SAC CONSULTING

Climate change adaptation for agriculture

Is your farm ready?

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Contents

The aim of this document is to provide a climate change adaptation checklist for your business, so that various climate change adaptation measures can be considered. This will help you determine the most suitable and effective methods for improving resilience to climate change on your farm. Additionally, the topics examined throughout this document will provide suggestions and ideas that can aid in the development of an Emergency Action Plan for your business.

1. Foreword

Scotland's climate is changing, and these changes are projected to continue and intensify in the decades ahead. Farmers are on the front line, dealing with changes first-hand – from increases in temperature, changes in rainfall and severe weather events.

The resilience of our food supply, health of our natural environment and wellbeing of communities will be strongly influenced by the actions that farmers take to adapt to climate change.
This guide provides simple, practical explanations about the key challenges to consider and actions that can be taken. The case studies share valuable practical experience of adaptation action being taken in many different contexts.

I look forward to hearing feedback on how the guide is being used and learning more about the adaptation actions developed on different farms across Scotland.

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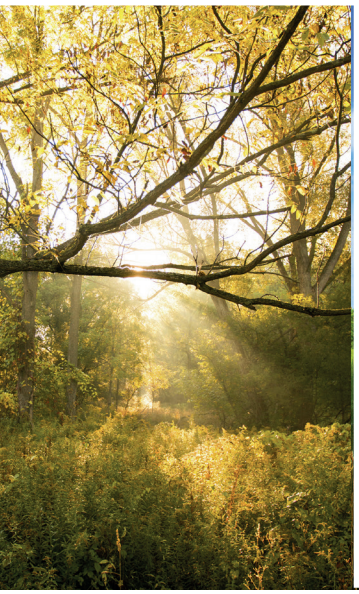
Adaptation Scotland – Adaptation Scotland is a programme funded by the Scottish Government and delivered by sustainability charity Sniffer.

Adaptation Scotland
supporting climate change resilience




2. Scotland's changing climate

In recent years Scotland has seen major developments in the effort to mitigate and adapt to climate change. In 2019 the Scottish Government declared a global climate emergency and revised the Climate Change Act's Greenhouse gas (GHG) emission targets to a reduction of 75% by 2030, 90% by 2040 in comparison with 1990 levels, and net zero emissions by 2045[1].

The latest climate change projections show that Scotland is expected to experience milder and wetter winters, hotter and drier summers and an increase in extreme weather event intensity. This poses a number of risks including increased flooding, droughts, incidences of pests and disease and losses of biodiversity[2].[a]

Emission reductions are the main focus in preventing further catastrophic climate change, however, the effects of a changing climate are already having an impact and affecting farm and rural businesses. It is important that farm businesses actively consider climate change adaptation to minimise potential risks and where possible benefit from any opportunities that may present themselves.

Adaptation definition:

"Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

United Nations Framework Convention on Climate Change

Current effects of climate change

In recent years, the effects of climate change have become more apparent and widespread in Scotland[3]. The agricultural sector has seen these impacts first-hand in the form of severe weather events and unpredictable seasons. Extreme weather conditions saw winter barley production down by 24% and wheat yield down by 16% in 2018[4] alone due to 'The Beast from the East' and poor conditions over the winter. In the summer of 2017/18 losses to livestock and crop sectors from snowfall in the late winter/spring months cost the agricultural sector an estimated £161 million[5]. Although winter temperatures are projected to increase, this does not mean severe snowstorms cannot or will not occur. In 2018 the late snowfall caused livestock deaths and reduced the growth period for crops. Following this the drought in summer 2018 reduced grazing land for livestock and affected crop productivity. Together these weather events resulted in serious losses to the sector, forcing farmers to adopt different practices and leading to financial difficulties.

According to the latest projections, summers like that of 2018 with prolonged dry, hot weather conditions could be experienced as often as every other year by 2050. Conversely periods of heavy rainfall and extreme weather events are also projected to increase in frequency and intensity[2]. Improving farm resilience through climate change adaptation will be vital in ensuring that the agricultural sector is prepared to deal with these conditions in the future.

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[a]Climate projections are in their nature uncertain however, while it is important to recognise these uncertainties, it is vital to understand that this is based around the level of change rather than the change itself. The projections around the changes in Scotland's summer and winter climates are clear, but trends surrounding the intensity, frequency and power of future extreme weather events are less so. Nonetheless there is a need to think about and prepare for these issues to ensure that Agribusinesses can withstand their impacts.

Further information:

- Adaptation Scotland: www.adaptationscotland.org.uk/
- Agricultural Weather Advisory Panel: www.gov.scot/groups/agricultural-weather-advisory-panel/
- Farming for a Better Climate: www.farmingforabetterclimate.org/
- Met Office – Past weather events: www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
- Scottish Government - Agriculture and the Environment: www.gov.scot/policies/agriculture-and-the-environment/

Potential risks and benefits of climate change for farms in Scotland

There are both significant risks to and opportunities for the agricultural sector due to climate change[6]. These can be divided into two subgroups: direct risk/opportunity such as changes in weather, and indirect risk/opportunity such as market force changes. Direct impacts consist of the effects from physical environment changes, whereas indirect impacts are those that occur as a result of sectorial changes such as impact to supply chains, markets and customers. While indirect risks and opportunities are mentioned throughout this publication, the focus shall remain on the direct impacts of climate change on farm and the adaptation options available to exploit and mitigate these effects.

Risks and problems can arise from:

- Baseline changes in temperature and rainfall;
- Extremes of temperature and rainfall;
- Lack of water resulting in increased water stress;
- Topsoil erosion during cold/wet events (run-off) and hot periods (wind erosion) and;
- Increased range and spread of invasive species, pests and disease.

Benefits and opportunities can arise from:

+ Longer growing seasons;
+ Greater variety and yields of some crops;
+ Novel crops, previously uneconomic in Scotland;
+ Increased area for arable and doubling of grassland production in some parts of Scotland and;
+ Overall increase in agricultural production.

There are a number of different impacts that are likely to cause problems for the agricultural sector. Increased risk of pests such as the Liver Fluke parasite that favour wet summers and mild winters for example, are predicted to become more prevalent in Scotland's changing climate[7]. Climate change may also cause changes to patterns of availability and food distribution, both locally and on an international scale. As well as food production, climate change threatens many important habitats, sensitive landscapes and environmentally important areas. We are already beginning to see social, economic, and political efforts to protect these environments. This will impact how farm businesses are managed in the future and will place farmers in the forefront of the transition to a net-zero carbon society.

However, it is not all bad news. Climate change offers a range of potential opportunities where certain areas of the agricultural sector may benefit; including longer growing seasons, greater yields of some crops, market opportunities or the introduction of new lucrative crops. Future climate conditions could contribute to an increase in Scottish prime land. Some sources suggest an increase from 6% to 26-46% could be achieved by 2050[8], supplying a considerable boost to the sector. Examples of Scotland's warming climate already improving certain crops can be seen in potato yields for eastern parts of Scotland where a 13-26% increase has been recorded since 1960[9].

While these benefits have the potential to boost Scottish agriculture, climate is just one factor that determines land productivity. Other factors such as soil health are equally important. With increased rainfall and intense weather events predicted, there is an increased risk of soil saturation and erosion, leading to issues such as nutrient loss, crop damage and diffuse pollution that could negatively impact farmland and surrounding watercourses. Therefore, careful land management, an understanding of the effects and the adoption of climate change adaptation methods are essential to minimise risk and maximise any potential benefits from a changing climate[10].

See the "Climate Change Implications for the Agricultural Sector" section for a more in-depth overview of the implications of climate change on the sector.

The Committee on Climate Change published a UK Climate Change Risk Assessment in 2017. The assessment identifies the priorities for climate change until 2022. In addition to general risks, specific risks associated with agriculture are highlighted.

