

**CREW**  CENTRE OF  
EXPERTISE  
FOR WATERS



# Planning for Water Scarcity

Practical guidance for Scottish farmers and growers

**SRUC** 

 The James  
**Hutton**  
Institute

 UNIVERSITY OF  
**ABERDEEN**

**SAOS**   
Working together to shape the future  
of farming and food

# Planning for Water Scarcity

**For decades, Scotland's agricultural sector has navigated fluctuating water cycles. From periods of abundance and full groundwater level recharge, to severe, localised scarcity. As explained in Section 1 these trends are projected to intensify, presenting significant challenges for both land and water management.**

This guidance has been developed to provide farmers and growers with the practical tools and methods to build climate resilience and maintain a profitable business. The guidance will help to protect crop yields, improve biodiversity, and contribute towards supporting rural livelihoods in the face of increasing water stress.

Whilst water availability and requirements vary by holding, Sections 1-3 discuss water availability background and authorisations you need to be aware of, and Sections 4-7 suggest ways to manage water more efficiently on farm, secure your supply and safeguard for the future protecting your business for the years ahead.



## Contents

Section 1 – Water availability in Scotland	4
Section 2 – Regulation: know your responsibility	10
Section 3 – Valuing water	14
Section 4 – How resilient is your farm business to water scarcity?	22
Section 5 – Water resources and authorisation	34
Section 6 – Manage water and irrigate efficiently	46
Section 7 – Increasing resilience to water scarcity on the farm; steps and strategies	62
Appendix 1: Know your risk assessment	76
Appendix 2: Creating a weather resilience plan	89
Glossary of terms	90
References	90

# Section 1 – Water availability in Scotland

This section considers how water availability is changing across Scotland, and how a changing climate could impact water use on the farm.

Scotland is widely considered to be a wet country, with plenty of rain and water in abundance. However, this is predicted to change. How this impacts businesses will depend on the mitigation measures in place and level of demand. Water is a key resource across the nation, from drinking water to hydropower, to food businesses and whisky production. Both surface and ground water is in demand, and this resource needs to be protected and used efficiently to sustain supply for all sectors when needed.

## Water scarcity

We used to talk about drought as something that happened during the summer months, due to lack of rainfall. Today we are increasingly hearing the term ‘water scarcity.’ Consider this in terms of supply and demand – our needs increase at a time when water availability in our rivers, burns and groundwaters is already low and under pressure. Water scarcity can last for years if not effectively managed and can have a lasting impact on both water users and the environment.

*In May 2025, the whole of Scotland was classified as at ‘early warning’ to ‘moderate’ in terms of water scarcity levels: The risk of water scarcity is affecting all of Scotland.*

## Patterns are changing

It is now widely accepted that climate change is the main driver behind water scarcity risk. Historical records, though limited, highlight that severe water scarcity events in Scotland have occurred and caused significant impacts. Evidence (and recent experience) appears to confirm that we are seeing a trend in Scotland’s climate towards prolonged drier spells.

## 2018

Most of Scotland was under alert or at higher risk of water scarcity at some point

## 2022–23

Pockets of moderate to significant water scarcity

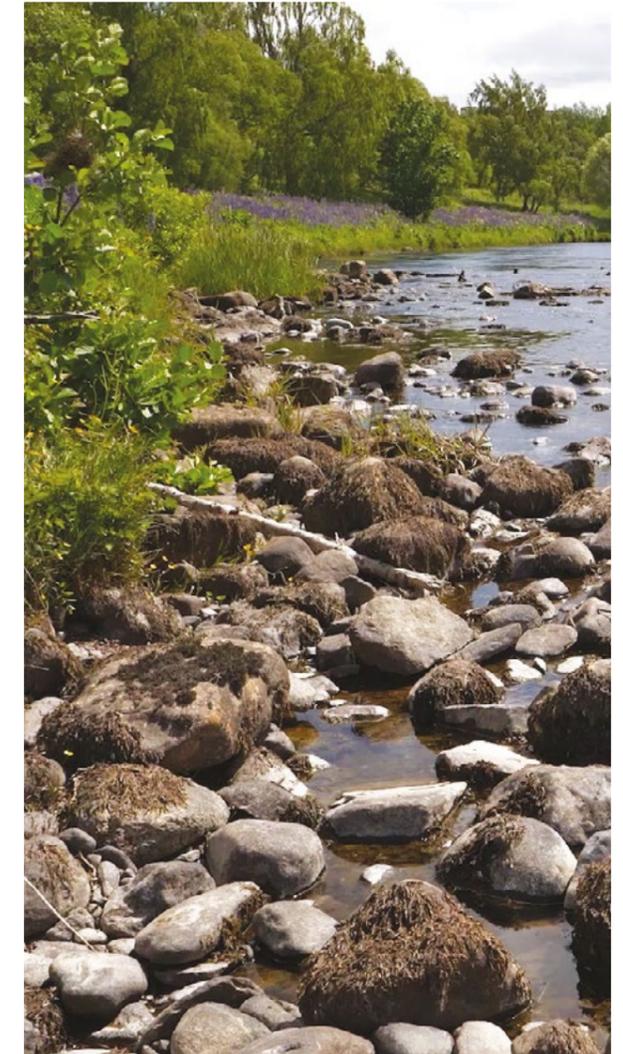
## 2025

Groundwater levels reached record lows during August and September

These recent water scarcity events have had an impact on farm businesses, for example:

- Restrictions in irrigation.
- Rainfed crops and pasture suffered considerable **yield losses** due to changing climate conditions.
- The 2018 season’s combined winter and spring extreme weather led to major losses in both crop and livestock sectors (e.g. estimates suggest £34 million lost in wheat yields alone).
- June 2023 saw several eastern catchments reaching **Significant scarcity** status (the highest water scarcity alert level) unusually early.
- This led to **emergency measures**, and some irrigation licenses were temporarily suspended, particularly in parts of the River Eden and others, to preserve environmental flows.

*In 2018, farming losses due to drought topped £161 million, showing just how costly water shortages can be (WWF Scotland).<sup>[1]</sup>*



Climate change predictions show that these trends in water scarcity are set to become more common.

Water scarcity is set to become a more common feature. It is projected that by 2050, the occurrence droughts across 23 of Scotland's rivers will almost double on average.<sup>[2]</sup>



Climate projections suggest a shift toward drier springs and summers, with more concentrated rainfall in autumn and winter months. Spring (especially April–May) and late summer (August–September) are projected to be noticeably drier coinciding with key stages in crop production (i.e., spring crop establishment and grain filling).<sup>[3]</sup>

Some catchments could see severely low river flows every second year on average, rather than only a couple of times per decade.

By the 2040's, summers on the east coast of Scotland are likely to be drier and warmer on average, increasing crop water demand and evaporation.<sup>[3]</sup>

In short, the changes we see in rainfall and temperature are having (and will continue to have) an impact on water availability across Scotland (Figure 1).<sup>[2]</sup>

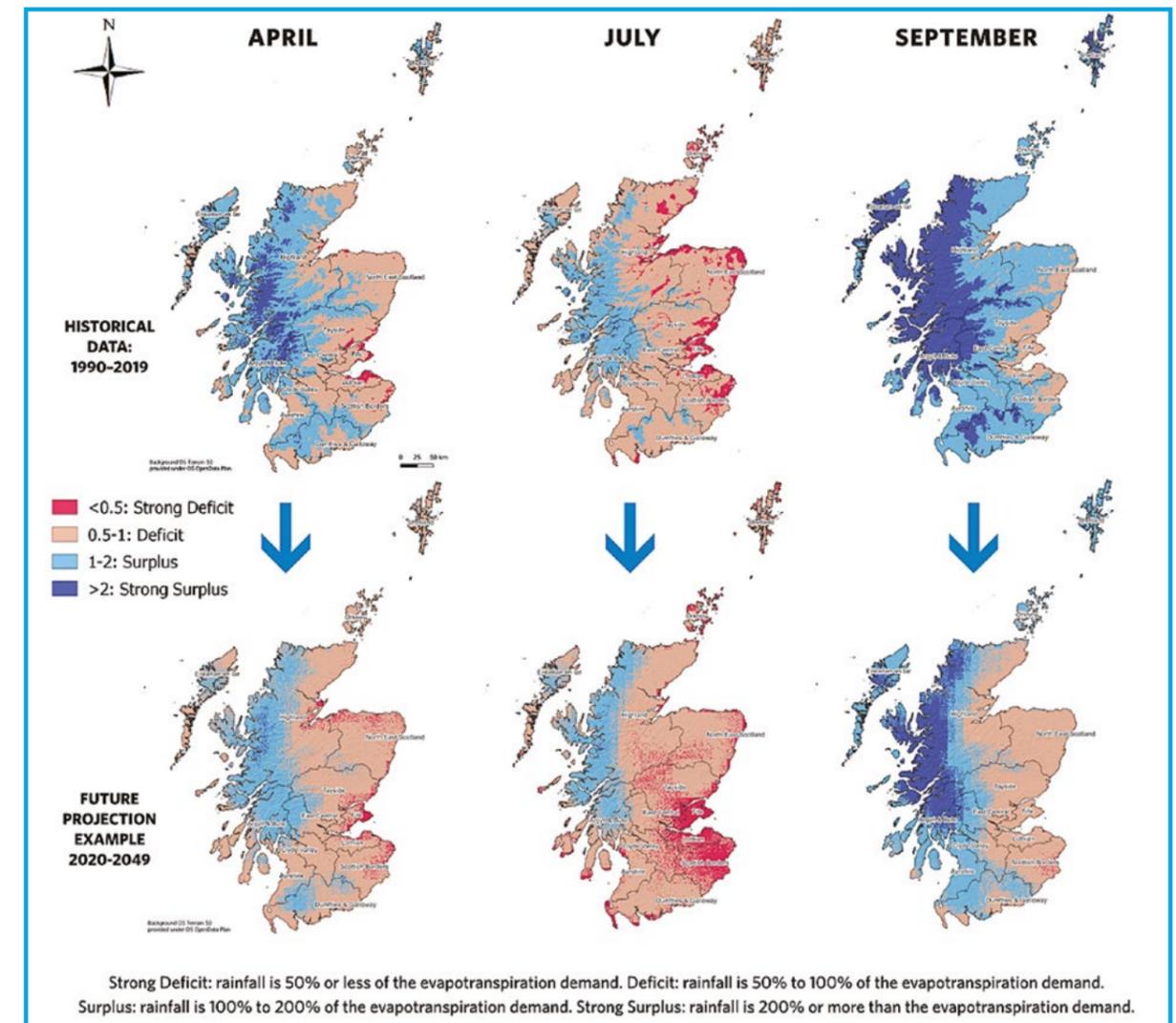


Figure 1: Future Projections for water scarcity in Scotland: Impact on the arable sector<sup>[2]</sup>

## Potential impacts on agricultural production

Dry spells reduce soil moisture, lower river flows, and can lead to irrigation bans. This affects both irrigated and rainfed crops. In 2018, farming losses topped £161 million, showing just how costly drought can be.<sup>[1]</sup> Critically, the timing of dry spells is shifting. Dry springs can delay germination or stunt early crop growth, while late-summer drought can hit yields during grain filling or cause early senescence in crops like potatoes and vegetables. The impact of dry spells on grassland can lead to the reduction of yield and nutritional value to grazing animals. Grass can be forced into dormancy, turn yellow or go to seed.

Warmer temperatures accompanying these periods (the climate change predictions suggest we will see a trend towards warmer than average summers in Scotland) will further intensify crop water demand and stress. Even rainfed cereal and grassland systems that usually don't irrigate could

see yield reductions in dry years due to soil moisture deficits. The evidence clearly indicates that drought is not solely a concern for traditionally irrigated crops, but a broader risk for all arable and livestock farming through reduced soil moisture and water availability when it's needed most.

SEPA's records show that water scarcity can develop at any time from late spring into autumn, depending on rainfall patterns. It is also highly spatially variable – one region can be in drought while another has normal conditions, as seen in typical summers. This variability complicates risk assessment: a farm's drought risk is very location-specific, tied to its catchment's hydrology and its water source. For instance, farms drawing from small burns or shallow wells are often at higher risk of running dry than those on large rivers or deep boreholes, because small sources respond more quickly to rainfall shortages.

