect (+/-)	**Adaptive Capacity**							
	Level 1 (None)		**Level 2 (Low)**		**Level 3 (Moderate)**		**Level 4 (High)**	
Level 1 (Low)	Low	Low	Low	Low	Low	Low	Low	Low
Level 2 (Moderate)	Moderate	Low	Moderate	Low	Low	Moderate	Low	Moderate
Level 3 (High)	High	Low	High	Moderate	Moderate	Moderate	Low	High
Level 4 (Very High)	Very High	Moderate	Very High	Moderate	Moderate	High	Moderate	Very High
Level 5 (Extreme/Fantastic)	Extreme	Moderate	Very High	High	High	Very High	Moderate	Fantastic

	Vulnerability / Opportunity of Asset or Service		
Time frame	Vulnerability	Opportunity	
Short			
Medium			
Long			

STEP 7: Collating the risk assessment in a table



Indicator	Time Frame	Exposure	Temporal scale (Modifier)	Modified Exposure	Sensitivity (+/-)	Spatial Scale (Modifier) (+/-)	Compounding/synergistic effects i.e. will it affect multiple assets or be a stimulus for secondary effects (+/-)	Modified Sensitivity (+/-)	Effect (+/-)	Adaptive Capacity	**Vulnerability** / Opportunity	**Confidence**
* = Means score went above the category level. This is accounted for in final scores with an extra category added.												

6.3 Appendix D: Questionnaire

Questionnaire

Asset: Indicator

Assets	Indicators
e.g. Carbon Storage	e.g. Woodland Carbon Cycle
	e.g. Carbon Storage of Peatlands

Definition of indicator:

Timeframe Impact considered over: Short term: 2030 – 2040 Medium term: 2050 – 2060 Long term: 2070 – 2080 (see Climate Change in the LDNP table below).

Climate Change in the LDNP						
1981-2000 baseline	**Percentile**	**Sea Level Rise (M)**	**Summer Rainfall (%)**	**Winter Rainfall (%)**	**Winter Temperature (°C)**	**Summer Temperature (°C)**
Current Average (2010-2020)	10th	0.04	-11.16%	+5.32%	+0.80°C	+1.34°C
	50th	**0.06**				
	90th	0.09				
Future Short Term (2030-2040)	10th	0.07	-7.85%	+6.19%	+1.26°C	+2.16°C
	50th	**0.10**				
	90th	0.14				
Future Medium Term (2050-2060)	10th	0.15	-23.83%	+16.58%	+2.18°C	+3.56°C
	50th	**0.21**				
	90th	0.43				
Future Long Term (2070-2080)	10th	0.30	-32.28%	+26.20%	+3.2°C	+5.30°C
	50th	**0.43**				
	90th	0.6				
Rainfall Intensity: % increase in severity of extreme rainfall events for England (Environment Agency 2016). As national figures likely to be a conservative estimate for the wetter north west where the Lake District National Park is situated.						
Based 1961-90 baseline	Uplift: Factors are advised for return periods greater than 5 years. Estimates based on maximum daily total rainfall.					
Future Short Term (2030-2040)	+10%					
Future Medium Term (2050-2060)	+20%					
Future Long Term (2070-2080)	+40%					

1. How likely are _____ to be influenced by climate change effects in the short, medium and long term?

Please indicate which climate change effects are relevant for each time frame.

Very unlikely (<10%)	Unlikely (10-33%)	Possible (34-66%)	Likely (67-90%)	Very Likely (>90%)

Short:

Medium:

Long:

Explanatory note / Links to any evidence

2. Taking a 10 year time frame how frequently will _____ be influenced by the climate change effect(s) listed?

Intermittent (<1 event/decade)	Occasional (1-5 events/decade)	Frequent (5-10 events/decade)	Impacting most years

Short:

Medium:

Long:

Explanatory note / Links to any evidence

Very Low	Low	Moderate	High	Very High
Slight negative impact but effects not yet measurable. All components of asset/service remain essentially intact.	Some components affected or disrupted but impact is generally superficial. Overall condition remains unaffected by climate change.	A number of the assets/services' components disrupted or affected. Overall condition is in decline and	Significant number of components affected/disrupted/lost. Overall condition is in decline and principally driven by climate change.	Potential for complete loss of asset/service and or with irreversible damage to overall condition

		caused in part by climate change.		caused by climate change.
Slight positive response to climate change but effects not yet measurable. Value and importance of asset/services remains unchanged.	Positive change driven by climate change is starting to have a measurable effect. However value and or significance of asset/service remains unchanged.	Positive change from climate change is starting to increase value and or significance of asset/service.	Value of asset/ service has increased due to positive change brought by climate change.	The positive effects of climate change have enhanced the value and or significance of asset/service by a tremendous degree.