- **Ne3: Risks and opportunities from changes in agricutural and forestry productivity and land suitability**
- **Ne6: Risks to agriculture and wildlife from water scarcity and flooding**
- **Ne8: Risks of land management practices exacerbating flood risk**
- **Ne9: Risks to agriculture, forestry, landscapes and wildlife from pests, pathogens and invasive species**
- **Ne10: Risks to agriculture, forestry, wildlife and heritage from changes in frequency and/or mangnitude of extreme events and wildfire events**

Further information:

- Intergovernmental Panel on Climate Change (IPCC) – Special Report of Climate Change and Land: www.ipcc.ch/srccl/
- ClimateXChange (2016) - How is changing climate affecting crop suitability and productivity in Scotland's agriculture? www.climatexchange.org.uk/research/indicators-and-trends/natural-environment/suitability-and-productivity-agriculture/
- Committee on Climate Change: www.theccc.org.uk/

Climate change implications for the agricultural sector (positive and negative)

Natural environment
- Ecosystem changes
- Pressure on habitats and important species
- Invasive species encroaching
- Degradation of environment
- Wildfire risk
- Environmental enhancement opportunities

Pest & disease
- Increased pest population numbers
- Spread of disease
- New pests and diseases
- Crop damage and livestock health concerns
- Changed to yield

Farm productivity & income
- Varied and unpredictable productivity
- Market volatility on grain and animal products
- Changes in fuel and fertiliser costs
- Increased reliance on pesticides and herbicides
- Longer growing season
- Opportunities to exploit new markets

Quality of soil
- Rainfall and temperature changes
- Increasing temperatures threaten peat
- Waterlogging and surface run-off
- Wind erosion in dry conditions
- Loss of nutrients
- Changes in organic matter decomposition rates
- Changes in areas of prime land

Food security
- Global market and supply uncertainties
- Increased global demand with rising populations
- Food shortages
- Fluctuations in grain markets
- Changes in crops
- New or greater variety of crops grown

Quality of water
- Droughts
- Flooding
- Eutrophication risks due to nutrient loss from the soil
- Groundwater pressure (irrigation)
- Salinsation of water sources
- Acidification of water sources
- More abundent water supply at certain times of year

Environmental hazards
- Heavy rainfall periods and flash flooding risk
- Waterlogged fields impacting crop production and livestock grazing
- Flooded paths and roads reducing access to livestock and land
- Increased drought and fire risk
- Increased storminess and extreme events

Business resilience
- Supporting businesses to manage and respond to change
- Minimising disruption to supply chains
- Diversifying business to adapt to new consumer demands or requirements
- Changes to workload and demands
- Staff health and wellbeing
- Identifying new opportunities in the market

Infrastructure & energy
- Power lines coming down
- Pipes bursting
- Network connectivity and energy security
- Increased demand on utilities
- Transport
- Maximising the potential for retrofitting buildings
- Green energy, renewables and efficiency options

Climate change adaptation

Attention has been on climate change mitigation measures, reducing emissions and increasing sustainability. However, there is also a need to provide resources and aid understanding about **how farming can adapt to climate change** to deal with current and future threats, whilst maintaining a profitable business. The effects of climate change outlined in this document, the economic importance of farming and shifting links with Europe mean that minimising the impact of climatic changes through effective and strategic implementation of adaptive practices will be critical.

> ***"Scotland's climate has already changed. The ten warmest years in the UK have all been since 2003. Since the early 20th century, rainfall levels have increased in Scotland by around 11% and on a shorter timescale, since the early 1960s, by around 27%. We expect these changes to continue and intensify".***
>
> *Climate Ready Scotland: Second Scottish Climate Change Adaptation Programme 2019-2024*

In September 2019 the Scottish Government published a new five-year Climate Change Adaptation Programme to ensure communities, the economy and natural environment are resilient to the changing climate. The Scottish Government has also published an update to the Climate Change Plan 2018-2032 - Securing a Green Recovery on a Path to Net Zero, emphasising the opportunity to work alongside agriculture to develop new policies that deliver on climate change and other wider environmental outcomes, including climate adaptation to facilitate a sustainable future for farming. Additionally, the European Environment Agency's (EEA) report on "Climate change adaptation in the agriculture sector in Europe" outlines the impact of climate change on farms in Europe, what policies are in place at international, EU and national levels to help agriculture adapt to climate change and suggests the way forward to increase adaptation across the sector[11].

There are a large variety of measures [12] [13] [14] that can help you become more resilient to the effects of climate change such as crop diversification, increased water efficiency and improved agricultural planning and management techniques. This document will highlight some of the methods and other ecosystem services[15] that can improve your resilience to a changing climate. It will also explore outcomes and actions for agriculture that can help build resilience, and ensure the sector is informed, sustainable, flexible, and responsive to the changing climate. There are various tools and resources from organisations such as Adaptation Scotland, which help prepare communities and businesses and may offer useful insights for both individual farmers and agricultural organisations.

Further information:

- Adaptation Scotland - Tools and resources: www.adaptationscotland.org.uk/how-adapt/tools-and-resources
- ClimateXChange: www.climatexchange.org.uk/
- European Environment Agency (EEA) - Climate-ADAPT: https://climate-adapt.eea.europa.eu/
- Farming for a Better Climate – Adapting to climate change: www.farmingforabetterclimate.org/adapting-to-climate-change/
- Scottish Government – Climate Ready Scotland: climate change adaptation programme 2019-2024: www.gov.scot/publications/climate-ready-scotland-second-scottish-climate-change-adaptation-programme-2019-2024/
- Climate Change Plan 2018-2032 - Securing a Green Recovery on a Path to Net Zero: www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/pages/13/

3. What can farmers do to prepare?

With the uncertainty that comes with climate change, having the ability to be flexible and a willingness to embrace adaptation measures is key to success. The next section is designed to offer practical, flexible ideas and practices, which can be considered, tweaked and implemented to help protect and improve resilience within the farm business.

For many, some of these practices will already be commonplace and not necessarily considered climate change adaptation at first glance. However, it is important to be able to identify and acknowledge the actions that have or can be implemented to ensure that adaptation is done effectively and to the benefit of your farm. By implementing just one or more adaptation schemes, you can enhance and protect your business against some of the negative environmental impacts of our changing climate.

Every farm is different and as a result it is a good idea to do a SWOT analysis of your business to consider and define the **S**trengths **W**eaknesses **O**pportunities and **T**hreats that climate change poses to your farm and what adaptations you can implement to address this, before moving on to the checklists.

Strengths

What do you already do well?

What assets and resources do you have?

What do you do that no one else does?

What sustainability, adaptation and mitigations measures do you have in place?

Weaknesses

What assets and resources are you missing or need more of?

What are your main disadvantages?

What limits the growth of your business?

What impacts are you already experiencing?

Opportunities

What areas of your business could benefit from climate change?

Are there new markets you could access?

Can you develop new products or services?

Is now the time to diversify the business?

Threats

What are the main environmental risks?

How will customer attitudes change?

What new or proposed regulations are coming in?

Is the market undergoing any changes?

4. Flooding & heavy rain

Over the past few decades Scotland has seen an increase in annual average rainfall and extreme rainfall events, which has led to an increased risk of flooding. The annual average rainfall in the last decade (2009-2018) was 15% wetter than the 1961-1990 average, with winters 25% wetter. This trend is predicted to continue, as long, wetter periods become more frequent. These changes are already negatively impacting soil quality, livestock and crops costing farmers time and money. To alleviate these negative impacts there are a number of options that can be considered. See the checklist below to see what additional actions you may want to consider to improve your farms resilience to heavy rainfall and increased flooding.

Issues

Flooded fields

Fields, which are submerged under water for long periods are not cost effective. Longterm submersion can affect harvests, animal health and soil quality due to lack of oxygen and build-up of anaerobic conditions, which can damage crop roots.

Soil structure

Soil structure is delicate and can be susceptible to compaction, leading to increased runoff rates. Runoff can increase the likelihood of soil erosion, loss of nutrients and pesticides that can cause diffuse pollution to nearby watercourses.

Reduced grazing

Waterlogged fields may lead to livestock being kept indoors for longer and not being able to be let outside until the fields have drained and are accessible.

Soil health

Flooded fields result in changes to soil biology, chemistry and physics, which can lead to a reduction in soil health. Crop disease and pests can increase under these conditions resulting in reduced yields and poor crop health.