### Increased frequency and duration of surface-water droughts will lead to:



Reduced soil moisture



Lower river flows

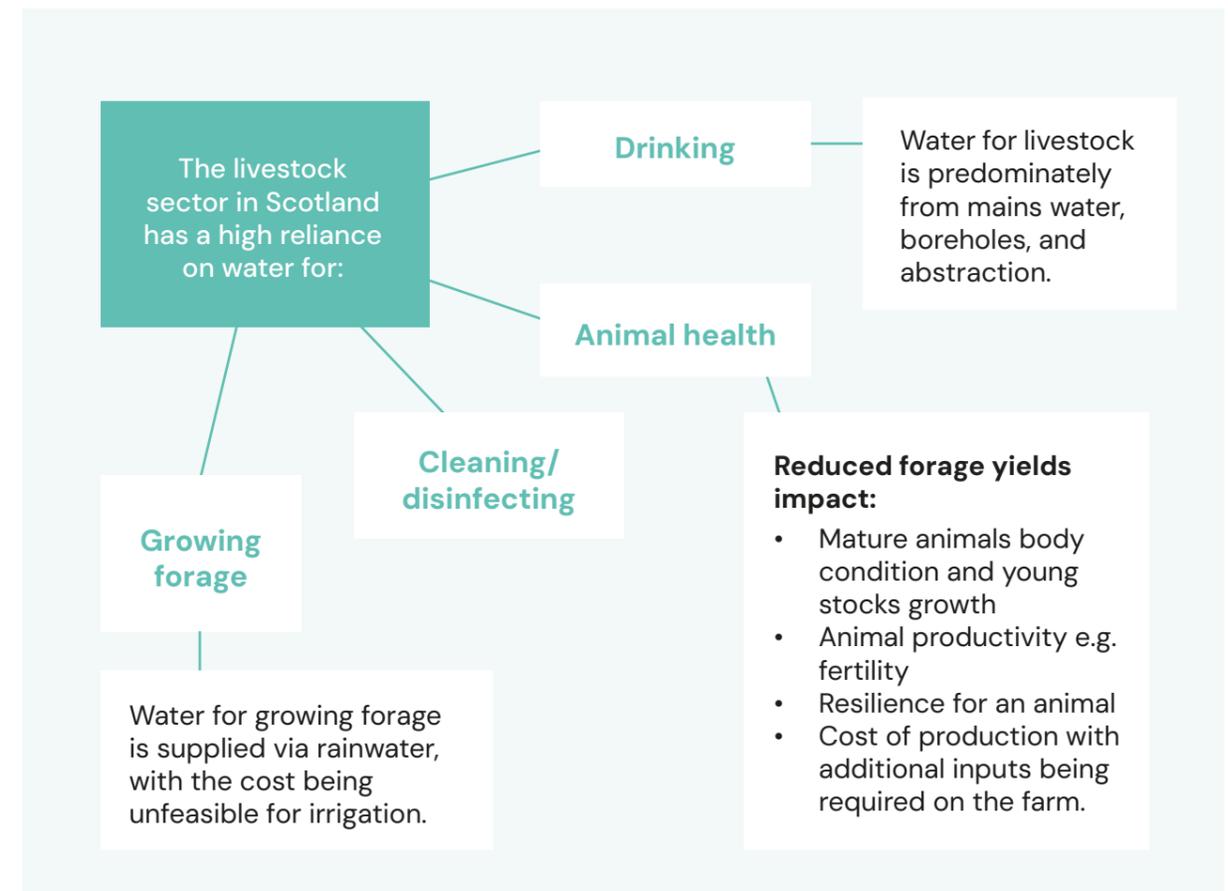


Irrigation restrictions

Water scarcity affects both irrigated and rain-fed crops, leading to a significant production risk for both arable and forage crops.

## Impacts on Livestock

It is not just horticulture and arable producers that will be impacted. Those with livestock will need to put measures in place to protect water resources and availability, both for access to drinking water and to ensure forage quality.



Reduced grass growth in the spring and summer will impact winter forage supplies, leading to additional cost for the farm business.

### Further information and resources

- The full report and supporting material of [CREW's Climate Crisis: informing Scotland's actionable mitigation and adaptation response to water scarcity can be found here](#)
- CREW produced a report in 2024 which examines the [Future Predictions of Water Scarcity in Scotland: Impacts to Distilleries and Agricultural Abstractors](#), includes link to video output explaining the project.
- The Farm Advisory Service has a stock of [information on water management](#), with top tips and practical advice

# Section 2 – Regulation: know your responsibility

This section explores the implications of water scarcity on water users in Scotland and the processes, which are in place to ensure there is enough water for all.

## Wider environmental impacts

During dry periods, water levels in rivers and streams drop, placing stress on aquatic species such as damselflies and mayflies and putting species of conservation concern at risk (e.g. freshwater pearl mussels, salmon). It is not only invertebrates and fish that suffer. As streams dry out, the specialist plant species that live in rivers and riverbanks, for example hemlock, water-dropwort and water crowfoot, also suffer. Riverbank vegetation provides essential habitats and refuge for many species, and its loss further increases the pressure on already stressed ecosystems. Impacts of drought are often exacerbated by human activity, particularly water abstraction during dry periods when natural flows are already low.

The effect of drought extends beyond reduced flow rates. As water levels drop, pollutants can become more concentrated, and fine sediments settle on the riverbed, smothering gravel habitats used by aquatic insects and spawning fish. Droughts often coincide with heatwaves and streams with low flow rates are particularly prone to overheating. Elevated water temperatures reduce oxygen levels harming a wide range of aquatic life, including economically important salmon populations. Warm, nutrient-rich conditions can also encourage algal blooms, which further deplete oxygen and create poor conditions for aquatic life, making this water unpalatable, if not toxic for both wildlife and livestock.

Restoring rivers to more natural conditions, removing man-made barriers such as dams and weirs (operation, modification and removal of a dam or weir will need authorisation from SEPA), and reinstating aquatic and riverside vegetation build resilience, helping freshwater ecosystems recover from periods of drought.

Abstracting water at times of low flows will put additional pressure on both the environment and other water users. Over-abstraction impacts may include:

- Lower river levels
- Reduced oxygen content
- Disrupted aquatic habitats

Groundwater abstraction (if unmanaged) can lower water tables, which affects springs, wetlands, neighbouring boreholes and also impacts river baseflow. Removing water from the environment, whether from surface or ground sources, can lead to long-term harm to the environment, soils, and biodiversity. Earthworms, fungi, and bacteria, which play a vital role in maintaining soil structure and fertility, struggle during extreme drought. Steps to increase soil water retention and infiltration, for example building organic matter or reducing compaction, can help mitigate these impacts and build resilience into the farm business.

## Managing abstraction volumes

SEPA's authorisation framework prioritises the protection of physical and ecological status, and everyone who takes water is expected to demonstrate that their use is **sustainable**.

### All abstractions over 10 cubic metres per day require authorisation from SEPA.

As part of the authorisation framework, farms must monitor water use and provide returns to SEPA as part of their permit to abstract. Being familiar with your permit conditions, water use and [SEPA's water scarcity](#) guidance can help prevent disruption. During water scarcity, temporary suspensions or curtailments can be issued, with all water users expected to comply promptly.



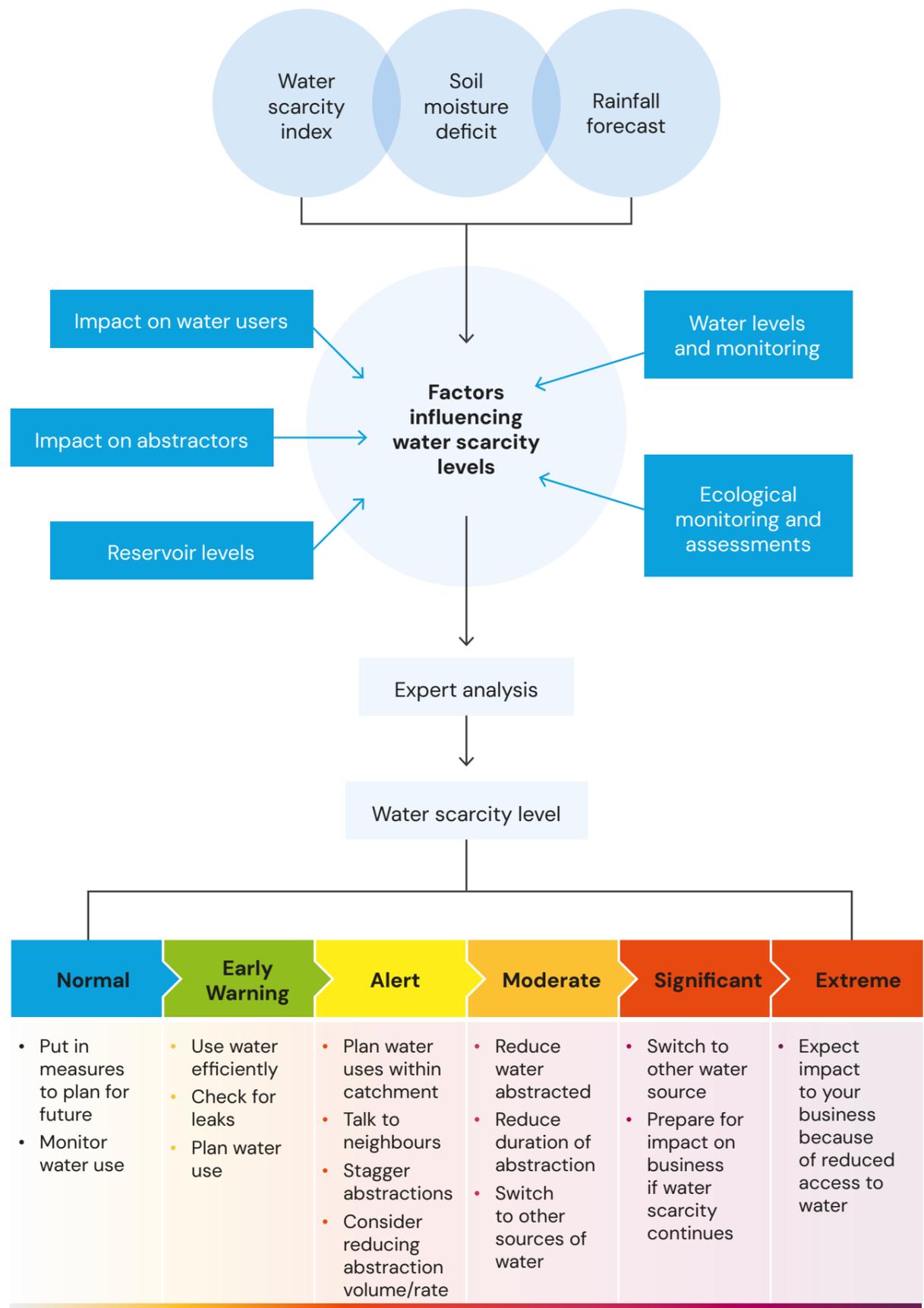


Figure 2: Process used to amend EASR abstraction permits adapted from [Scotland's National Water Scarcity Plan \(2020\)](#)

## SEPA National Water Scarcity plan

For farms reliant on irrigation, it is likely that this water is drawn from local rivers under an abstraction permit. Dry spells leading to low river flows reduce the water available for all users and can trigger regulatory action.

[Scotland's National Water Scarcity Plan](#) provides a framework to better manage water resources, highlighting water scarcity risk across Scotland. This includes:

- **Early Warning and Alert** – users will be asked to voluntarily reduce use.
- **Moderate and Significant scarcity** – restrictions can be imposed.
- **Significant scarcity** – SEPA may temporarily stop or change your abstraction permit conditions to protect river wildlife and habitats.

This means your main source of water for irrigation could be legally or physically unavailable at a time of peak demand (typically summer), putting your business at increased risk.

Figure 2 gives an outline of some of the factors that SEPA consider when changing abstraction permit conditions.

SEPA provide a [Weekly Water Situation Report](#) during May to September, which highlights the water scarcity status risk in your area. Licence holders can sign up to a text service to help anticipate restrictions and plan ahead (Figure 3).