3. If climate change effect(s) do influence the _____ to what degree will they be affected, either adversely or beneficially?

Short:

Medium:

Long:

Explanatory note / Links to any evidence

4. Will there be features of _____ more affected more than others by climate change (e.g. some species more vulnerable than others?)

5. Thinking about _____ as a whole then (e.g. different plant species being its constituent parts), what extent of its constituent parts will be affected by climate change effects in the short, medium and long term?

Restricted (<10%)	Localised (11-50%)	Extensive (51-90%)	Very widespread (91-100%)

Short:

Medium:

Long:

Explanatory note / Links to any evidence

6. Are there any non-climate related factors that could interact with the climate change effect(s) to magnify how _____ respond to climate change? If so what are they?

7. What is the probability that there will be in-combination response between climate change effect(s) and these non-climate related factors?

Very unlikely/unknown	Low probability	Medium probability	High probability

Short:

Medium:

Long:

Explanatory note / Links to any evidence

Adaptive Capacity

8. Is there currently action/resource on the ground or planned to help buffer the impacts from climate change on _____? If so what is it?

9. How much current/or planned action/resource on the ground is there?

No action / resource either underway or planned	Low level of action/resource underway or planned	Moderate level of action/resource underway or planned	High level of action/resource currently underway or planned.

Short:

Medium:

Long:

Explanatory note / Links to any evidence

10. Are there any characteristics of _____ in the Lake District National Park which may offer them some protection from climate change impacts e.g. microclimates, species resilience?

11. With this in mind how much internal capacity does this give _____ to respond to climate change?

No capacity to adapt or activate contingencies	Low capacity to adapt or activate contingencies	Moderate capacity to adapt behaviour or activate contingencies	High capacity to adapt behaviour or activate contingencies

Short:

Medium:

Long:

Explanatory note / Links to any evidence

12. Taken together how effective are 9 and 11 in buffering the impacts of climate change on

Very Low / Negligible	Low Level of effectiveness	Moderate level of effectiveness	High level of effectiveness

Short:

Medium:

Long:

Explanatory note / Links to any evidence

Action Planning

Have you thought about what the effects of climate change are going to be on _____ in the short, medium and long term. Now in this context, please highlight what measures, if any, are required to be implemented in order for any vulnerability or opportunity identified to be addressed.

Please categorise your list of measures according to the following titles.

Nature Recovery: Measures linked to environmental conservation management such as a modification of existing practices or introduction of new ones. Highlight funding mechanism if known (e.g. ELMs). Links made to the wider objectives/priorities for the Nature Recovery Network in the National Park.

E.g. Tree/Scrub Planting, River Restoration

Future of Farming: Measures linked to current or changed agricultural practices. They should appreciate and relate to the changing farming economy and be sensitive to World Heritage OUV.

E.g. Regenerative Grazing

Planning, Strategy and Policy: Measures relating to risk assessments, management /action plans which effectively coordinate resource to ensure climate change impacts when they do happen are kept to the minimum. Or alternatively allow assets to take advantage of the opportunities that climate change affords.

E.g. Risk assessment/emergency action plan setting out the immediate response (how resource is coordinated / who is involved) to wild fires to ensure the conservation of natural/historic assets.

Capital Works: Any measures that relate to engineering, or constructing or installing facilities and fixtures to buffer assets from negative impacts, or to exploit potential beneficial effects from climate change.

E.g. flood alleviation schemes, Micro-renewable energy schemes

Behaviour change, citizen engagement: Measures relating to initiatives looking at citizen engagement in order to promote behaviour change through awareness raising.