Blocked drains

Increasing sediment loads in surface run-off during heavy rainfall can highten the risk of blocked drains. This will put additional strain on drainage systems and can lead to further erosion, flooding and high repair costs.

Fence or hedge damage

Heavy rain periods can remove or destroy boundary features. This can lead to costs in replacements and more damage to your land and water, due to poaching and livestock accessing areas previously prohibited to them.

Flooding & heavy rain checklist

Question	Answer	Action
Do any of your fields or steading currently suffer from water logging or flooding after periods of rainfall?	Yes ☐	• Check your soil for signs of compaction using the free Visual Evaluation of Soil Structure (VESS) guide (www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure). If you see signs of compaction it is important to consider what farming practices are causing it and try to reverse the impact and prevent reoccurrence. • Check your current drainage system. Can you see any blockages, could any improvements be made? Check drain depths; make sure lateral drains meet with leader drains; introduce or increase the amount of permeable backfill surrounding drain pipes; regularly check along watercourses to ensure drains have a clean exit etc. • Is this a recurring problem? Would setting aside land to save the rest of your field be financially viable and safeguard your land? Would including Sustainable Drainage Systems (SuDS) into your farm be of benefit? Check out the latest funding and grant opportunities that could be available to support this. • Can you improve natural flood management such as woodland planting or restoring peatland to help store and slow down water in your catchment? • Maintain steading drains, keep them clean, ensuring guttering and downpipes are functional and free from defects.
	No ☐	• Ensure that all drainage is to the required standard (e.g. CREW Rural SuDS Design and Build Guide) and is maintained to prolong the lifetime of the systems. • Regularly check your soil for compaction using the free VESS guide.
Have you noticed deterioration in soil quality?	Yes ☐	• Could you improve drainage on farm? Is your soil compacted? By improving these attributes, you can significantly safeguard your farm and offer resilience to wetter weather. • Could you plant cover crops over the winter to reduce soil erosion and relieve compaction? • Consider leaving crop residues and straw on the soil over winter, or sow a winter crop, to reduce the impact of rain on the soil surface as this can lead to increased erosion and loss of structure. • Could you introduce reduced tillage practices? Reduced tillage practices can help retain soil by reducing soil erosion risk and minimise diffuse pollution. • Are you using floatation tyres on tractors and trailed equipment? Flotation tyres can help reduce soil compaction from the use of heavy machinery.
	No ☐	• Ensure you regularly assess soil structure to identify and remedy any soil compaction. • Maintain a regular program of soil and pH testing to optimise yields. The more you know about your soil, the more you can be prepared for change.
Have you noticed your current drainage system struggling with the increase in rainfall?	Yes ☐	• Check for blockages or 'weak' areas, which can be maintained or improved. Check and clean drainage outlets. • Increasing the use of permeable backfill can help improve or prolong the life of existing drainage systems. • Could you put in SuDS to assist your current drainage system such as offline storage areas and wetlands to store overflow water and remove additional pressure?
	No ☐	• Make sure you maintain and regularly check your drainage systems to ensure that no problems arise.
Have you been affected by the loss or damage of fences, gates or hedges due to flooding?	Yes ☐	• Consider installing spring-back fencing to cope with flooding in fields, which are near to waterways. These fences can be 'flattened' when a storm event is expected and restored to the upright position once the water has receded. • Maintain hedges and replace any gaps or damages to protect the natural environment and retain the benefits of having hedges. Hedges reduce the speed and intensity of water transport in the environment, provide a habitat for wildlife, reduce the spread of disease, act as natural barriers for livestock and provide wind protection and shelter. • If loss of hedges and fences is a common occurrence then it may indicate bank stabilisation issues upstream, causing increased flood debris being washed downstream. Stabilising any waterway banks through techniques such as willow spiling may help reduce land loss and debris damage downstream.
	No ☐	• Regularly check fences and hedges for damage and repair defects in a timely manner to reduce long-term expensive repair costs and to retain their benefit to the farm business as well as the environment. • Consider willow spiling or bank stabilisation if losing fences/hedges and riverbank disturbance is a future concern.

Have you identified land for sustainable drainage systems (SuDS)?	Yes ☐	• Review your current drainage design - there may be further opportunities for SuDS to incorporate a variety of schemes on your farm.
	No ☐	• Consider identifying ideal locations for implementing SuDS drainage solutions to suit your farm, which range in scale from first stage components such as filter strips, to wetlands and offline storage areas.
Have you noticed an increase in soil erosion within your fields?	Yes ☐	• Check your soil for signs of compaction. Are tramlines acting as roadways for water? If so, could you change your tramline procedure (e.g. work across the slope rather than down) or install sediment traps or bunds to catch the overflow and retain materials on farm? • Leave stubble and straw on the surface over winter or plant crops to provide a cover over the soil to reduce the impact of rain on soil dispersion. Cover crops can provide a range of benefits to the soil if introduced in the rotation. • Could cut-off drains be installed to slow down the flow of water through your farm? • Could your soil structure be improved to hold water back and prevent surface run-off or waterlogging? • Are animals poaching soil around riverbanks? This must be avoided (prevent significant poaching within 5 m of a watercourse SEPA CAR Guidance GBR 19). Visit the Farming and Water Scotland website for more information. • If feasible, regularly move or rotate the use of drinking / feeding troughs to reduce the impact of livestock in one location. • Is the cropping regime suitable for the field topography? • Try to avoid harvesting or ploughing on sloping ground during wet conditions and avoid taking machinery on to fields when the ground is saturated.
	No ☐	• Ensure that you check for compaction and monitor any changes closely; early action can save a lot of money and loss of nutrients.
Do you have provisions to cope with damage from flooding and heavy rain?	Yes ☐	• Ensuring that your farm has the ability to adapt and mitigate against flooding and heavy rain events can safeguard your farm for the future.
	No ☐	• Draw up a flood risk plan for your farm; this should include a plan for getting to, moving and rehousing stock if necessary and crop, feed and materials storage. • Consider putting in SuDS designs or natural flood management schemes into your farm to try and absorb the water from changing weather conditions. These schemes can vary from small to large and can offer security on farm. • Does your insurance cover damage from the natural environment?
Have your crop yields suffered damage from increased rainfall?	Yes ☐	• Areas of the field, which are compacted or low-lying can become flooded and damage crops. Check your soil for signs of compaction using the free VESS guide. • Could you change variety next year to a more tolerant species or incorporate greater crop variety to alter harvest times? • Pick the best window of opportunity to harvest when crop, weather and ground conditions are suitable to prevent soil compaction and damage by machinery. Carry out a machinery and equipment capacity calculation for your farm to find out if you are under resourced or have excess capacity to complete operations when weather is less than ideal and have a contingency plan to implement. • Can you make use of the latest technology or consider using lighter machinery or machinery with optimised tyres to reduce compaction across the field and reduce the areas affected by waterlogging? • Prolonged periods of rain and warm weather can lengthen the growing season, resulting in crops and grass growing too high to support themselves, or being too wet, flattening crop (lodging) and making them difficult to harvest. • Consider putting in field drainage if you have not done so already. If field drainage is already present, make sure that it is working effectively as poor drainage may indicate the need for maintenance. For more information on field drainage see the FAS technical notes (TN728).
	No ☐	• Monitor soil structure to ensure that long-term compaction issues do not arise as this can lead to waterlogging, reduced cropping area and reduced yields. • Prepare cropping plans to target crops to the most suitable land for growing that crop and be aware of issues on particular land with different livestock types, that may cause damage to soil structure and grass sward.