### Further information and resources

- [SEPA Water Scarcity Reports](#)
- [Scotland's National Water Scarcity Plan \(2020\)](#)
- Abstraction volumes and levels of Authorisation, can be found [on SEPA surface and groundwater abstraction webpages](#)
- Guidance on protecting and improving water quality is available at [Farming and Water Scotland](#)

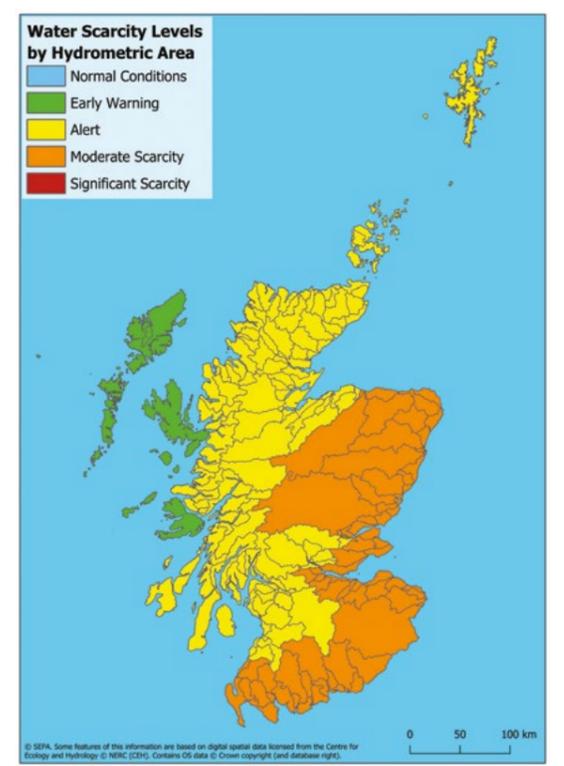


Figure 3: Water Scarcity Levels in Scotland: 22 May 2025 © SEPA. Some features of this information are based on digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH). Contains OS data © Crown copyright (and database rights)

*In 2020–2022 and 2025, several Scottish growers experienced periods where they had to stop or reduce irrigating because watercourses fell to critical lows.*

# Section 3

## - Valuing water

This section looks at some of the financial aspects of water use in times of water scarcity, considering both livestock needs and crop irrigation.

### Rainfed crops and grassland

The majority of crop and grassland production in Scotland is achieved through rainfed sources, meaning there are often no direct water costs. Value is associated with soil moisture availability and its influence on crop growth and yield.

During extreme weather events in 2017-2018, including drought events, a **9% reduction in yield for cereal crops was recorded**.<sup>[4]</sup> The below-average grassland growth had an impact on livestock numbers, due to reduced grass growth limiting feed, body condition and productivity resulting in animals being marketed earlier or herds/flocks being reduced to protect feed stock.<sup>[1]</sup>

associated with irrigation.<sup>[5][6]</sup> The increased value per crop calculated can be seen in Figure 4 (per m<sup>3</sup> water used):



Figure 4: Increased value per crop (per m<sup>3</sup> water used)

*Maintaining sustainable and profitable agricultural production is key to Scotland's food security. This is being further challenged by climate change and biodiversity loss.*

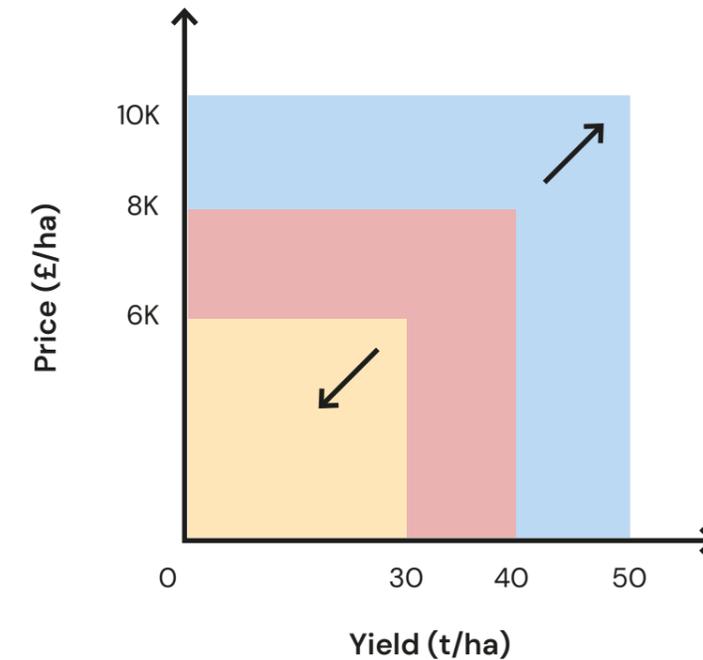
*Efficient irrigation equals the ratio between the actual water used by crops and the amount of water applied.*

### Irrigated crops

Irrigation is required for certain vegetable and fruit crops to both increase yield, quality, and value<sup>[4]</sup> when this cannot be met by rainfall. Studies in eastern England have indicated that efficient irrigation can bring yield improvements and increased value per m<sup>3</sup> of water used for irrigation compared to the same non-irrigated crop, even after accounting for the additional costs

For some crops, the additional costs of irrigation are greater than the price and yield benefits. During a dry year when crops require additional water (such as those above), it is vital that irrigation methods are as efficient as possible to realise the quality and yield benefits and ensure the costs of irrigation don't exceed the revenue benefits, (Figure 5). Our guidance on how to improve irrigation efficiencies, monitor and measure water and soil conditions, and adapt to changing climatic conditions can help ensure the maximum value of irrigation.

Using a potato crop as an example, Figure 5 compares efficient and inefficient irrigation and the impact that has on both yield and profit.



Baseline non-irrigate price and yield.

Efficient irrigation improves crop quality, increasing yield and price. However, irrigation increases production costs. There has to be a balance between the increased costs in irrigation to the income generated from higher prices/yields gained.

Inefficient irrigation can reduce or have no impact on crop quality due to over irrigating or water not reaching crops. Yield and price are either reduced or unaffected and additional or higher irrigation costs reduce revenue.

Values are for example purposes only, yield and price will vary under different location, weather and crop conditions.

Figure 5: The price and yield benefits of irrigation - where is the balance? <sup>[7]</sup>

## Livestock requirements

Estimations for livestock water use involve using the daily drinking water requirement for different animals and the number of animals in a livestock unit. Note these figures are a guide as the figure depends on factors such as weather conditions, grass dry matter, and whether the animal is lactating. The daily livestock water use values used to calculate livestock are provided in Table 1.

**Table 1: Daily livestock water use**

Livestock type	Average daily water use (l)	Source
Dairy cattle (in milk)	75–125	<a href="#">SAC Consulting Farm Management Handbook 2024/2025 page 409–410</a>
Beef cattle (spring calving)	14–40	
Calves	5	
Growing cattle	15–75	
Sheep (in lamb)	3–6	
Lambs	2	
Sow (in lactation)	15–30	
Finishing pigs	5–6	
Poultry broilers (per 100 birds)	0.19–0.20	

The dry matter of the diet will also impact on how much water an animal requires, e.g. a silage ration with a dry matter of 25% will require less water than a straw-based ration, where the dry matter would be closer to 86%.

What is not factored here is how much water will be required for cleaning and disinfecting. This will depend on infrastructure available. However, there must be enough water supply available to maintain this.



## Livestock

Access to drinking water is essential for animal health, welfare, and productivity. If water intake is restricted, it can result in reduced milk yields, reduce body condition score (BCS), reduce feed intake and feed conversion, reduced fertility, growth and more.

Measuring and monitoring water use to understand the amount of water that is required for animal rearing and production is critical for your business. The economic cost of water to a livestock system is extremely difficult to calculate, due to varying water requirements e.g. a dairy cow requires in the region of 150 litres per day, where as a beef cow requires approximately 30 litres.

If an animal is limited in available nutrition from forage, their body condition will be compromised (see box 1). Low condition directly affects the productivity of the sheep including fertility, lamb survival, death rate, mothering ability or lamb growth rates. A loss of one unit, as measured by BCS is 12–13% of their live weight. An example here would be an 80 kg ewe, 1 unit of BCS, is ~9.6 kg of live weight or a 750 kg cow, 1 unit of BCS, is ~90 kg of liveweight. A body condition unit takes in the region of 6–8 weeks to regain, with additional energy and protein sources being required.

### Box 1

#### Impact of dry conditions on flock productivity

A flock of 100 ewes who are below their target condition score at weaning (July/August).

The target for a lowland ewe is BCS 2.5 at weaning (summer), and BCS 3.5 at tugging (autumn).

To achieve this, it requires 55–65 MJ ME/kg gain. This has to be eaten in addition to maintenance; this will only occur if the D value (digestibility) of the grass is high enough to enable the ewe to eat around 3 % of bodyweight/day.

In dry conditions there will be less leaf on grass than typical growing conditions, stems have a 20 % lower intake level than leaves, due to taking longer to break down. It takes approx. 6–8 weeks to gain a BCS, which means a gain of ~170grams/head/day. This increase in BCS will increase her scanning percentage by 20–40 %. However, if her condition is below the 2.5 at weaning, she will require supplementary feeding in concentrates.





### Monitoring, metering and adapting

Estimates of crop and livestock water requirements are helpful for planning your water use. Metering and or monitor water conditions and usage helps to further increase efficiency and help adapt to changing conditions.

- Monitoring near-future weather forecasts can help determine if water applications are required. Additionally, weekly SEPA water scarcity updates provide local climate and water conditions to help support water use management.
- Monitoring soil moisture can inform if, and when additional water is required for crops. The latest soil moisture sensors can provide real-time measurements to inform irrigation scheduling to increase crop water uptake efficiency. Having accurate data on when to irrigate could prevent overwatering and reduce the amount of water, money and time that may be wasted, while protecting crop quality and yield.
- Metering water and associated energy use, as well as monitoring associated time spent on irrigation, provides accurate information on daily and annual usage. Gaining this accurate information provides a better understanding of efficiencies and identifies where savings could be made and reduces time spent estimating usage for regulatory compliance.
- Water metering can allow for measuring water use across different enterprises, for example, differentiating between water use for livestock practices and irrigation.
- Monitoring and accurate metering allow for adaptation to be made due to changing circumstances and between growing seasons to improve efficiencies and resilience.
- Monitoring allows you to benchmark farm performance against similar farm enterprises.
- Monitoring allows for efficient water management and use. Through monitoring you can develop more accurate scheduling plans which will lead to more efficient water application to your land. Further information can be found in Section 4, p22-33.

**Monitor weather forecasts**

**Monitor soil moisture**

**Monitor time spent irrigating**

**Monitor water use via different tasks**

#### Further information and resources

- Monthly climatic water balance information and historical and future trends are available from [Scotland's observed climate trends and future projections](#).
- Soil available water capacity map can be sourced from [Scotland's soils: Map of available water capacity](#).
- A more detailed analysis of potato irrigation requirements for Scottish conditions is provided by Knox et al., (2009) Assessing Water Requirements for Irrigated Agriculture in Scotland.<sup>[8]</sup>
- For more information on water requirements which can be estimated for other commonly irrigated crops such as sugar beet, carrots, onions and soft fruits using soil type and different geographic locations from England are provided by Mathieson et al., (2002) Optimum Use of Water for Industry and Agriculture Dependent on Direct Abstraction.<sup>[9]</sup>

## Calculating water requirements

Measuring water use can help you to monitor costs, improve efficiency, and ensure both crops and livestock are receiving the appropriate amount of water, optimising outputs. Increased costs associated with inefficient irrigation, including pumping, and energy costs due to overwatering, can negatively impact farm revenues. You do not want to pay for more than you need, so understanding crop water requirements and taking accurate water use measurements can benefit the farm business. Taking too much water can also have negative implications for neighbouring water users, the public water supply, and the local environment. Abstraction authorisations require the permit holder to submit a record of their annual water use for the authorised activity under the authorisation.

Following from this, Figure 6, offers a different way to look at factors influencing crop water requirements. By examining the climate water balance and soil available water capacity, an overview of potential issues can be gained with water availability.