E.g. Public forums, training days

6.4 Appendix D: Environmental Change Literature Review

Time-Frame	Climate: Based on a 1981-2000 baseline				Environmental Responses driven by climate change							
	Warmer Wetter Winters	Hotter Drier Summers	Sea Level Rise		Longer growing season and associated phonological changes	Sustained Terrestrial Ponding	Nitrogen Deposition	Soil Temperature	Fewer Ground Frosts	Droughts	Increase in Non Native invasives (NNI)	Intense Storm events / Flash flooding
Current Average (2010-2020)	+0.80°C +5.32%	+1.34°C -11.16% (rainfall)	10th Percentile	0.04		The impacts from more frequent, intense storm events are already occurring (Christidis and Scott 2015). This is leading to longer periods of inundation of terrerstrial lands (e.g. grasslands) (Defra, 2012). It has been predicted that UK agricultural land on average could be flooded once every 3 years (Defra, 2012). Wetter conditions could reduce accessibility for management operations, which could lead to an increase in rushes juncus spp, which may need controlling (Natural England 2015)			Compared to an average for 1981-2010 there are already a fewer number of ground frost days. In the past decade alone there has been 15-16% fewer annual days of air and ground frosts per year. This is only set to increase through the century as average temperatures get higher (Kendon et al, 2019). Key upland hay meadow species such as Geranium sylvaticum that require vernalisation may become less compeitive and be lost (Rodwell et al., 2007)			
			50th Percentile	**0.06**								
			90th Percentile	0.09								
Future Short Term (2030-2040)	+1.26°C +6.19%	+2.16°C -7.85% (rainfall)	10th Percentile	0.07								
			50th Percentile	**0.10**								
			90th Percentile	0.14								
Future Medium Term (2050-2060)	+2.18°C +16.58%	+3.56°C -23.83% (rainfall)	10th Percentile	0.15	Between 2006-2015 the average number of growing season days was 15% higher than 1961-1990 and 5% higher than 1981-2010 (Met Office 2015) with research indicating spring is occurring much earlier than it did previously (CEH 2006). This is already having an impact on phenology (Menzel et al., 2006, Bell et al., 2019) leading to more significant events over time.Thackeray et al., (2016) suggest by 2050 primary consumers (seed eating birds, herbivorous insects) will have shifted their seasonal timing more than twice as much primary producers (flowering plants) and secondary consumers - an average of 6.2 days earlier vs 2.5-2.9 days respectively.For upland hay meadows this could mean competitive species gain an advantage over slower growing stress tolerant species (Natural England, 2015). Boreal-montane species are likely to be increasingly out-competed by species with more southerly distributions (Natural Engand, 2015)		There's a positive correlation between precipitation and wet nitrogen deposition (Zhang et al., 2019). Wetter winters could mean increased periods of increased N deposition exacerbating the effect this is already having on terrestrial biodiversity (Defra 2018). It is little understood how climate change will drive N deposition in the future in the UK. However significantly more rain projected in themid to long term could mean a significant synergistic effect of climate change on N deposition in this time frame in the Lake District.	It's been shown that in northern temperate regions soil temperatures will increase by up to 1.9 in the mid-term (2040-2069), and by 3.3 in the long term (2070-99) Houle et al., (2012). This has implications for a longer growing season, and biological processes such as vernalisation Junggvist et al., (2014).				It is expected that climate change is going to increase the frequency of extreme rainfall events (Sanderson 2010). It is thought that a climate change linked increase in frequency of extreme rainfall events will become evident in at mid-point of the 21st century (Fowler and Wilby 2010). By the end of the century it is thought that there could be a 50% -100% increase in the frequency of the largest winter floods in upland Britain linked to climate change (Watts et al., 2015).
			50th Percentile	**0.21**								
			90th Percentile	0.43								
Future Long Term (2070-2080)	+3.2°C +26.20%	+5.30°C -32.28% (rainfall)	10th Percentile	0.30						No consensus within the literature around the future forecasting of the severity and frequency of droughts within the UK. Though generally agreed that the frequency of droughts will increase over the short, medium and long term time frames (Watts et al., 2015). However in the long term (2070-2100) severe droughts are thought will become much more frequent, with the probability of long duration droughts that have significance for water supply becoming more likely – e.g. 1 in 100 year floods becoming 1 in 10 year occurences (Burke et al., 2010). Although this based on a national picture and the north west maybe better protected than drier areas in the uk such as south east. Implications for upland hay meadows may mean stress tolerant and deep-rooted species are favoured and ruderal species and where there are open gaps in the sward. This may lead to the decline of representative plant species such as wood cranes bill and lady's mantle (Carey 2013).	Upland infertile habitats have fewer incidences of colonisation by non-native invasives (Maskell et al. 2006). However a combination factors such as Nitrogen deposition (Smart et al., 2004), colonization by mesotrophic species (Smart et al. 2005) could provide opportunities for NNI in the longer term (Natural England 2011).	
			50th Percentile	**0.43**								
			90th Percentile	0.60								
Blue indicates no significant change, or research unable to attribute causal link to climate change. Red indicates a significant change and driven by anthropogenic climate change. Links to climate time frame in far left column.												