If wet periods extend, do you have resources to keep livestock indoors for longer periods?	Yes ☐	• Being prepared will ensure the welfare of your animals and offer you options in extreme weather conditions. • As prolonged wetter periods become a more prominent part of Scottish climate, having the means to keep livestock indoors can be crucial to the wellbeing of your livestock.
	No ☐	• Complete a Farm Slurry and Manure Management Plan for the production, storage and spreading of slurry and farm yard manure. • Be aware of potential diseases and pests that can occur from housing animals or from periods of warm wet weather. Improving shed ventilation, floor surfaces/bedding etc. can help mitigate many of the potential health problems that may occur. • Ensure that you have enough feed stored for any prolonged indoor periods. • Ensure that you have adequate slurry and manure storage facilities to cope with prolonged indoor housing; particularly when periods of rainfall are high. • Consider covering slurry lagoons or tanks to exclude rainwater and retain capacity for slurry produced on farm. This will also help reduce emissions.
Are you seeing problems with farm tracks, access and steading drainage?	Yes ☐	• Ensure that all tracks and drainage are suitably designed and constructed. • Compacted tramlines can contribute to the amount of soil eroded and accelerate runoff from a field. Tramlines should work across the slope rather than down, install sediment traps or bunds to catch the overflow and retain materials on farm and adopt methods to reduce compaction. • Cow tracks can lengthen the grazing season from reduced damage to pasture and improved field access in poor weather. Consider installing cow tracks to reduce compaction and erosion from cow movement. See the FAS technical note TN730 for more information on the benefits and construction of cow tracks. • Ensure field access is appropriate and take steps to minimise diffuse pollution from fields onto public roads. • Are there natural flood management and greening solutions you can install in the steading, such as permeable paving, swales or other SuDS options? • Can you add filter strips (vegetated gentle slopes, where runoff can be diverted) along roads and tracks?
	No ☐	• Ensure that existing access, tracks and drainage options have capacity to deal with future climate change and weather events. • Look for potential improvements you can make on farm to future proof your business.

What can you do now to help future proof the business?

Many of the impacts discussed above are not new, however, climate change is exacerbating the impact to the agricultural community. Implementing measures to adapt against changing rain patterns now can help reduce risks and aid the longevity of your farming business and the productivity of your land.

Alongside monitoring weather forecasts, SEPA's live flooding information page will help you to plan ahead and mitigate any negative effects of flooding. Signing up to SEPA's 'Floodline' service will ensure you receive messages when flooding is forecast in your area. Flood maps can be viewed online so that plans can be made to adapt to areas, which have an increased risk of flooding.

Keep enough provisions to house livestock for longer periods

Explore implementing SuDS and improve drainage

Make use of precision farming techniques and cover crops

Check soil for compaction using the free VESS guide

Maintain fences and hedges

Monitor weather forecasts; have a flood/ wet weather plan in place

Further information:

- Farming and Water Scotland: www.farmingandwaterscotland.org/
- SEPA – Flooding: www.sepa.org.uk/environment/water/flooding/
- SEPA – sign up to Floodline: www.sepa.org.uk/environment/water/flooding/floodline/
- Visual Evaluation of Soil Structure (VESS): www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure
- Farm Advisory Service (FAS): www.fas.scot
- FAS technical notes: www.fas.scot/publication/technical-notes/
- CREW Rural SuDs Design and Build Guide: www.crew.ac.uk/publication/rural-sustainable-drainage-systems-practical-design-and-build-guide-scotlands-farmers
- SRUC Natural Land Management: https://www.sruc.ac.uk/info/120731/natural_land_management

Case study: Adapting to climate change at SRUC Kirkton & Auchtertyre farms

SRUC Kirkton & Auchtertyre farms are situated between the villages of Crianlarich and Tyndrum in west Perthshire, some 56 km north-west of Stirling and in the north-west corner of the Loch Lomond and the Trossachs National Park. The farms cover 2,225 ha of land rising from 170 m on the floodplain of the River Fillan, to 1,025 m at the summit of Ben Challum. The estate is managed by Scotland's Rural College and is a centre for research and demonstration into sustainable land management in hill and mountain areas and is the location for the SRUC Hill & Mountain Research Centre. Currently the farm has 1,090 breeding ewes (900 Scottish Blackface and 190 Lleyn), plus a small herd of suckler cows (24 Aberdeen Angus cross cows and two Highland cows). The farms are made up of 74 ha of improved pasture, 153 ha of semi-improved pasture, 1,677 ha of unimproved rough grazing, and 307 ha of woodland and scrub.

The mean annual rainfall for the farm is over 2,500 mm, with an average of 280 rain days a year. Weather data has been collected at Kirkton since 1991 and although there is no clear trend of increasing annual rainfall totals, the data does indicate more variability with the two wettest years and the driest year all occurring since 2010. The pattern of rainfall through the year also appears to be changing, as does the frequency of extreme weather events. An intense thunderstorm on the evening of the 28th June 2012 resulted in flash flooding that caused extensive damage to the farm infrastructure (including fences, roads, bridges, fields and buildings). **There is clear evidence of warming temperatures with seven of the highest monthly maximum temperatures occurring in the last eight years and the two highest summer temperatures (31.6°C and 29.1°C) being recorded in 2018 and 2019 respectively.**

The high rainfall together with the short growing season, acidic soils, poor quality hill pasture and exposed and steep terrain pose major challenges to the farming operations on the estate. The changing climate will make these challenges even harder.

What is being done to safeguard land?

Looking at ways to mitigate and adapt to climate change on the farms are key areas of interest both in terms of research and management. Some of the land management practices that have been undertaken to try to reduce carbon emissions and mitigate flooding include:

- Peatland restoration;
- Woodland planting;
- Fencing-off more than 2 km of water margin; and
- Management of inbye wetlands.

Dam installation

Peatland restoration work has been carried out on approximately 80 ha of degraded blanket bog on the estate. This has involved re-profiling peat erosion features, known as peat hags; installing peat, wood and gravel dams to slow down and trap water in eroded gullies; and fencing, re-wetting and re-seeding an area of bare peat to encourage regrowth of the vegetation and stabilisation of the peat. The peatland restoration work has not resulted in an actively growing blanket bog yet; however, the peat has become wetter and the area of exposed peat has been reduced, leading to reduced emissions of CO_2 and reduced carbon loss through wind and water erosion.

Peatland restoration provides multiple benefits including:

- Prevents the peat from drying out and releasing CO_2 into the atmosphere;
- Reduces the impacts of flooding by storing more water and slowing down water flow;
- Improves water quality by reducing the amount of particulates and dissolved organic carbon within the water; and
- Improves the quality and condition of the peatland habitat which supports a range of plants, birds, amphibians and invertebrates.

Hag re-profiling

Woodland planting

Over the last twenty years more than 270 ha of native woodland and scrub (over 400,000 trees) have been planted on the estate, most of it at high altitude (above 300 m) in Gleann a'Chlachain, one of the hill glens. More than half of the trees planted were Downy Birch, with the other main species being Alder, Rowan, Scots Pine, Grey Willow, Eared Willow and Hazel. A mountain woodland of low growing trees and shrubs with extensive open areas has been developed, creating a diverse and species-rich habitat. Not only is carbon being stored in the trees but large amounts of carbon is also being stored in the ground vegetation, which is now dominated by heather, other dwarf-shrubs and Purple Moor-grass. The ground vegetation is also rich in flowering tall-herb species such as Meadowsweet, Wood-Crane's-bill and Smooth Lady's-Mantle. The soil beneath this vegetation has developed a thick organic litter layer that is holding more water. The vegetation and soil are also slowing down the flow of water and potentially reducing the risk of flooding down-stream.

Glenn a'Chlachain gorge

Fenced water margin, with a magnificent display of flowering tall

There has also been some tree planting on the inbye ground with two small shelterbelts established under the Agri-environment and Climate Scheme (AECS) and some individually protected trees planted in existing wood pasture. These trees will provide shelter and shade for the livestock, as well as storing carbon, improve soil water infiltration, increase soil nutrient cycling and provide habitat for a range of plants and animals.

New shelterbelt (AECS)

Water margins

Over 2 km of water margin have been fenced-off on the inbye ground at Kirkton & Auchtertyre. Most of these water margins have been established under agri-environment schemes (Countryside Premium Scheme (CPS) and Agri-environment and Climate Scheme (AECS)). These water margins help mitigate flooding by slowing down water flow. They provide buffers reducing the risk of diffuse pollution from the fields, and the lush vegetation growing in the ungrazed strips also stores carbon. They are rich in biodiversity, with many invertebrates (including pollinating insects), birds and mammals using the habitat network that has been created along the burn sides. During the summer they provide a colourful display of flowering tall-herb species that enhances the landscape.