## Factors influencing crop water requirements

Climatic water balance, soil available water capacity and crop water demand are the three key factors which influence crop water requirements (Figure 6):

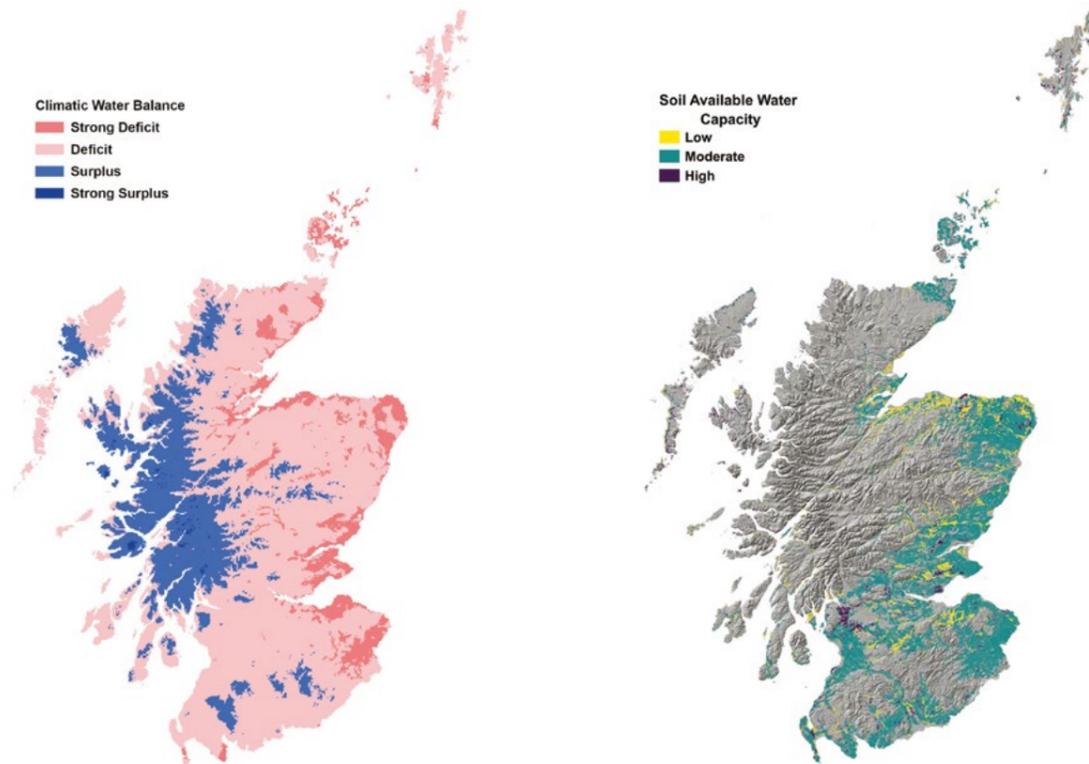


Figure 6: Factors influencing crop water requirements. Climatic water balance derived from Rivington and Jabloun (2023)<sup>[10]</sup> and soil available water capacity from Hollis et al., (2015)<sup>[11]</sup> and Gagkas et al., (2018)<sup>[12]</sup>

## Potato irrigation requirements: look-up table

The look-up table (Table 2) uses the example irrigation requirements for potatoes. Both the climatic water balance and soil available water capacity influence the irrigation requirement. It's important to note that climatic water balance can change during the growth period and should be monitored to inform irrigation requirements. There is more information on increasing soil water retention in Section 6.

Table 2: Potato irrigation requirements look-up table

Soil Available Water Capacity	Climatic Water Balance			
	Strong Surplus	Surplus	Deficit	Strong Deficit
Low				
Medium				
High				

■ Lower Irrigation Requirement     
 ■ Moderate Irrigation Requirement     
 ■ Higher Irrigation Requirement

### Climatic water balance

If rainfall is greater than evapotranspiration, there is a surplus of water available for soil moisture. If evapotranspiration is greater than rainfall, there is a deficit of water available for soil moisture. If there are stronger deficits, irrigation requirements might be higher.

Climatic water balance varies across the country and at different times of the year. An example of the typical national variation of climatic water balance during summer months for Scotland is provided in Figure 6.

### Soil available water capacity

This is the amount of water different soils can store and make available to crops. Low available water holding capacity means soils don't intercept and retain water effectively, and irrigation requirements will be higher for these soil types.

### Crop type

Different crops require different volumes of water at different growth stages due to characteristics such as height and leaf index.

The combination of climatic water balance, soil available water capacity and crop type all influence irrigation requirements. We provide an example look-up table for how irrigation requirements for potatoes might change based on your local soil and climate conditions (Table 2).

### Crop Water Demand

The amount of water a crop needs at different growing stages varies due to different crop characteristics, for example height and leaf properties.

# Section 4 – How resilient is your farm business to water scarcity?

This section considers ways to identify and assess farm risk and resilience to water scarcity, both now and in the future.

## Assessing the risk

Knowing the risk to future changes in water availability can help with planning ahead, reducing impacts and improve farm resilience.

### Vulnerability:

The likelihood of water shortfalls that could harm crop and animal production, considering both hazard (frequency/severity of dry conditions) and vulnerability (farm dependence on water, availability of alternatives).



### Resilience:

Farm capacity to withstand and recover from events. Building resilience is increasingly seen as part of climate adaptation for Scottish agriculture.



Water scarcity can develop at any time from late spring into autumn, depending on rainfall patterns. It is also variable – one region can be in drought while another has normal conditions seen in typical summers. During prolonged dry weather river levels can drop sharply, triggering escalation of SEPA’s water scarcity alerts and restricting (or halting) abstraction volumes. The following pages, explain a step-by-step process to examine business risk to reduce vulnerability to water scarcity. A farm drought risk assessment can be conducted through a 5-step process, shown in Figure 7. Step 1-3 are explained in Section 4 of the guidance document, while all steps are explained in Appendix 1: Know your risk assessment.

## Farm drought risk assessment: 5-step process infographic.



### Step 1 – Understand your local hazard (p27-28, 76-78).

- Check SEPA Water Scarcity (May-Sept)
- Check [Drought Risk Assessment Tool \(DRAT\)](#) consecutive low-flow days
- Log past restrictions and seasonal hotspots



### Step 2 – Assess your exposure (p28-30, 79-80).

- Map water sources and uses
- Meter peak day demand
- Identify high-value irrigated crops and stock needs



### Step 3 – Assess your vulnerability (p31-33, 81-82).

- Storage days of cover = storage – peak demand
- Backup sources; soil rooting
- Efficiency: leaks, pressure



### Step 4 – Build your drought risk profile (p83-85).

- Score hazard/exposure/vulnerability
- Overall risk
- Set triggers



### Step 5 – Test your resilience (p85-88).

- Tabletop plus live drill
- Water budget
- Rationing rules and neighbour rota

Figure 7: Farm drought risk assessment: 5-step process infographic.

Farms drawing from small burns or shallow wells are often at higher risk of running dry than those on large rivers or with deep boreholes, as small sources respond more quickly to rainfall shortages.



Water availability for irrigation on farm can be a balance between different factors such as:



#### External conditions

Is there enough rainfall or streamflow this season?



#### Infrastructure

Does the farm have storage or access to alternative sources?



#### Authorisation

Are there permit or environmental constraints limiting water use under drought conditions?

In addition to understanding water requirements for crop and livestock, this variability makes each farm risk assessment unique. It is vital to understand the limitations of different water resources – rivers, boreholes, and private supplies on farm (Section 5 – Water resources and authorisation). Doing so supports more resilient farm planning, helps safeguard ecosystems, and ensures long-term productivity.

## Know your risk assessment

Assessing drought risk does not have to be complicated. Examining local hazards, water demand, and looking at mitigation measures currently in place allows businesses to explore how vulnerable they may be.

Figure 8 highlights some key questions businesses may want to start looking at to begin resilience planning. From there, informed choices about storage, efficiency, and diversification can be made, looking to future proof businesses.

Think of drought risk as a combination of three things: hazard, exposure, and vulnerability.

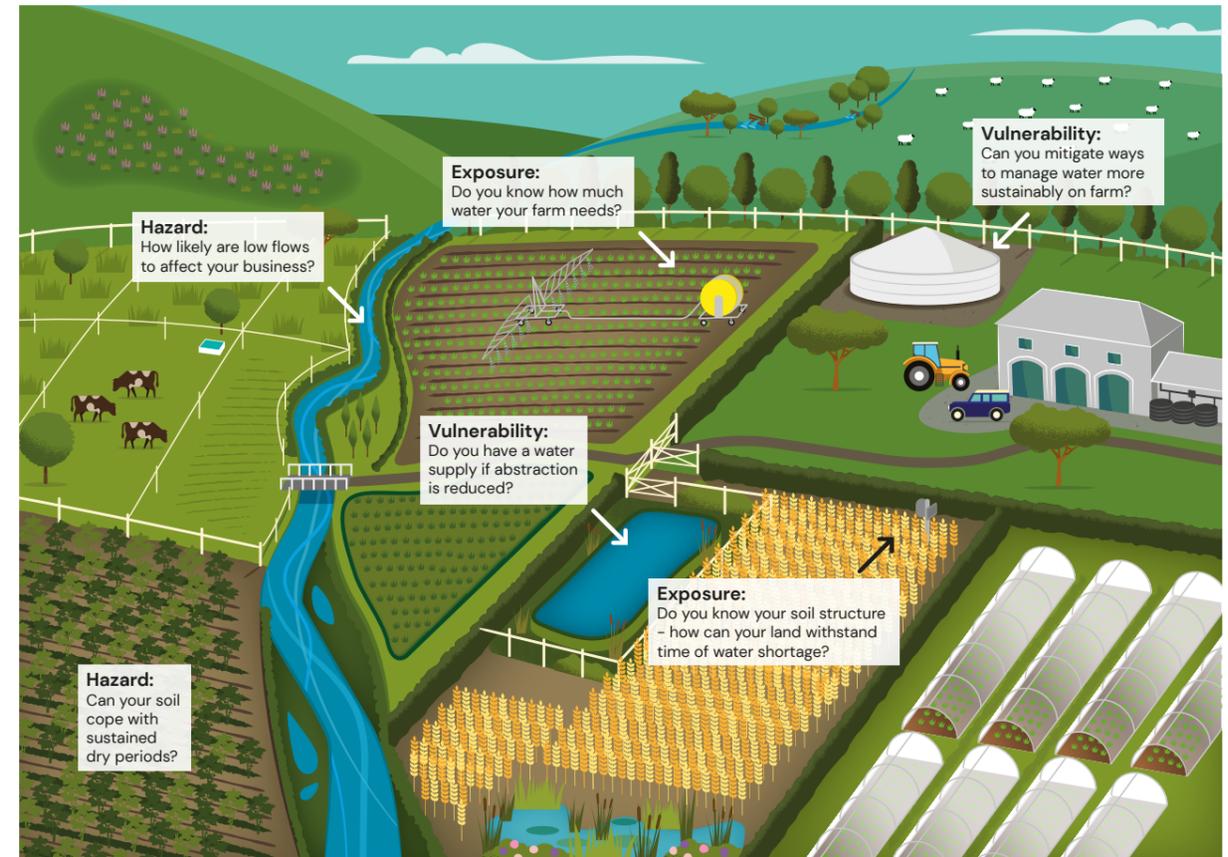


Figure 8: Do you know your Hazard, Exposure or Vulnerability?

### Step 1: Hazard: Understanding your water scarcity hazard level

Hazard refers to the likelihood that an area will experience extended periods of dry weather and low river or groundwater levels, which could reduce the available water for farming.

In Scotland, drought is typically defined as a period when mean **river flows drop to the lowest 5% of normal levels**, lasting for an extended time, usually 30 days or more.

#### What can you do:

##### Build a baseline

Record how often your area has reached alert, moderate or significant water scarcity levels

Record any temporary extraction suspensions or limits in your area

Record the time of year restrictions or limits are put in place

##### Monitor weekly

Use SEPA's [Drought Risk Assessment Tool](#) (DRAT)

Discuss the situation with neighbours or an agronomist. Are they experiencing similar conditions, or are they using different management practices?

Record rainfall and soil moisture levels

##### SEPA water scarcity

Follow advice from [SEPA's water scarcity levels webpage](#)

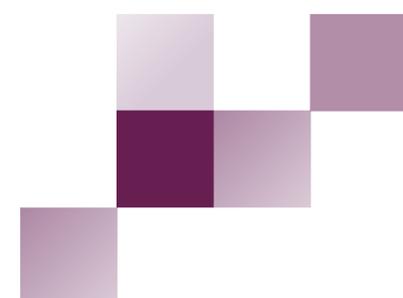
The information and knowledge obtained above can be used to quickly calculate a hazard rating:

Item	Low = 1 point	Medium = 2 points	High = 3 points	Score
How often has your area experienced alert, moderate, or significant water scarcity levels in the past five years?	Rarely above Alert	Often at Alert	Regularly at Moderate/ Significant	
Frequency of temporary suspensions or limits in past five years	None	Once	≥2 times	
SEPA DRAT trend (this season)	Stable/short low-flow runs	Rising some weeks	Rising ≥2 weeks and lengthening	
Number of seasonal restrictions within the season	Late spring/late-summer stress	One season at risk	Both April–May and August–September often dry	
<b>Total Score:</b>				

Total points	Hazard level	Advice
5–7	Low	Keep watch, proceed to exposure/vulnerability steps.
8–11	Moderate	Prepare to ration, ready storage/rotations.
12–15	High	Assume restrictions likely; act early on storage and scheduling.

**Next step:**

Use this score to give you an idea of your business hazard risk to water scarcity. If you do this regularly you can spot trends and are able to act to put in plans to secure your business.



**Step 2: Assess your exposure**

Exposure refers to how dependent a farm is on water (how much, when, and where it is needed) and how reliant operations are on a single water source.

In Scotland, farm water typically comes from rivers and lochs, private supplies (such as springs, small streams, rainwater, or ponds), groundwater boreholes, mains water, and on-farm storage. Figure 9 lists management steps to highlight farm exposure to water use and availability.