Time-Frame	Climate: Based on a 1981-2000 baseline				Environmental Responses driven by climate change							
	Warmer Wetter Winters	Hotter Drier Summers	Sea Level Rise		Coastal Erosion	Higher River Flows	Landslips and debris flows	Increase in disease vectors/Increased Voltinism (number of insect broods per year)	Increased Voltinism: Amount of insect broods per year	Wild Fires	Saline Intrusion / Storm Surges	Peat desiccation, erosion and carbon loss
Current Average (2010-2020)	+0.80°C +5.32%	+1.34°C -11.16% (rainfall)	10th Percentile	0.04								
			50th Percentile	**0.06**								
			90th Percentile	0.09								
Future Short Term (2030-2040)	+1.26°C +6.19%	+2.16°C -7.85% (rainfall)	10th Percentile	0.07								
			50th Percentile	**0.10**								
			90th Percentile	0.14								
Future Medium Term (2050-2060)	+2.18°C +16.58%	+3.56°C -23.83% (rainfall)	10th Percentile	0.15		Wetter winters could lead to an increase in river flows. The Future Flows Project undertaken by the Centre of Ecology and Hydrology showed using the latest climate projections for the United Kingdom that river flows in the Lake District could increase by up to 20% by the 2050s (CEH 2015). This could have implications for historic bridges when considering design features such as vertical clearance and or the potential for greater scouring effects.	Increased winter rainfall and a general increase in high intensity rainfall events are significant issues for landslides and debris flows. There is not much research forecasting the frequency of future landslips and debris flows with climate change but it is likely that they will increase as the century progresses and the relevant climate dirivers (rainfall intensity, and total rainfall) become more intense (Dijkstra et al., 2017).	Warmer temperatures in late winter could result in advances in emergence/flight date, lengthening season for suitable reproduction and increasing rate of life cycles, increasing number of generations completed Mossman et al., (2015) Bale et al., (2002). After a lag in the short to medium term without any discernible change, towards the end of the century there could be an increase of one more generation per year on average (Chen 2011). Linked disease vectors it is suggested that there could be a 17% increase in incidence of the blue tongue virus.	Warmer temperatures in late winter could result in advances in emergence/flight date, lengthening season for suitable reproduction and increasing rate of life cycles, increasing number of generations completed Mossman et al., (2015) Bale et al., (2002). After a lag in the short to medium term without any discernible change, towards the end of the century there could be an increase of one more generation per year on average (Chen 2011).	Little change in wildfire incidence projected in the short/medium term but as climate change intensifies, the danger of summer wildfires increases from 2070 Albertson et al., (2010)	Sea level rise rather than storm surge is thought to be the primary mechanism by which coastal flood risk is expected to change in the UK (Edwards 2017, Met Office 2018). Research suggests this is an issue that becomes more significant in the longer term (Edwards 2017).	Li et al., (2017) found that peatland erosion was driven by the effects of temperatre and precipitation on weathering processes. Although the wetter British climate does afford some protection from peatland dessication, erosion rates were found to increase during 2070 to 2099. This is becasuse it was shown that blanket peat erosion was generaly more sensitive to temperature than precipation. Peatlands loss could lead these habitats becoming a source of carbon loss rather than a sink.
			50th Percentile	0.21								
			90th Percentile	0.43								
Future Long Term (2070-2080)	+3.2°C +26.20%	+5.30°C -32.28% (rainfall)	10th Percentile	0.30	Coastal erosion is expected to increase with climate change as sea levels rise in the UK (Defra 2012). Up to 6000ha and 10000ha of agricultural land and up to 280ha and 540ha of BAP habitats could be lost by the 2050s and 2080s respectively (Defra 2012). The scale of erosion at a regional scale is highly dependent on localised geomorphological features (MCCIP 2008). Large areas of the LDNP's coast is of a geology resistant to erosion/weathering, perhaps offering some mitigation (MCCIP 2008). However other features may make other areas more vulnerable. Further research is required.							
			50th Percentile	**0.43**								

			90th Percentile	0.60			This could have potential implications in terms of damage to surrounding infrastructure.						
Blue indicates no significant change, or research unable to attribute causal link to climate change. Red indicates a significant change and driven by anthropogenic climate change. Links to climate time frame in far left column.													