Managed wetland with wader scrapes

Managing inbye wetland areas

A number of inbye wetland areas on the estate are being managed under the AEC scheme. Within these wetland areas six wader scrapes have also been created. Although primarily managed for biodiversity, these wetlands together with the wader scrapes help mitigate flooding by storing water and slowing down the flow of water into the adjacent burns.

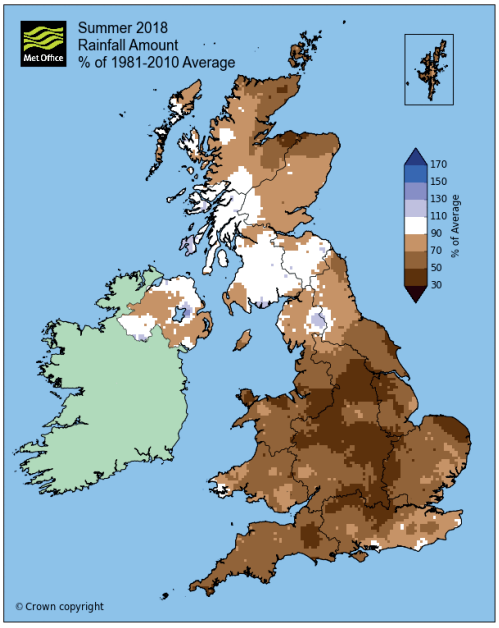
Overview

Through introducing and implementing all these different elements into the farms at Kirkton & Auchtertyre, they are providing vital barriers to the changing climate. Introducing these schemes early can reduce risk and safeguard land, which otherwise could be eroded and washed away. Additionally, while safeguarding the land they provide key areas for biodiversity to expand and offer great amenity and carbon storage.

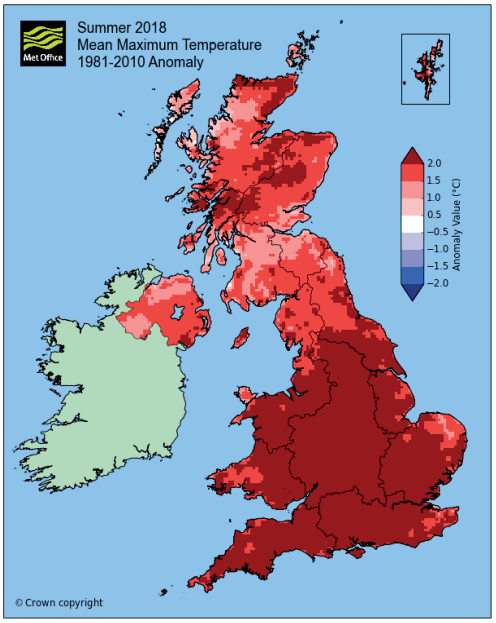
5. Drought & high temperatures

In recent years, there have been increasing concerns about the occurrence of drought conditions and higher temperatures in Scotland. SEPA reported that in 2018 there was a significant drop in average rainfall over the winter months, followed by an unprecedented dry summer with hotter temperatures and heatwaves in the North East of Scotland. This resulted in farmers having to irrigate more than normal, depleting the natural store of water, which was not replenished over the unusually dry winter[16]. Projections for Scotland indicate that even under a low emissions pathway, there will be a 50% chance of each summer being hotter than that of 2018[17].

Soil moisture deficits have also risen since the 1980's resulting in an increased drought risk in the east of Scotland, therefore, demand for irrigation is expected to rise[18]. Furthermore, insurance claims for fire damage in 2018 rose by around 20% from 2017. While the news regularly has stories of wildfires worldwide in countries including Australia, Brazil and the USA, in 2019 the UK broke its record for the largest burnt area (29,334 hectares) and highest number of annual fires (135). Titles that were previously held by the year 2018[19].



Variation of Summer 2018 rainfall across the UK as a percentage of the 1981 to 2010 average rainfall [20]



Variations in summer 2018 mean maximum temperature 1981 to 2010 anomaly values across the UK[20]

Water storage and supply

Streams, rivers and ground water sources used for irrigation, livestock or private drinking water supply may be at risk of drying up during drought conditions.

Water and heat stess (crops)

Many crops will not be able to cope with water stress and yields may be effected by drought through reduced growth, smaller grain size and yield.

Water and heat stress (livestock)

Water and heat stress, lack of shade and relief from direct sunlight on a hot day can lead to dehydration, illness and potentially death of livestock.

Wildfires

Prolonged dry periods such as heatwaves can lead to wildfires, often caused by human activity (either intentionally or accidentally). Impacts include destruction of crops, grassland, heath and peatland.

Drought & high temperatures checklist

Question	Answer	Action
Do you have capacity to store water on farm?	Yes ☐	• Ensure that water storage is maintained, and that drinking water is not likely to be contaminated. • Ensure any non-mains water is treated appropriately and safe to drink for both human and livestock.
	No ☐	• Having the options to store clean water on your farm offers the potential to offset the impact that the unpredictable changes in weather patterns can cause. Whether for irrigation or drinking water for livestock, having a backup can take the pressure off very dry periods. • Consider off-stream reservoirs that can collect winter excess rainfall for use in summer when supplies may be reduced and for winter flood mitigation. • Consider rainwater harvesting systems and abstraction options. Ensure compliance with SEPA regulations regarding when and how much water can be abstracted from burns, rivers, wells and boreholes.
Do you have an irrigation system in place?	Yes ☐	• By having an irrigation system in place you can safeguard your crop. Ensure it is well maintained and complies with SEPA regulations. • Consider all irrigation types for the crop to be irrigated as some are more efficient than others.
	No ☐	• Having the option to be able to water your high value crops can be a way to safeguard your crop and ensure that you do not suffer yield penalties due to lack of water. Many crops cannot cope with drought so having means to provide water may be key as Scottish temperatures increase and rainfall patterns change. • If abstracting water from local burns, rivers or groundwater ensure compliance with SEPA regulations and do not over-extract beyond the limits set. • If abstracting, work with neighbours to draw up an irrigation schedule so as you are not all drawing on the same water source at the same time. • Consider installing systems to collect water over the winter months.
Do you have a backup water source if your current water source runs dry?	Yes ☐	• This can protect your livestock and crops at times when otherwise the land and animals may struggle. • Consider additional back-up measures to ensure long-term resilience and to ensure you can meet drinking water requirements for livestock on your farm.
	No ☐	• To avoid heat stress in livestock, planning ahead will lead to a safer environment for your animals. You have a legal obligation to ensure farm animals do not become dehydrated. Young animals, housed animals on dry-feed only and lactating animals have the biggest risk of dehydration in hot weather. • It is good practice to assess for maximum livestock water requirements and install additional storage to allow for water shortages, and equipment break down. • Additional tree planting and agro-forestry schemes introduce shaded areas where livestock can keep cool. • Multiple water troughs provide extra capacity and allow livestock to easily access water. • It is good practice to build storage into troughs and storage tanks/reservoirs where water supply may be limited. • Consider covering water tanks to reduce evaporation during hot periods for example by using foam or shade balls. • Consider installing nose (pasture) pump water troughs so that water is used by livestock on demand to reduce evaporation. • Have an emergency plan in place with neighbours to share water sources e.g. boreholes. Consider forming an abstraction group to manage water use within a particular catchment. • Collecting and storing rainwater is an option however, if used for animals it will require treatment to meet health standards.