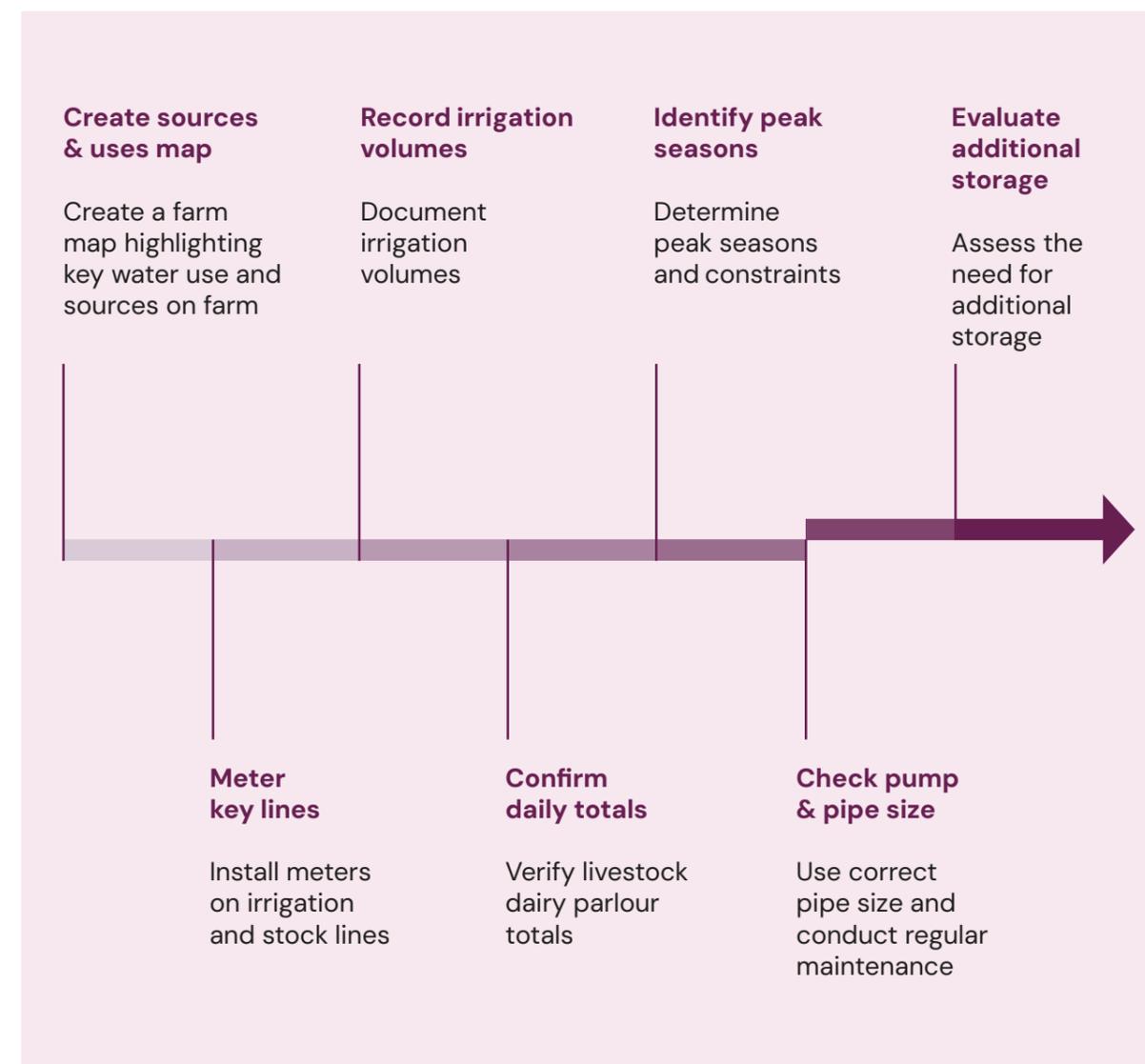


Figure 9: Assess farm exposure

The information and knowledge obtained above can be used to quickly calculate an exposure rating:

Item	Low = 1 point	Medium = 2 points	High = 3 points	Score
Proportion of income from irrigated or high-water use crops	<15%	15–40%	>40%	
Where do you source most of your water?	Large river/lochs or resilient aquifer	Mid-size burn or mixed sources	Small burn/spring or shallow well	
Number of water sources used (incl. storage)	≥2	1 + backup via mains/tanker	1 only	
Peak-day demand vs. licenced /available rate	≤60%	60–90%	>90%	
Daily peak flow vs. pump/pipe capacity	Comfortable	Tight at peaks	Frequently short	
Distance/head to main fields	Low	Moderate	High/awkward	
<b>Total Score:</b>				

Total points	Hazard level	Advice
5–7	Low	Good baseline: Improve measurement and keep storage topped up.
8–11	Moderate	Consider storage, peak-shaving (irrigation at cooler times of day), and backup.
12–15	High	Prioritise storage/backup, review cropping pattern, and coordinate abstractions.

**Next steps:**

- **Measure what matters:** meters on main lines pay for themselves by finding leaks and confirming peaks.
- **Match peaks with buffering:** storage + correct pump/pipe sizing turns a fragile system into a robust one.
- **Reality-check the paperwork:** ensure licence limits and conditions align with your calculated peak needs before the season starts.



**Step 3: Assess your vulnerability**

Vulnerability refers to **how well your farm can handle water scarcity**. Two farms with the same drought hazard and the same exposure may cope very differently depending on factors like water storage (buffers), alternative water sources (backups), soil quality, crop variety, and how efficiently they manage their available water.

Lower vulnerability means you can **maintain water supplies for priority crops or livestock for a longer period**, comply with any restrictions, and avoid costly emergency measures.

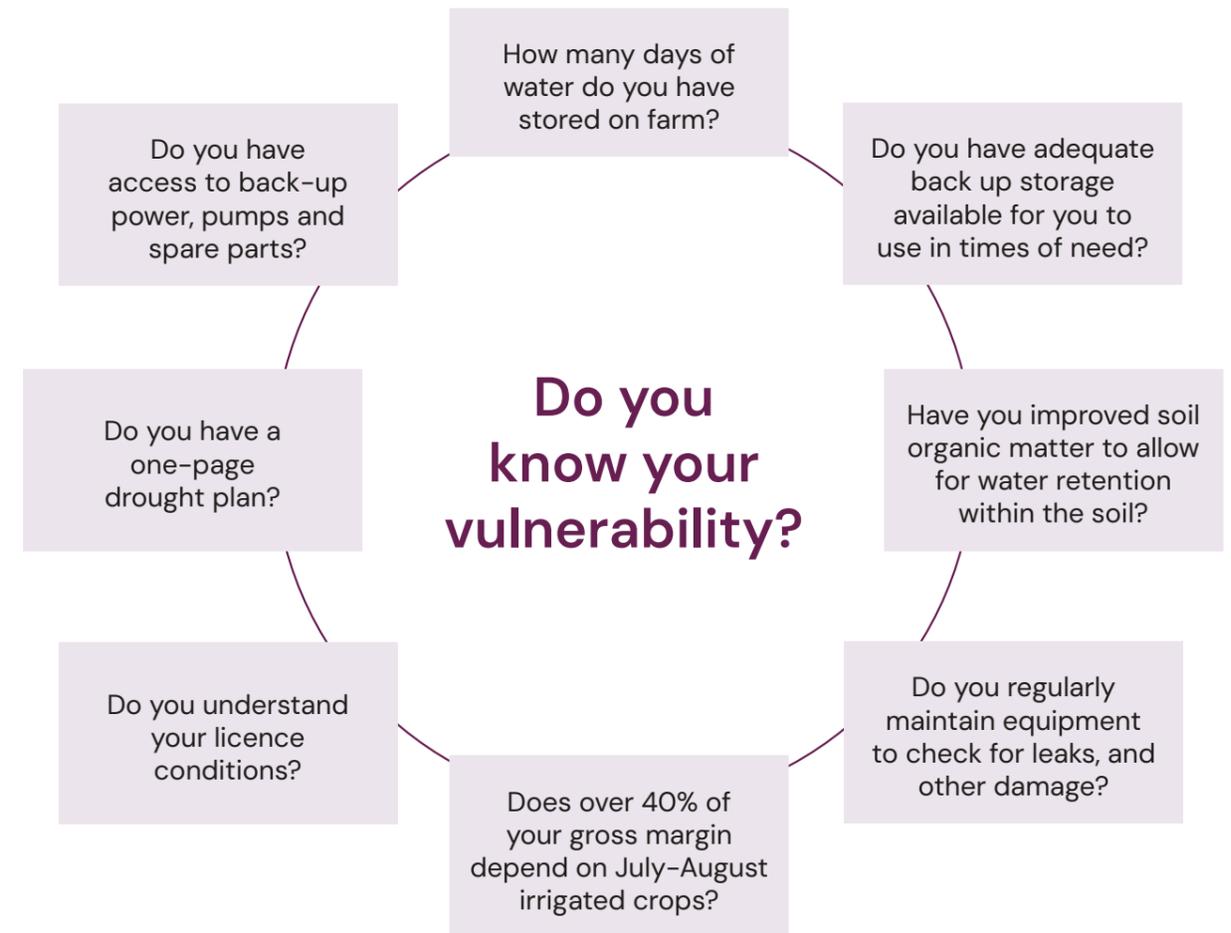
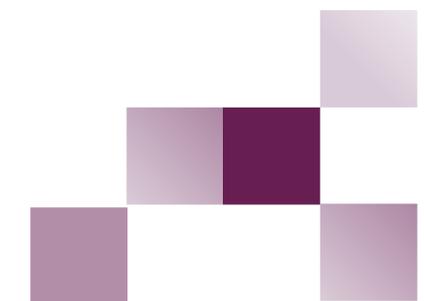


Figure 10: Do you know your vulnerability?



From answering the questions in Figure 10 the table below can be used to quickly calculate a vulnerability rating:

Item	Low = 1 point	Medium = 2 points	High = 3 points	Score
Storage days of cover (= usable storage (m <sup>3</sup> ) ÷ peak daily demand (m <sup>3</sup> /day))	>21	7–20	<7	
Number of independent sources (incl. storage)	>2	1 + credible backup	1 only	
Soil and rooting	Medium/heavy or deep roots	Mixed	Light/sandy + shallow roots	
Dependency on irrigated crops for business gross margin	< 15%	15–40 %	>40 %	
Water system efficiency (e.g., uniformity, leaks)	Verified good	Some issues	Poor/unknown	
Frequency of licence constraints during dry summers	Rare	Occasional	Frequent	
Power or hardware backup	Generator + spares	Partial	None	
People and plan	Written plan + trained	Informal	None	
<b>Total Score:</b>				

Total points	Hazard level	Advice
8–11	Low	Keep good practice; revisit annually.
12–17	Moderate	Target 2–3 improvements (storage, fixes, plan).
18–24	High	Prioritise storage/backup, system fixes, and a written plan now.

**Next steps:**

- **Know your buffer:** Days of cover is the single clearest indicator of vulnerability.
- **Redundancy beats hope:** A second source or proper storage is worth more than a normal summer.
- **Tighten the system:** Efficient, well-maintained kit turns limited water into saved crops.
- **Make decisions easy:** A simple drought plan and priority list cuts losses when restrictions arrive.

**Further information and resources**

- [Farm Advisory Service \(FAS\) Water Management](#)
- [SEPA Drought Risk Assessment Tool](#)
- [SEPA Water Scarcity](#)



# Section 5

## – Water resources and authorisation

This section reviews the main sources of water used for agricultural production in Scotland and consider the suitability of alternative or supplementary water supplies.

Most farms typically rely on rainfall and soil moisture, irrigation from rivers or burns, and/or groundwater from boreholes, all of which are jeopardised by prolonged dry weather. Table 3 summarises the pros and cons of the main water sources in use on farms. Farm ponds are unlikely to be used as a source of water for irrigation, but included here for information.

Table 3: Source of water resource

Source	Pros	Cons
<b>Mains Supply</b>	Clean and treated drinking water, suitable for domestic and livestock use. No (limited) disruption to supply.	Cost. Connection may be an issue for remote locations.
<b>Surface water sources, e.g. rivers and burns</b>	Can offer large volumes of water for irrigation. Direct and easy access to flowing water (subject to farm geography). Easy to connect to all irrigation systems.	Water availability not guaranteed, issue for high water demand and or value crops. Small rivers and burns may dry up during prolonged hot spells/high demand. Authorised abstraction from SEPA required; volumes may be reduced or permits temporarily suspended at periods of peak demand.