Are you at risk from wildfires?	Yes ☐	• Do you and your team have a fire action plan? Making staff aware and having equipment available onsite to combat wildfires can be crucial to reducing fire risk and destruction. • Avoid unnecessary sparks and naked flames and be aware of fire risk in dry conditions. • Avoid smoking in outdoor and indoor areas where there is a risk of fire catching; designate a safe area for workers to smoke and ensure that cigarettes are firmly put out to stop smouldering in dry grass or near flammable liquids. • Discuss fire fighting capabilities and procedures with your local fire station. The Scottish Wildfire Forum also raises awareness of the work being done across Scotland to minimise the impact of wildfire. • Understand what areas of your land and crops are at risk of wildfires and plan accordingly. • Follow the Muirburn code.
	No ☐	• Familiarise yourself and your staff with the on-farm fire safety protocols to ensure that the farm business stays safe and the risk of wildfires remains low. • Make sure to stay up to date on wildfire risk in your area. The situation may change in the future.
Are you starting to see issues with crops due to drought or hot weather?	Yes ☐	• Investigate alternative tillage and cropping systems that may be able to help conserve soil moisture. • Have you considered alternative bedding solutions? Drought conditions can have a significant impact on straw availability and prices. Having a plan for times when straw becomes an unsustainable bedding source will save you time and money in the future. Refer to the FAS webpage for an overview of alternative bedding solutions. • Are there more drought resistant crop varieties available on the market? • Due to climate change, water stress on crops may be more likely, so it is beneficial to have irrigation options for coping with water deficiencies. • Pests and disease risk increase with hotter temperatures; investigate mechanisms to control pests.
	No ☐	• Continue to monitor crop health and productivity and consider options for diversifying the rotation in order to future-proof the business, protect soil health and conserve soil moisture.

What can you do now to future proof the business?

While the future impact of drought within Scotland is unknown, and will likely vary annually, it is important to be prepared for all outcomes to safeguard your business. By ensuring that you have some back up provisions for providing water and shade you can minimise the impact of high temperatures and water shortages on your farm. Providing habitats for pollinators such as cover crops, wildflower meadows, green roofs, and halting habitat fragmentation can assist crops and can also reduce the effects of extreme dry or wet periods by improving soil water retention and reducing erosion and diffuse pollution risks.

Store water and cover to prevent evaporation or contamination

Invest in irrigation – comply with limits for abstraction set by SEPA

Plant trees/hedges for shade and consider agro-forestry

Provide multiple water troughs with mechanisms to reduce evaporation

Look at ways of minimising and better managing water use on farm

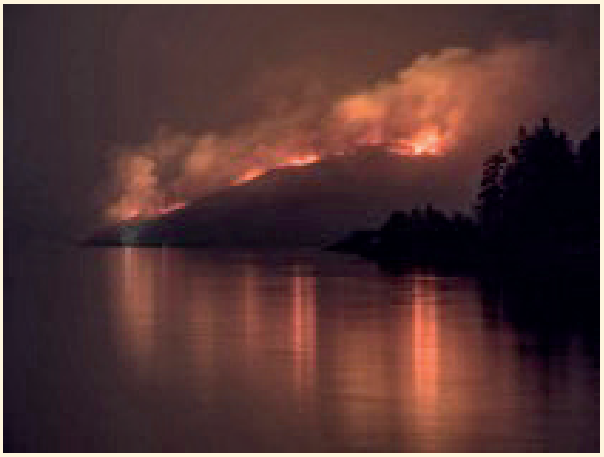
Develop a farm fire action plan to minimise risk

Further information:

- Farming and Water Scotland: www.farmingandwaterscotland.org/
- Scottish Wildfire Forum: www.scottishwildfireforum.co.uk/
- The Muirburn code: www.nature.scot/professional-advice/land-and-sea-management/managing-land/upland-and-moorland/muirburn-code
- Various resources from Scotland's Farm Advisory Service (FAS):
  - o www.fas.scot/news/prolonged-dry-spell-what-can-be-done/
  - o www.fas.scot/publication/feast-or-famine-water-on-your-farm-water-scarcity-video/

Case study: Wildfire in Argyll

Farms and estates in remote locations are becoming more aware of fire risk following a spate of fires across Scotland in 2019. An estate in Argyll with a significant area of hill ground and forestry is now well prepared following a serious hill fire two years ago. Due to the distance from the local fire service to the estate and the possibility of more hill or forestry fires, this estate decided to equip themselves to deal with these in the future.



Hillside fire in Argyll in 2019 © H Bibby

They bought two lightweight firefighting suits with torches, gloves, and helmets, plus a 220 litre water tank, which they could mount on their eight-wheeled argocat. To this, they attached a modified pressure washer and 40 m hose to build themselves a fire fighting unit. They also trained their staff and gamekeepers on safe burning as well as the use of this equipment.

Earlier in 2019, there was another fire on the estate hill ground caused by a portable barbecue. Although the fire was not spotted for some time, the estate workers managed to put it out themselves before the fire service arrived. The local fire service had limited access to the fire and do not carry lightweight suits because they are equipped to deal with structural fires rather than hill fires. Since then, the estate has added 2 leaf blowers to their firefighting equipment, which are supposed to be very effective in tackling some types of hill fires although they have yet to try them out.

When asked if they were more worried about fire now than in the past they said, *"yes, much more"*. This is due to having less controlled burning in the area, although the estate does still burn to manage heather and rank vegetation. They also mentioned climate change producing periods of very dry weather as well as wet, this year was their driest April on record. There are few genuine wildfires and the fires that have occurred on the estate are all manmade. Culturally the Scots are not used to high fire risk in the way that Australians are, therefore, more education and fire warning signs in a local area may prevent fires starting in the first place.

When asked what more they could do in the future they stated that having a coordinated group, possibly run by the local fire service set up to tackle grass fires or at least knowing who to contact and who had the equipment to deal with hill fires may help. If the local fire service was equipped with lightweight clothing, leaf blowers, and training on hill fires that would also be a step forward.

Helen Bibby
Conservation Consultant, Oban

6. Increased storminess

While gales and storms are a common occurrence over winter months in Scotland, it is projected that by 2080 the intensity of storms will increase, with some models also projecting an increased frequency[21]. While there is uncertainty in some of the models, history shows us the damage that extreme weather events can cause. The Great Storm of October 1987 caused significant devastation across the UK; high gusts of winds of up to 100 mph resulted in infrastructure damage with trees falling on roads and bringing down utility lines[22]. Thunderstorms can bring severe damage to properties, hailstones can damage roofs and tiles, dent vehicles, damage glasshouses and bring down vegetation[23]. Strong winds can cause mechanical damage to crops, which will affect growth, yields and pest and disease incidence. Increased susceptibility to disease affects harvest quality, and crop may not meet requirements of its intended market. While plants can adapt and be resilient to high winds, plant specific issues may still occur. Examples of this include, leaf stripping, folding, abrasion and sandblasting[24 25].

The UK Met Office Storm Centre names and dates storms that impact on the UK and provides updates on storms, which are forecasted and monitors storminess. The Met Office reported that over a three month period, between mid-December 2013 and mid-February 2014, there were 12 major storm events making this the stormiest period the UK has seen in 20 years[26]. Since then the UK has experienced numerous storms of comparable or more severe intensities, causing widespread disruption.

The following section looks at the issues associated with storm events and suggests ways to adapt to increased storminess across the farm business.

Issues

Health and safety

Storms, strong winds and high rainfall put staff and livestock health and safety at risk.

Tree damage

Falling trees can block roads, damage fences and hedges and bring down utility lines as well as damage nearby buildings or vehicles.

Infrastructure damage

High winds, heavy rain and hailstones can damage buildings, utilities, roads and other farm structures.

Flooding of coastal areas

Storm surges and rising sea levels are likely to increase flooding low-lying fields resulting in crop loss and soil damage.

Crop and soil damage

High winds and heavy rainfall can reduce crop yields due to stem and tissue damage, increased disease incidence and soil erosion.

Increased storminess checklist

Question	Answer	Action
Have your crops or livestock been affected by high winds and heavy rainfall?	Yes ☐	• Consider using woodland areas and agroforestry techniques to create sheltered areas on the farm for crops and livestock. • Exposed standing crops can be flattened making harvesting difficult or impossible; consider using shelter belts to help reduce wind speeds over cropped areas. • Branches can fall from trees into cropped fields making harvesting more difficult. Be sure to inspect fields regularly and remove fallen branches to reduce chances of equipment damage and contamination of the crop. • Established cover crops are an effective way to reduce soil erosion risk, providing protection for the soil surface. • Hedges provide shelter for crops and livestock from strong winds, heavy rain and reduce wind-chill in livestock.
	No ☐	• Look out for ways to future-proof the business such as regularly inspecting areas in fields under trees for broken branches, identifying areas for agroforestry or hedges, inspecting buildings for signs of damage and keeping livestock and grain reserves secure and protected during storms.
Have you suffered from fallen trees blocking your farm access road?	Yes ☐	• Ensure that you are able to contact the emergency services or neighbours in the event of a tree blocking access to your farm. • Check that you always have adequate provisions of food, water and first aid in case you are trapped in poor weather conditions and are unable to receive help. • Consider how the import and export of products will be affected if access roads are blocked by trees and reduce the flow of goods or uplift of milk, which will affect your business profitability. • Let delivery drivers and customers know in advance that operations have been reduced to manage expectations and protect your farms business relationships. • If the track is used for moving animals around the farm, ensure you have adequate food and water provisions for where the livestock is likely to be before, during and after a storm event.
	No ☐	• Make sure that existing trees are healthy and do not pose a risk of falling on access roads. Do not fell trees without seeking permission as this may be an offense if the species if protected or registered through a Tree Preservation Order (TPO). • Always keep an eye on the weather forecast and make necessary preparations.

Have you suffered from roof damage and damage around buildings?	Yes ☐	• Ensure that roofs are maintained and that loose tiles and sheets are fixed properly to the roof in order to avoid them falling and damaging property or potentially injuring livestock, staff or visitors on the farm. You have a duty to provide a safe working environment for all staff. • Repair any issues with roofs that house livestock to prevent injury to animals. • Roof repairs are also essential for ensuring no water damage is incurred on other valuable farm materials such as grain, electrical items, machinery or fertilisers stored inside.
	No ☐	• Routinely inspect your building structure for damage and look out for signs such as cracks, damp areas, holes or vandalism.
Have you suffered from property damage in general?	Yes ☐	• Ensure that property is secured at all times in the event of a storm to ensure items are not 'picked up' by the wind as this could result in damage or injury to persons or property. • Ensure that doors and windows are locked and secure so that they are not damaged due to high winds as damage can lead to costly repairs.
	No ☐	• Plan ahead for when a storm is expected; keep property secure and maintain buildings to ensure no structural damage to the building or surrounding area. • Ensure that you have appropriate and up to date insurance cover and be aware exactly what you are covered for.
Have you suffered from fallen trees bringing down power or utility lines?	Yes ☐	• Ensure you know who to contact in the event of a power cut or loss of utility access. • Do not fell trees without seeking permission as this may be an offense if the species if protected or registered through a Tree Preservation Order (TPO) or if there are restrictions on operating machinery near utility lines.
	No ☐	• Make sure that existing trees do not risk interfering with overhead power and utility lines and contact the relevant utility company to investigate any concerns. Do not fell trees on your own as this may be an offence if the species is protected or registered through a Tree Preservation Order (TPO).
Have areas of your farm suffered from landslides due to heavy rainfall during storm events?	Yes ☐	• Bare slopes are at an increased risk of suffering from landslides. Vegetation, trees and hedges help to maintain soil structure and prevent rapid soil loss. • Where possible, plough across rather than up and down the slope to prevent preferential flow channels developing the tracks as this can lead to increased soil erosion and runoff.
	No ☐	• Consider the sustainability of management practices particularly on slopes and those that are steep to prevent any issues appearing in the future.

What Can You Do Now to Future Proof the Business?

The increase in frequency and intensity of storm events will put more pressure on agricultural businesses. It is vital your farm business is prepared for all potential impacts. Keeping your steading, access roads and livestock paths clear and maintained and regularly checking weather forecasts are just some of the actions that can be taken to mitigate future losses due to storms. Carry out tree assessment surveys on a regular basis to identify and prune/remove problem trees prior to high winds occurring.

Ensure existing trees are not at risk of falling onto access roads or utility lines.

Always be prepared with food, water and first aid in an emergency where access to/from the farm could be limited.

Maintain roofs and building structures to prevent damage or injury to persons or livestock.

Keep an eye on the weather forecast and sign up for weather alerts so you can secure property when a storm is expected.

Investigate if cover crops or agroforestry can be used to protect soil from erosion and nutrients from being lost to the wider environment.

Maintain fences and hedges to prevent storm damage and prevent livestock escaping from fields.

Further information:

- Agricultural Weather Advisory Panel: www.gov.scot/groups/agricultural-weather-advisory-panel/
- UK Met Office Storm Centre: www.metoffice.gov.uk/weather/warnings-and-advice/uk-storm-centre/index
- Various resources on Scotland's Farm Advisory Service (FAS), including www.fas.scot/publication/storminess-in-a-changing-climate-video/

7. Snowfall and extreme cold weather

Climate projections indicate that much of Scotland will see a reduction in the occurrence of frost and snowfall over the next century, however, smaller decreases will be seen in mountainous regions, particularly in the north and west[2].

Cold weather and snowfall events will continue to be issues that farmers will need to deal with from time to time. Sub-zero temperatures and snowfall conditions can cause damage to infrastructure, crops and livestock. Frost can cause low crop yields by restricting stem growth. At emergence, crops can be vulnerable to hard frost and growth may be restricted. Livestock can suffer from cold stress which can result in injury to limbs and require increased energy to sustain their growth[27]. Additionally, by not preparing for snowfall, there is a chance of reduced access to the farm business and damage to pipes and infrastructure.

Extreme cold spells over recent years, such as 'The Beast from the East,' wreaked havoc on farms across the country, causing, premature deaths of smaller livestock such as lambs and preventing collection and delivery of milk and other goods.

Issues

Farm access

Roads or paths may be blocked and access made more difficult if snow or ice prevents staff, vehicles or machinery from working or moving around the farm. Product uplift deliveries may be reduced, which will impact supply to customers and the profits of the business.

Livestock welfare

Livestock movement around the farm can be impacted by snowfall and icy conditions or flooding due to snowmelt. Livestock may need to be housed for longer during prolonged cold periods. Access to water can be an issue when temperatures are below freezing causing water troughs to freeze.

Infrastructure

Sub-zero temperatures can cause pipes to freeze and burst causing damage and disrupting supply. The weight of snow on building roofs can cause roofs to collapse or water ingress. Freeze-thaw throughout the day may cause building damage where the structure is weaker.

Crop frost damage

Frozen grass and crops can be damaged by repeated freeze-thaw as the water in crops cells expands when freezing. Unexpected low temperatures may cause damage to young crops or crops varieties that are not as winter hardy.

Soil damage

Soil can be damaged during wet and cold conditions due to compaction and water not infiltrating the soil resulting in surface water freezing. Spreading of organic materials must not be done on snow covered ground to protect water quality and the soil from damage.

Sub-zero temperatures

Below freezing conditions affect all aspects of the farm including the health and productivity of livestock and crops. There is also the welfare of staff across the farm as working in freezing conditions can cause sickness, stress and mental health issues.