Source	Pros	Cons
<b>Boreholes</b>	Offers potential security of private supply. Provides a steady and independent water source. Offers a buffer against short-term low rainfall. Could support supplementary irrigation alongside livestock and domestic needs.	Installation cost. May require <a href="#">SEPA authorisation</a> . Risk of over abstraction impacting domestic needs and effectively emptying borehole in shorter term. Risk of groundwater contamination making source unusable for others. Consider temperature shock to crop on application of irrigation. Apply close to ambient temperature where possible.
<b>Storage Lagoon</b>	Excavated pond for storing water. Filled during the winter months when water is plentiful. Can be filled by rainwater. Provides an additional supply of water on farm. May attract funding support for installation ( <a href="#">see Scottish Government RPID Grants</a> ). Additional biodiversity value.	Installation cost. Location/land take. Volume of water available may not match needs at times of significant water scarcity. Requires planning consent. SEPA authorisation for abstraction to fill may be required.
<b>On-farm Ponds</b>	Cost effective – already established or potential to reinstate ('ghost ponds'). Can supplement in-field livestock drinking or emergency low volume abstraction needs (subject to pond size). High amenity value.	High risk of degrading biodiversity and amenity value if used for other purposes at times of high-water scarcity. Pollution and poaching/erosion risk from direct/unchecked livestock access. Water quality risk for livestock drinking – some algal blooms can be highly toxic. Potential risk of liver fluke. SEPA authorisation for abstraction to fill may be required. Potential evaporation losses.
<b>Rainwater Harvesting</b>	Collect rainwater from shed roofs around the steading for storage in tanks. Recycling rainwater which would ordinarily be lost. Good for small scale use (e.g., washing down yards and machinery). Supplementary source taking the pressure off other sources of water during water scarcity periods.	Cost for installation. Storage limited as dependent on tank size. May be contamination issues from bird faeces in roof water/staleness from untreated storage. Treatment of water may be required for livestock and some edible crops (such as salad leaves).



**Farms with limited or no water storage and those fully dependent on real-time river flows are at highest risk.** By contrast, some larger enterprises (and distilleries, as a parallel water-intensive sector) have invested in measures like offline storage reservoirs (which collect winter water for summer use) or efficient irrigation technology.

These investments can help to improve farm resilience, decoupling irrigation supply from immediate river levels. However, uptake of such solutions is not yet widespread across all farms because of capital costs, planning requirements and differing farm sizes.

The source, size and form of water storage should be considered to fit the needs of your business, space available and water use. The following section looks at groundwater and boreholes.

### Groundwater availability

As the pressure on surface waters increases, some businesses are looking to secure supplies through access to groundwater (e.g., private boreholes). Groundwater can temporarily buffer short-term droughts, but supplies are not infinite. Areas with

aquifers of limited storage (like shallow sand and gravel or fractured bedrock aquifers in parts of the east and northeast) are particularly vulnerable to depletion and in certain areas the risk of salinisation may be an issue. If recharge (mostly from winter rain) declines, these aquifers might not fully recharge annually.<sup>[3]</sup>

Some aquifers in eastern Scotland are under pressure and recharge slowly (Figure 11), especially during prolonged dry periods. Over-abstraction risks depleting local water tables, potentially affecting neighbouring farms or local ecosystems.

As shown in Figure 11, many groundwater abstraction points fall within, or near, areas currently classed as having poor groundwater levels. This is a potential issue if your main source of water is from groundwater. Building your resilience and increase water sources may be key. Groundwater classification is based on their condition and how they differ from a near natural condition. This classification process follows EU and UK guidance. Further information can be found <https://informatics.sepa.org.uk/WaterClassificationHub/> where you can look at specific areas using an interactive tool.

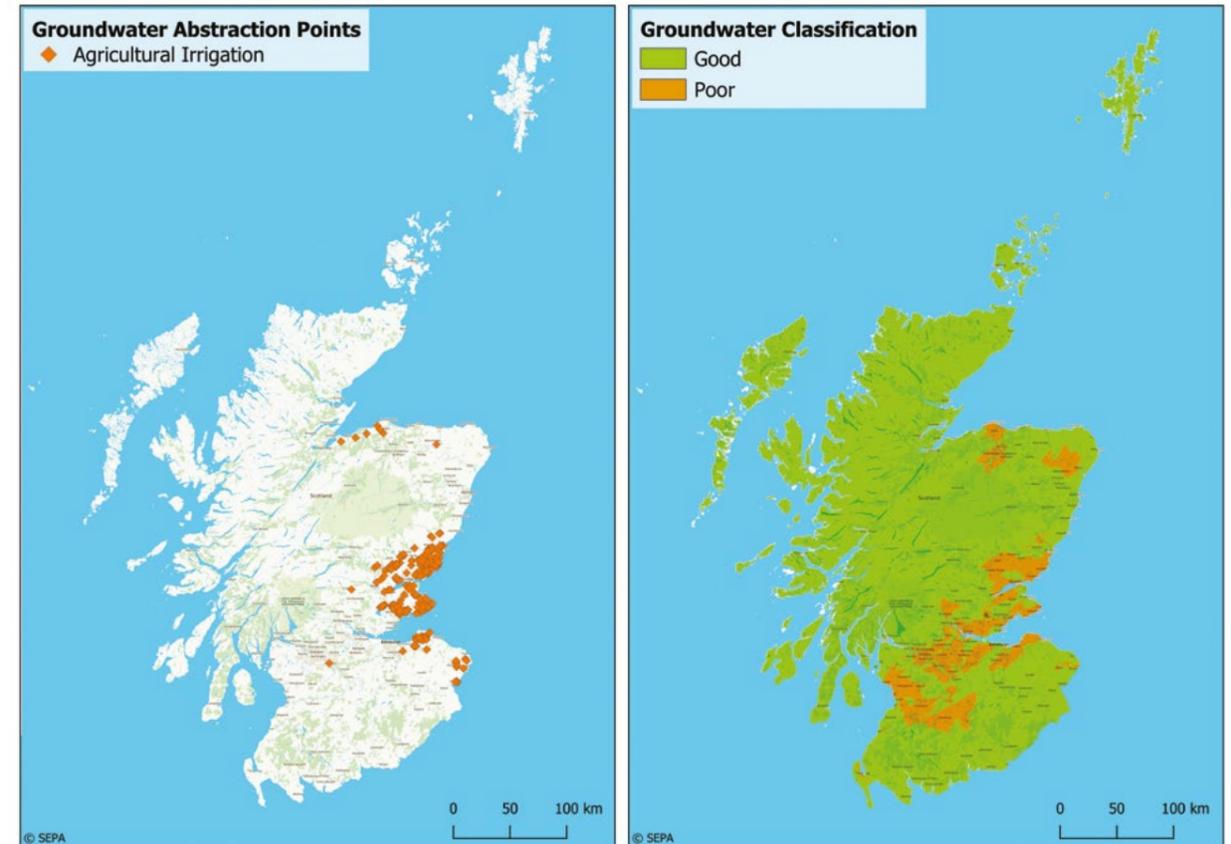
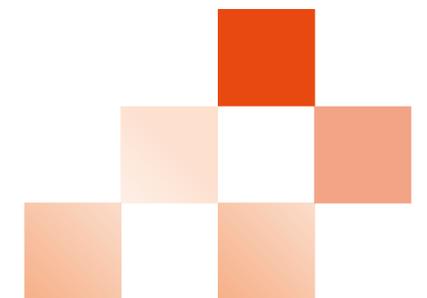


Figure 11: Groundwater Classifications in Scotland © Crown Copyright. Scottish Government Licence No. 100020540

All data is protected by SEPA, and follows their [guidance: Environmental data](#) and [General data reuse statement](#).

The British Geological Survey (BGS) has developed a Groundwater Resilience Framework to identify locations where aquifers could sustain abstraction amid climate change. Although groundwater can be a valuable alternative when surface water is limited, its sustainable use depends on a clear understanding of available volumes – over-reliance might cause water tables to drop and boreholes to run dry during drought

years. Transitioning to a system where you have access to a borehole combined with additional water storage facilities, such as a lagoon or rainwater harvesting system on your farm, can boost the farm's resilience to water shortages. It is recommended that you seek specialised advice to conduct assessments of your water levels before investing in this water source.



## Boreholes

For those with good access to groundwater, a borehole can provide a steady and independent water source, often assisting during dry periods. Many Scottish farms (especially those located further from rivers) have invested in boreholes to supply irrigation, livestock, or domestic needs. The stability of groundwater makes it an appealing option, particularly during summer droughts, however, as described above, these sources are not infinite and need careful management.

Installing a borehole is a significant investment, and it is important to ensure that the benefits justify the costs – including installation, ongoing maintenance, and the time required to obtain a SEPA authorisation. If groundwater levels cannot sustain abstraction levels, SEPA can reduce or freeze abstraction from this water source, and you may not be able to access the water you need.

### Considering a borehole?

- Contact SEPA as early as possible to discuss a proposed project, SEPA can advise on location, groundwater levels, and environmental constraints such as Special Areas of Conservation (SAC), Site of Special Scientific Interest (SSSI) or Ramsar. Early engagement can save time, money, and effort. Offering the opportunity to discuss and highlighting risks you may not be aware of.
- The British Geological Survey (BGS) must be informed of any borehole deeper than 15 meters.
- A specialist can help you plan, investigate, and assist in discussions with SEPA to allow your project to be streamlined, comply with authorisation and offer you the best options for your business.

## Planning

When planning a borehole, it is advised that you appoint an appropriate specialist. Surveys must be conducted to confirm sufficient water supply and that ground conditions are suitable. Bringing in specialist help can ensure that all relevant areas are investigated and evaluated. Early engagement with SEPA is advised to discuss any potential issues.

*Boreholes can provide resilience to water scarcity. However, combining these systems with other on farm storage can provide additional security when water is scarce.*

## Location

The location of your borehole needs to ensure all other water users within your catchment will not be negatively impacted from the increased water abstraction. Inappropriate siting could have severe negative impact to the land and water supply. This could include unstable soil structure, leading to potential sink holes/landslides from the removal of too much water, to contamination of water sources from salinisation or pollutants. Drilling in the right place is critical. Full guidance on what is permitted, rules which must be followed and the information required can be found on the [Borehole construction section of SEPA's website](#).

## Authorisation

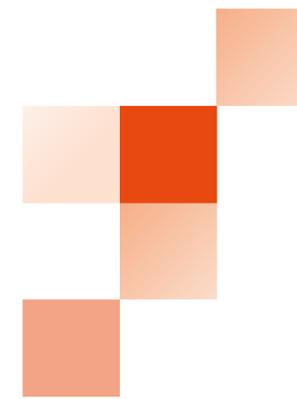
The installation of boreholes is authorised by SEPA in Scotland. Table 4 highlights the distinct levels of authorisation required for abstractions with boreholes.

Table 4: Borehole level of authorisation required\*

Borehole construction and operation	Description	Authorisation level	Requirements
<b>Borehole up to 200m deep, less than 10m<sup>3</sup> per day.</b>	Water may be abstracted if abstraction less than 10m <sup>3</sup> per day.	General Binding Rule (GBR)	Authorised by GBR3 is covered by General Binding Rules.  You do not need to apply to SEPA for an authorisation.
<b>Borehole up to 200m in depth.</b>	Any borehole with a depth of less than or equal to 200m.	Registration	Fit and Proper Person test applicable.  Standard conditions will apply.
<b>Borehole is more than 200m in depth.</b>	Any borehole with a depth of more than 200m.	Permit	Fit and Proper Person test applicable.  Standard conditions will apply.  Site-specific conditions may be applied following assessment.

\*(valid as of 24/11/2025). Please visit SEPA's website for full details for full detailed guidance, information and application forms. This is an abbreviated version of the authorisation required, before beginning to ensure that you have spoken to SEPA and have the correct authorisation level in place.

*Early engagement can save time, money, and effort, and offers the opportunity to discuss and highlight risks you may not be aware of.*



## Storing water on farm

This section discusses different water collection and storage options suitable for use on the farm.

On farm water systems, such as storage lagoons and rainwater tanks can provide cost-effective and self-sufficient options when water availability is scarce.

The main challenge here is scale. Water collected from farm buildings or a small lagoon may not meet the demands of a dry growing season; however, they can help at times when other sources are restricted.

Water quality issues can arise if runoff is collected from areas with contaminants (e.g. bird droppings from collected roof water). For high-value crops, such as soft fruit, water treatment (e.g., UV filtration) may be needed. Storage capacity and design should match business needs, available space and intended water uses.

All water storage facilities, where the water is intended to be used on farm, cannot be directly connected to the water environment. Water can be collected during times of surplus, with the correct authorisations in place and stored within these features. Please note however, this cannot happen during times of restrictions and you must comply with authorisations.

**Online pond:** A pond or waterbody which is located on a stream, is filled directly by a stream or river.

**Offline pond:** A pond which is completely separated from the waterbody. No connection to the nearby stream/river. To fill you need to divert water from drains, or pump water into this feature.

## Irrigation lagoon

With periods of water scarcity becoming more commonplace, there has been a recent increase in installation of irrigation lagoons. These features collect and store water over the winter months, to support crop production at times of water scarcity. Here are some of the points to consider when planning an irrigation lagoon.

### Planning

Lagoons are bespoke structures, which need adequate planning to suit your requirements, topography, and space. The type of lining most suitable for you, identifying the site with the best proximity to a water course, health and safety obligations, and planning permissions and authorisations all need to be considered.

### Sizing the lagoon

The size of lagoon should match your requirements. What are your goals? Do you want to supply all your water from the lagoon and not abstract during summer months? Are you intending to have it as a backup plan if abstraction authorisations have to be reduced or paused?

As part of your planning process, you will need to have a good understanding of your current water use, taking into consideration any planned future expansion, or reduction, in water use. If you currently monitor your water use you can use this data, otherwise you will have to calculate it based on crop and or animal needs. Using these figures as a starting point you can start to plan for how much water you will need.

For the lagoon to be of benefit, there needs to be enough water available for you to take from the river (or source of abstraction) over the winter months to fill the lagoon. Knowing the size of lagoon you are proposing, alongside the history of water availability in your area will help SEPA to understand the benefit that a lagoon would have to your business and the water environment. Early engagement can highlight gains and opportunities along with any complications. Finding these out as soon as possible can save time and money.

### A benefit for biodiversity

Some lagoons are designed to purely store water. However, you can add features to benefit biodiversity at the design stage. The extent of how much you can include will depend on the surrounding area. You can use these sites to add to habitat corridors or stock fish (if stocking fish you will need to ensure that there is always a level of water retained within the lagoon to support the species).

If you decide an irrigation lagoon is right for your business, you may also require planning permission, which could involve additional archaeology or ecology assessments.

*When considering a lagoon, it would be worthwhile discussing your plans with SEPA and your local authority before any significant investment is made.*

If you plan for your lagoon to hold 25,000 cubic meters of water above natural ground level, it will fall under Reservoirs (Scotland) Act 2011 and will have to adhere to additional safety legislation.





### Case study: West Adamston Farm

*“The irrigation dam we constructed in 2004 has become an important asset of our potato production here at West Adamston, Dundee. Storing water collected over the winter months from field drainage, ensures a reliable supply for irrigating during the growing season when rainfall has been insufficient. This has certainly been evident over the last few years. The dam also allows more sustainable water management by reducing the reliance on natural water sources during peak demands which have become very low.”*

**Mike Brown – West Adamston Farm**

### Location

The location for your lagoon is ideally on flat, unproductive land where you can gain easy access, at a higher elevation than the fields to be irrigated (to reduce pumping cost) and near a source of surface water for refill (during times of surplus water availability).

You need to think about logistics of getting water to the lagoon. In Scotland, the lagoon must be ‘offline’ and not directly connected to the water environment. This means storing the water in the lagoon, beside the watercourse and not having a direct connection to the flowing water (i.e., the water from the river cannot flow freely in and out of the lagoon). If you intend to fill your lagoon through abstraction from the water environment, you will need to gain authorisation from SEPA. Alternatively, you can fill a lagoon by intercepting and taking water from underground field drains which requires an additional registration from SEPA. It is also useful to have the water stored near where you intend to use it to reduce transportation cost and issues with pumping/pipes.

#### The ideal spot would have:

Clay soils

Flat area of land

Close proximity to use

Good access

Electricity available

### Lining

Lagoons can be lined with a synthetic membrane or clay. Common synthetic materials include High-Density Polyethylene (HDPE), Ethylene Propylene Diene Monomer (EPDM) and Geosynthetic Clay Liner (GCL), through to natural clay and impacted earth bases. If you have clay soils on your farm, it may be worth assessing these sites first when planning your lagoon site, as this may be a cost-effective option when compared to the cost (and longevity) of a synthetic membrane. If you need to import clay onto your farm, this may not be the most cost-effective way to line a lagoon, and you may need to use synthetic materials. If you decide to use synthetic materials Table 5 highlights some of the advantages and disadvantages of using synthetic materials as liners on farm. You need to find a material to suit your topography, budget, and requirements.

**Table 5. Advantages and disadvantages for common synthetic materials**

Synthetic material	Advantages	Disadvantages
<b>High-Density Polyethylene (HDPE)</b>	Good chemical resistance, can be cost effective over large area.	Can be degraded by UV over time.  Can be less flexible than other options.
<b>Ethylene Propylene Diene Monomer (EPDM)</b>	Water resistant, copes well with UV, durable, flexible, chemical free.	Higher upfront costs.
<b>Geosynthetic Clay Liner (GCL)</b>	Flexible, durable, low permeability.	Can be susceptible to punctures.  Extreme temperatures can affect functionality.

## Rainwater harvesting

Rainwater harvesting is the collection of rainwater, rather than allowing the water to flow away or evaporate. The systems can be simple, for example retrofitting gutters to collect water from buildings, storing it in a container until the water is required. Catching and collecting rainwater has multiple benefits, such as reducing the amount of water running off building roofs and onto yards, which has to be managed and providing a water supply when other sources are not available.

### Use

Water stored within rainwater harvesters can be used for most activities on farm, however, if you are intending on using the water for ready-to-eat crops (such as salad leaves), during food processing or as potable water for livestock drinking, the stored water will need to have an additional treatment, such as using UV light to sanitise the water. You do not currently need authorisation from SEPA to collect rainwater via a harvester, although in some cases rainwater harvesters may require planning permission with regard to flood risk, or depending on scale, a building warrant may be required. Please contact your local planning authority to gain more information on the specific requirements.

### Location

The storage container can either be situated alongside buildings or sunk into the ground. This can be a personal choice when space may be an issue, having the tank underground allows for smaller areas to still be able to install these features. You do need to ensure that you prevent algal growth within the tank, however, this can be as simple as using a dark coloured material, such as polyethene, for the tank to reduce sunlight.

#### Benefits of rainwater harvesting:

Water security

Financial savings

Increase slurry storage capacity as cleanwater removed

Resilience

### Further information and resources

- SEPA have produced a practical guide on borehole construction, which should be consulted if you are investigating whether a borehole would be good for your business: [SEPA EASR Guidance: Borehole construction and decommissioning best practice guidance document](#).
- The Farm Advisory Service (FAS) has information on rainwater harvesting, from farmer video discussing the benefits to their business: [Resilient Technology Options for Water Management on Farm: Rainwater Harvesting](#) To a practical guide to installing these systems on farm: [Water Management on Your Farm: Rainwater Harvesting](#).
- To notify the British Geological Survey of your intention to drill a borehole [click here](#).
- An updated [Groundwater Classification Map of Scotland](#) can be found on the Scotland's environment website.



# Section 6

## - Manage water and irrigate efficiently

This section gives an overview of the main irrigation types seen in Scotland and discusses soil moisture monitoring techniques.

Efficient irrigation makes best use of water, supports the needs of the growing crop and helps to achieve target yields.

There are a range of irrigation systems available but deciding which technology fits best depends on crop, soil type, water source, scale, budget, and management priorities. This section looks at some of the irrigation systems and ways to maximise efficiency.

### Irrigation systems

#### Drip tape



Trickle or drip tape is thought to be the most water efficient and precise method of irrigation. This system is widely used in soft fruit production in Scotland. The system consists of plastic piping, which has pressure-regulated emitters moulded into it allowing water to gently trickle out, serviced by a header main connected to lay flat piping and a pump. This enables growers to apply

small quantities of water (2-10 litres/hr) to crops at frequent intervals (one to three days) within the soil profile. The system requires the lowest operating pressures (typically one to two bar) when compared to other systems, therefore, benefitting from lower energy costs. As the system is fixed for the season, it benefits from minimal labour requirements, notwithstanding initial installation. Fertigation (application of fertilisers) is also a possibility with the system.

A proactive approach to soil moisture should be considered when using trickle or drip tape, such as flow meters, timers and pressure gauges to monitor water applications; and soil moisture probes to monitor water movement and wetting. These systems are used in a range of different crop types, working especially well for soft fruit but being increasingly used for field scale vegetables.

Some disadvantages to the tape are pipe blockages, animal disturbance causing leaks, high labour costs during installation and removal, field topography (steep gradients are problematic for the low water pressure), committed expenditure laying tape regardless of rainfall and irrigation requirements during the season. Tape life expectancy varies according to the tape thickness, but generally its used once only. The resultant waste must be disposed of appropriately following the Prevention of Environmental Pollution from Agricultural Activity guidance (PEPFAA).

#### Pros

Most water efficient system  
Precise targeted application

#### Cons

Plastic waste  
Large investment

#### Boom



Irrigation booms on hose reels work similar to rainguns in that they are pulled on a 4-wheel chassis connected to a hose reel, serviced by a pump and pipework. They have gained relative popularity in recent years. A typical modern boom comprises a set of fixed spray nozzles located on a gantry mounted to the chassis. Booms can apply the same volume of water to an area more quickly than rainguns. They use a smaller droplet size, spraying water directly onto crop canopies, reducing the effects of wind drift and offering improved accuracy and water efficiency. As the pumping pressure is less (three to four bar) when compared to a raingun, they also provide a fuel saving. These systems are used in a range of different crop types but are more common with vegetable and salad growers.

However, boom irrigation is not well suited to some of Scotland's undulating topography and irregular field shapes. Obstructions in fields such as power lines, trees and other obstacles, make boom irrigation unviable.

Application rates are high, therefore, there is the risk of water runoff and erosion on low infiltration rate soils.

#### Pros

Quick application, lower running costs  
Improved accuracy than rain gun

#### Cons

Not suitable for all terrain  
Risk of erosion/run off from application

#### Raingun



Rainguns are still by far the most widely used field irrigation method deployed by Scottish farmers, especially for vegetable growers. They are relatively cheap, can be deployed on undulating field and offer great flexibility, with a range of sizes and outputs. They work by being towed on a 4-wheel chassis through the field by a hose connected to a reel that winds the hose in (a drag-hose system). They abstract water via a pump serviced by pipes. Pressure is at its greatest at the pump (typically eight bars) which transports water through the pipes to the reel and gun. The amount of energy it costs to dispense one cubic meter depends on the pressure of its release and length of hose. Drag can be timed for desired cubic meter delivery. Typically, the 'sector angle' or rotation of the gun is set to 180° or 210° but can be adjusted. While these systems are used in a range of different crop types, they can be damaging on more delicate crops. Rainguns

offer the least efficient application and use the largest volume of water when comparing irrigation systems.

Rainguns are prone to uneven application and ununiform water distribution, particularly in windy conditions. This can lead to inefficiencies, over-watering, and under-watering in areas. They need correct management of pressure, lane spacings, nozzle size and gun angle to account for variable application conditions. Measures such as orientating fields/travel lanes perpendicularly to the prevailing wind direction and irrigating at night when wind speeds are typically lower can help reduce uneven applications.

**Pros**

Flexibility on a range of crops  
Relatively low equipment cost

**Cons**

Uneven application efficiency  
Water wastage

*“Sprinkler irrigation capital investment is high. A considerable amount of work and attention to detail is required for annual installation. The system (once installed) is simple to use, offers accurate efficient delivery of water and well worth the effort, especially in a dry year.”*

*Rob Cowe, R P Cowe & Co, Oldcastles Farm, Chirnside, Scottish Borders.*

**Pros**

Low energy use  
Efficient application

**Cons**

Labour intensive  
Can be more costly

**Pros**

Flexible  
Relatively efficient

**Cons**

Labour intensive  
Low output

and so creates crop circles. An advantage of these systems is the potential for fertigation. These systems are used in a range of different crop types but are more common with vegetable growers.

Central pivots are popular in deserts and semi-arid flat environments where land is less scarce than water such as in the Northwest of the USA, the northern plains of Mexico, Brazil, Argentina, South Africa, and New Zealand. Central pivots are less common in temperate climates with relative rainfall and smaller parcels of land, such as most of Europe.

**Pros**

Flexible

**Cons**

Labour intensive

**Central pivot / linear irrigation system**

Central pivot irrigation doesn't tend to be used in Scotland as it requires large flat fields and vast infrastructure and won't support all crops grown in a typical rotation. A centre-pivot or linear irrigation system or waterwheel is a pipe supported by towers on electric motor propelled wheels. It dispenses its water through nozzles one or two meter above the crop, at the end of the tube on the outside of the circle there is a rain gun like nozzle, but smaller. The system receives the water from the pivot, the centre, around which it turns

Table 6 shows the potential irrigation systems available to indoor and outdoor crop categories. To caveat, individual crop type may be suitable to irrigate using other or multiple systems listed. System descriptors (above) should also be considered when interpreting the table.