Snowfall and extreme cold weather checklist

Question	Answer	Action
Have you been unable to access areas of the farm due to heavy snowfall or icy conditions?	Yes ☐	• Do you have any means to clear snow from the road? Consider investing in a snow plough attachment or other equipment to clear the path for access or hiring winter maintenance contractors to provide snow ploughing or gritting services on farm roads to keep the farm open for business. • Can you access your livestock and/or livestock feed and drinking sources easily? Always ensure you have a plan for transporting feed to livestock during sub-zero weather conditions. Ensure livestock have enough food and water. • Repair potholes as these can not only damage vehicles but fill with snow or ice increasing the risk of losing traction on the road to vehicles. • Do you have adequate supplies of water, food and fuel to ensure the safety of you, staff, visitors, contractors and livestock in the event access is blocked?
	No ☐	• To future proof access to the farm, ensure you have equipment to clear the road of snow and grit available to spread during icy conditions. • Maintain the condition of the road so that access is not affected. • If you do not already have one, consider creating an emergency route plan or ways to clear your access for any possible future events.
Does your farm business regularly experience sub-zero temperatures?	Yes ☐	• There should be no spreading in winter when there is no crop demand. Carry out nutrient management and manure storage planning to ensure enough storage is available during periods when it may not be possible to access land for spreading. • Frozen pipes can result in flooding and leaks; check that they are properly insulated. Check that they are isolated particularly if an outside tap or if connected to a drinking trough for livestock. Consider using IBCs to shift water to troughs if pipes are frozen. • Make sure the working conditions are suitable for staff and that there is adequate personal protective equipment to keep warm. Ensure staff rest areas are warm enough to reduce stress and mental health issues. • Ensure livestock have suitable shelter that is dry, warm and well maintained. For slurry based systems, frozen floor surfaces heightens risks of injury; increasing the frequency that scraping systems run may help prevent them from freezing as well as keeping the floor surfaces free from liquids, that may freeze.
	No ☐	• Check that pipe insulation is maintained to reduce the risks of burst pipes or flooding. • Maintain staff rest and work areas to prevent problems during cold periods..
Have farm building roofs been damaged due to heavy snowfall?	Yes ☐	• Contract a qualified person (e.g. an architect, building surveyor or structural engineer) to inspect the damage and identify repair requirements and costs. • If erecting a new shed ensure it is built to spec with heavy snowfall in mind. • Ensure livestock, horses and/or ponies are stored in suitable alternative housing. • If the area is used by employed staff, you must ensure their safety; restrict access to unsafe areas for Health and Safety reasons. • Ensure roofs are safely cleared after any large amount of snowfall to reduce the risk of collapse. Climbing onto building roofs to clear them is not advised and should be avoided.
	No ☐	• Regularly inspect farm buildings for any issues and arrange to have repairs done as soon as possible. • Ensure roofs are safely cleared after any large amount of snowfall to reduce the risk of collapse.
Have your crops suffered frost damage due to frost and sub-zero temperatures?	Yes ☐	• Crops suffer at different sub-zero temperatures depending on the stage of growth. Flowering and fruiting stages are more susceptible than the germination phase when crops are typically most hardy. • Cover crops can be hardy winter crops that help to protect soil and water quality.
	No ☐	• Keep records and notes of any instances of frost that occur and damages crops in order to identify any trends relating to cropping or weather that might impact your business in the future.

Do you have livestock on the farm that could be affected by extreme cold weather?	Yes ☐	• Your business plan must meet your legal obligation to look after livestock health and wellbeing during extreme cold weather. There is increased feeding requirements in cold weather and youngstock e.g. calves/lambs etc. will need increased amounts of feed. • You must provide enough food and water for your animals on a daily basis (you can check the minimum daily water requirements for each animal type at www.gov.uk/guidance/keeping-farm-animals-and-horses-in-extreme-weather). • Check that drinking water sources for farm animals are not frozen over. It is a legal obligation to keep drinking water free from ice for outside animals. • Livestock must have access to shelter during extreme weather; this could mean moving them to another location or seeking suitable alternative livestock housing. • Calf/lamb jackets can reduce the energy lost to keeping warm.
	No ☐	• Livestock can become ill from extreme cold weather even when housed if buildings are not maintained properly. Ensure you regularly inspect, maintain and repair damages and manage livestock housing periods based on the outlook for the season e.g. consider bringing animals inside earlier.

What Can You Do Now to Future Proof the Business?

The impacts of sub-zero temperatures and snow are not new and will continue to cause some disruption to the farm business even with a changing climate. By implementing measures to adapt to periods of intense snow and falls in temperature, you can reduce the risks and prevent future negative impacts to your business. Planting shelter belts or hedges to protect against prevailing winds can have multiple other benefits including reducing surface runoff and increasing biodiversity.

Ensure livestock have suitable housing or shelter and access to feed during sub-zero temperatures or large amounts of snowfall.

Always be prepared with food, water, fuel, first aid and emergency supplies if access to and from the farm could be limited.

Maintain roofs and building structures to prevent damage or injury to people or livestock.

Keep an eye on the weather forecast and sign up for weather alerts so you can secure property and livestock when bad weather is expected.

Monitor the condition of buildings and roofs and clear snow build up or evacuate livestock in the event that too much snow has accumulated on top of the structures.

Consider investing in a snow plough or hiring winter contractors to keep access roads clear and safe.

Ensure there is a safe working environment for staff, visitors and contractors by providing appropriate cold weather PPE and access to warm rest facilities.

Further information:

- Agricultural Weather Advisory Panel: www.gov.scot/groups/agricultural-weather-advisory-panel/
- Winter preparation advice for farmers and crofters: www.gov.scot/publications/winter-preparation-advice-for-farmers-and-crofters-october-2018/
- Various resources on Scotland's Farm Advisory Service (FAS) website, including:
  - www.fas.scot/news/keeping-calves-productive-and-healthy-in-cold-conditions/
  - www.fas.scot/article/coping-with-the-bad-weather/
  - www.fas.scot/article/lambing-in-bad-weather/

Case study: Cold weather precautions for dairy farms

Cold, icy and weather with heavy snow can all have a detrimental effect on the smoothing running of a dairy farm. The welfare of the animals and the accessibility of staff and vehicles are important considerations. There are a number of systems that can be put in place to allow the continued functioning of the farm, even in very cold or snowy weather.

Outwintering heifers, Crichton Royal Farm

Ensuring that any outwintering animals have sufficient feed is important. Putting silage bales out in the field at the start of the season and opening them up as the animals are strip grazed down the field should be considered to reduce vehicle movements. If the ground is snow covered for an extended period then extra silage bales can be placed in the field.
A recent trial of outwintered in calf heifers showed that the animals continued to increase in liveweight over a period when snow was on the ground as long as they had access to big baled silage, however, during an extended period of wet and windy weather they struggled to maintain the gains expected.

Housed animals may need some extra protection from cold winds and easy to open and close doors at the end of the feeding passage is useful to allow heat to be maintained in the cowshed.

Access to the farm is important both in icy and snowy conditions. At Crichton Royal Farm there is a standing agreement with a local contractor to come to the farm when the temperatures are predicted to be below zero or snow is forecast, to spread grit and scrape the access roads clear of snow.

In addition, the telehandler has a bucket attachment that can scrape snow from the main drive and most commonly used access around the farm buildings. The bulk tank is also sufficient for two days' worth of milking to allow for any delay in reaching the farm if road conditions are poor.

Calves can be vulnerable to the cold weather and at Crichton we have individual hutches for the calves that are less than 2 weeks old to provide protection and once moved into the communal igloos they can decide themselves when they go inside the igloos and maintain their warmth. Deep bedded straw is used in both the hutches and group calf areas, including inside the igloos to allow the calves to bed down and keep warm. Big bales or straw bales are used as a wind break against the prevailing wind through the winter to provide extra protection.

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8. Summary

Weather uncertainties due to a changing climate can put the Scottish agricultural sector at risk. This document provides a checklist of actions, which farmers can adapt and consider for a range of climate change related scenarios and should help improve the resilience of farms in Scotland. In Scotland, climate change is generally expected to create wetter and milder winters and hotter and drier summers over the coming century. Extreme weather events, such as heatwaves, are also expected to increase in frequency and intensity. These changes will put considerable pressure on farm businesses as issues such as flooding, drought, pests and invasive species become more commonplace.

While it is important to try and prevent and minimise climate change, through reducing emissions and implementing other environmental measures, the effects of climate change are already being felt and experienced by many. To ensure that farm businesses are protected from the financial and physical impacts of these changes, climate change adaptation strategies that save costs as well as protect staff, crops and livestock health should be put in place. Protect farm income by investing in storage or facilities to mitigate potential effects of extreme weather. There are some potential positives as a result of a changing climate for Scottish agriculture, which farmers should also be aware of to maximise any benefits to their business.

This guide and checklists should be used to help your farm adapt and prepare Scottish agriculture for climate change.

Further resources:

- Adaptation Scotland - www.adaptationscotland.org.uk
- Agricultural Weather Advisory Panel - www.gov.scot/groups/agricultural-weather-advisory-panel/
- Farm Advisory Service - www.fas.scot
- Farming for a Better Climate - www.farmingforabetterclimate.org
- Farming and Water Scotland - www.farmingandwaterscotland.org
- Nature Friendly Farming Network - www.nffn.org.uk
- Scottish Government: Climate change adaptation - www.gov.scot/policies/climate-change/climate-change-adaptation
- Soil Association Scotland: Farming for the future - www.soilassociation.org/our-work-in-scotland/farming-for-the-future

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Farming for a Better Climate

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