**Table 6: Irrigation systems available to indoor and outdoor crop categories**

Irrigation systems	Horticulture crops	Combinable crops	Vegetable/salad crops	Grass and forage*
Drip tape	✓		✓	
Boom	✓	✓	✓	✓
Raingun		✓	✓	✓
Sprinkler	✓		✓	✓
K Line	✓			✓

\*Unlikely to irrigate grass and forage.

**Sprinkler**

The use of sprinkler systems is limited in Scotland, but interest is growing, especially in solid-set systems, which are installed for the duration of the crop. They offer advantages of low energy use due to low operating pressures (two to three bar), small water droplets, and an even application pattern. However, if using a mobile system, the sprinklers are very labour intensive and need to be moved every three to four hours. Depending on the husbandry of some crop types, removing fixed systems may be challenging. Newly developed sophisticated irrigation scheduling and remote-controlled systems have re-invigorated sprinkler irrigation, offering improved flexibility and precision. These systems are used in a range of different crop types.

**K-Lines**

K-Line systems are predominantly used in grass and forage settings but have the potential to be used on other crops, however, use in Scotland is limited. They consist of a flexible hose line around 100 m in length, consisting of a 40 mm pipe with eight or nine K-Line pods connected. The pods house sprinkler units and help protect the sprinkler, keeping it upright, whilst stopping the crop interfering with the sprinkler action. The system is manoeuvrable and can be repositioned by quad bike or other farm vehicles, therefore, initial set up costs are quite low. The system can work using single lines or multiple lines of pods, which can work in tandem or individually, depending on crop requirements.

The system runs on a low pressure and output, designed to distribute water slowly into soils, reducing run-off and pooling for up to a 24-hour period. Eliminating the need to move reels or pipes frequently.

## Irrigation efficiency

Effective irrigation maximises crop yield and output, helping to avoid crop stress through periods of dry weather. There are different methods to improve irrigation efficiency, which will be discussed in this section. Understanding how your soils absorb and store water is critical to maintaining and improving yields, whilst also making best use of limited resources.

How rain soaks in, runs off, or is stored within the soil directly impacts the water available for your crops (Figure 12). Getting rainfall to work for you is key to building your water reserves. In a dry spell, good soil management will help your land hang onto that moisture longer, cutting down on evaporation losses and protecting your yields.

*Supplementary irrigation, the addition of water to crops at time of water scarcity, is needed at times when water resources are most limited.*

Good soil management influences a number of processes on your land (Figure 13). The more resilient your soils, the better your crops will weather the weather. For example, soils rich in organic matter and with good structure act like a sponge, helping your fields survive dry spells with minimal stress.

Thin or poorly structured soils offer little defence against drought. They simply cannot hold enough moisture. However, every field has its limit (Figure 14). When the ground is saturated after heavy rain, you still need measures in place, such as a buffer strips or swales, to slow the flow, prevent runoff, and give the land time to use that excess water.

*Scotland's cultivated topsoil hold approximately 3,274 billion litres of water essential for crop productivity.*

Understanding the role your soils play in managing water, and how to improve their resilience, will help to guide irrigation scheduling and water management. The amount of water available for crop uptake is related to:

## Managing water

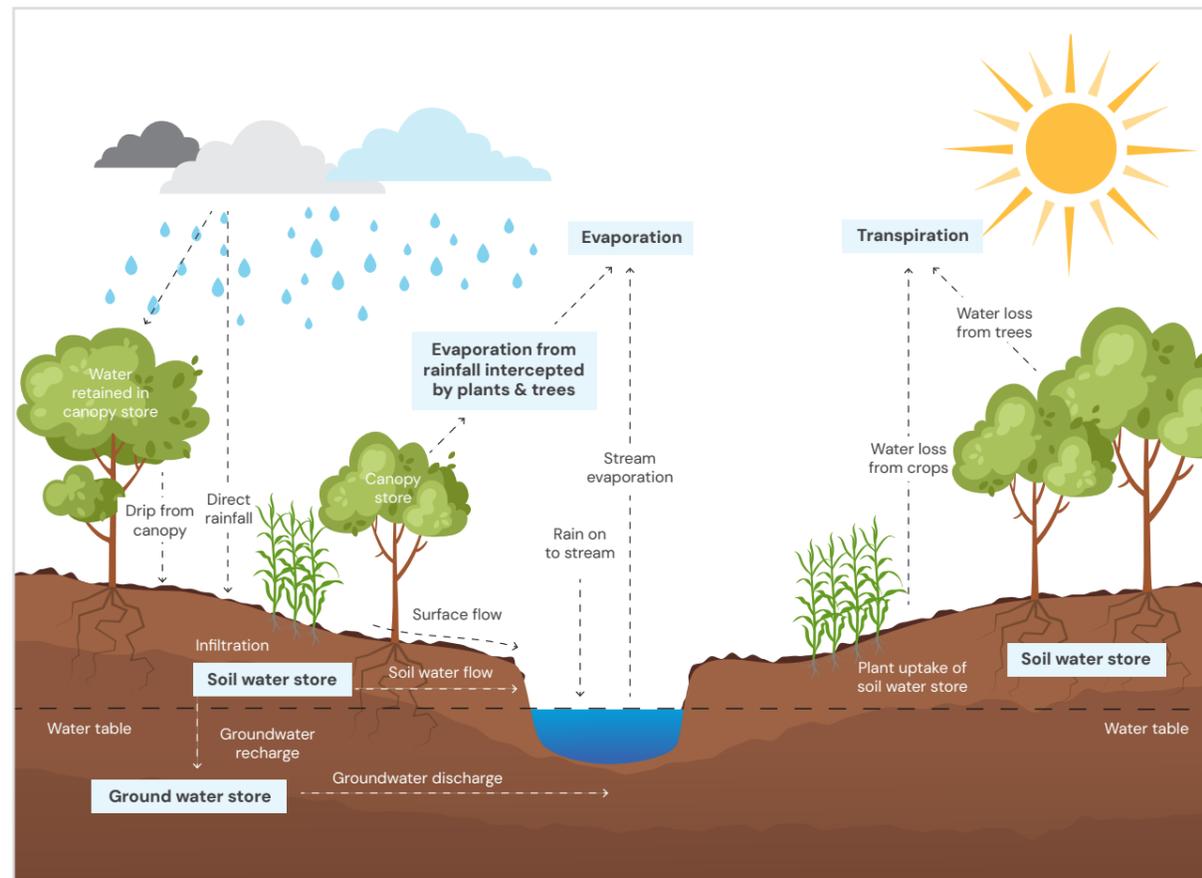
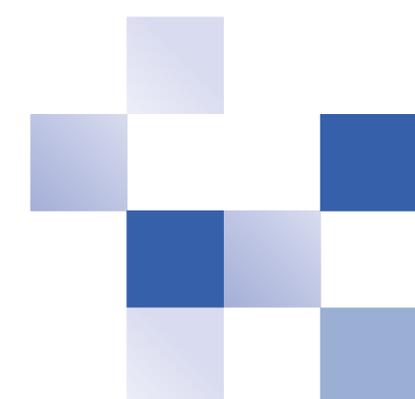


Figure 12: Water movement on the farm.

- Soil's water budget
- Soil texture (sand, clay, silt, etc.)
- Soil structure (loose, compacted, etc.)
- Organic matter
- Temperature
- Evapotranspiration

Field water holding capacity



Crop water availability is influenced by rooting depth. A crop with deep roots can draw upon a larger soil water reserve than one with shallow roots. Rooting depths can vary, especially by crop type, season and soil compaction (Figure 13).

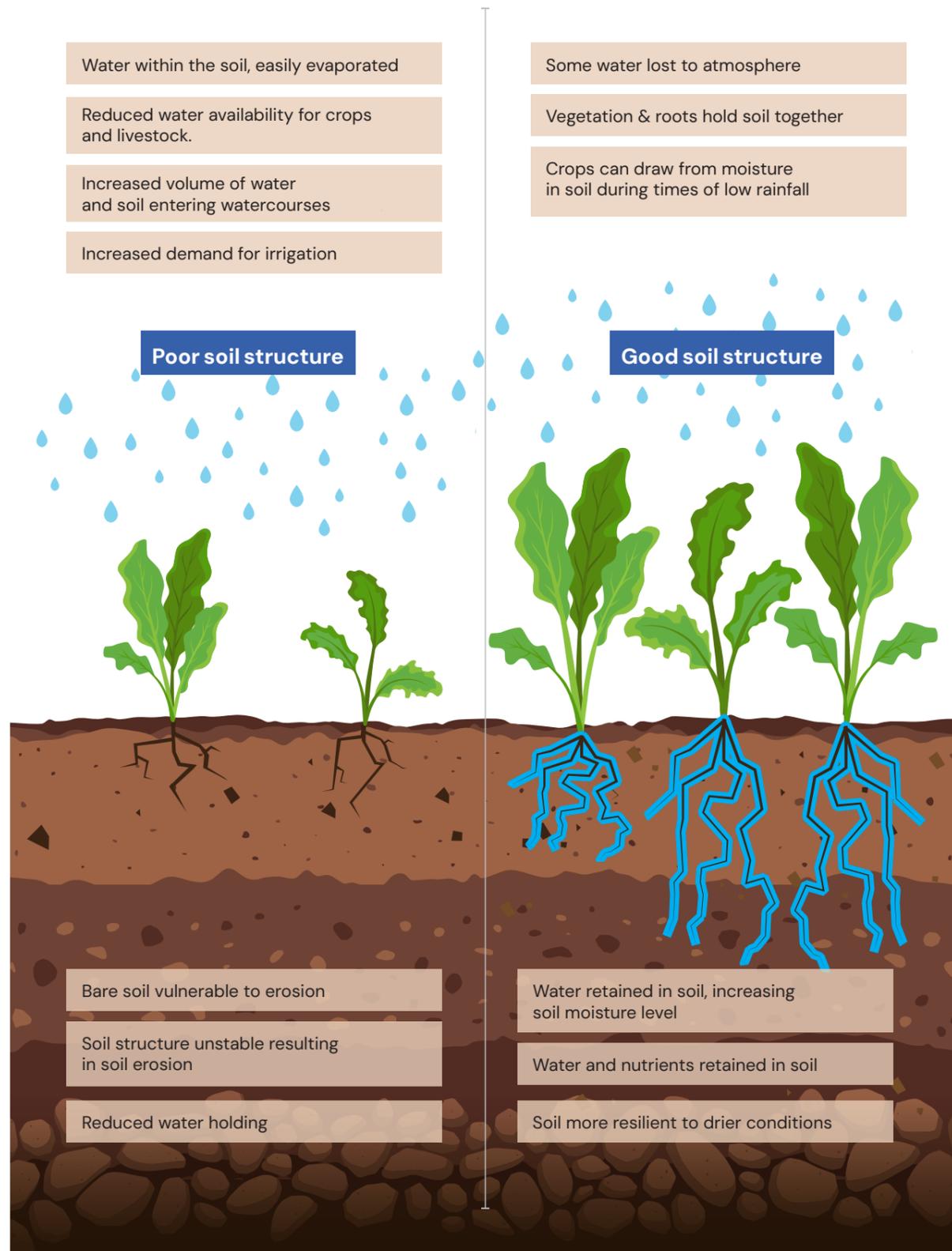


Figure 13: How soil structure impacts water retention.

## Irrigation scheduling

Both over and under irrigating can have detrimental impact on crop growth (Figure 14). Too little water the crops go into water stress and too much the plants begin to wilt if conditions do not allow water to naturally drain through the soil. Over watering can also lead to increased runoff, nutrient loss, soil erosion, and compaction. The field is so wet that soil pores are filled completely with water, leaving no room for air, which can inhibit root growth.

When you are planning your crop rotation you should conduct an irrigation plan. Review your irrigation history for the past few years; do you notice a trend? Using the **'Know your**

**risk assessment'** Section 4 p22- 33 you can observe areas where you may need to add mitigation measures to improve water management next season.

Are there specific fields/areas that need more attention? Modelling and technology can inform decisions and help focus time and financial investment.

## Weather

Weather extremes massively impact how well your irrigation performs. Having an adaptable irrigation plan, which takes account of weekly weather forecast will allow you to adjust your schedule to avoid inefficient conditions. For example, if heavy rainfall is forecast you can reduce irrigation to allow the soil to have

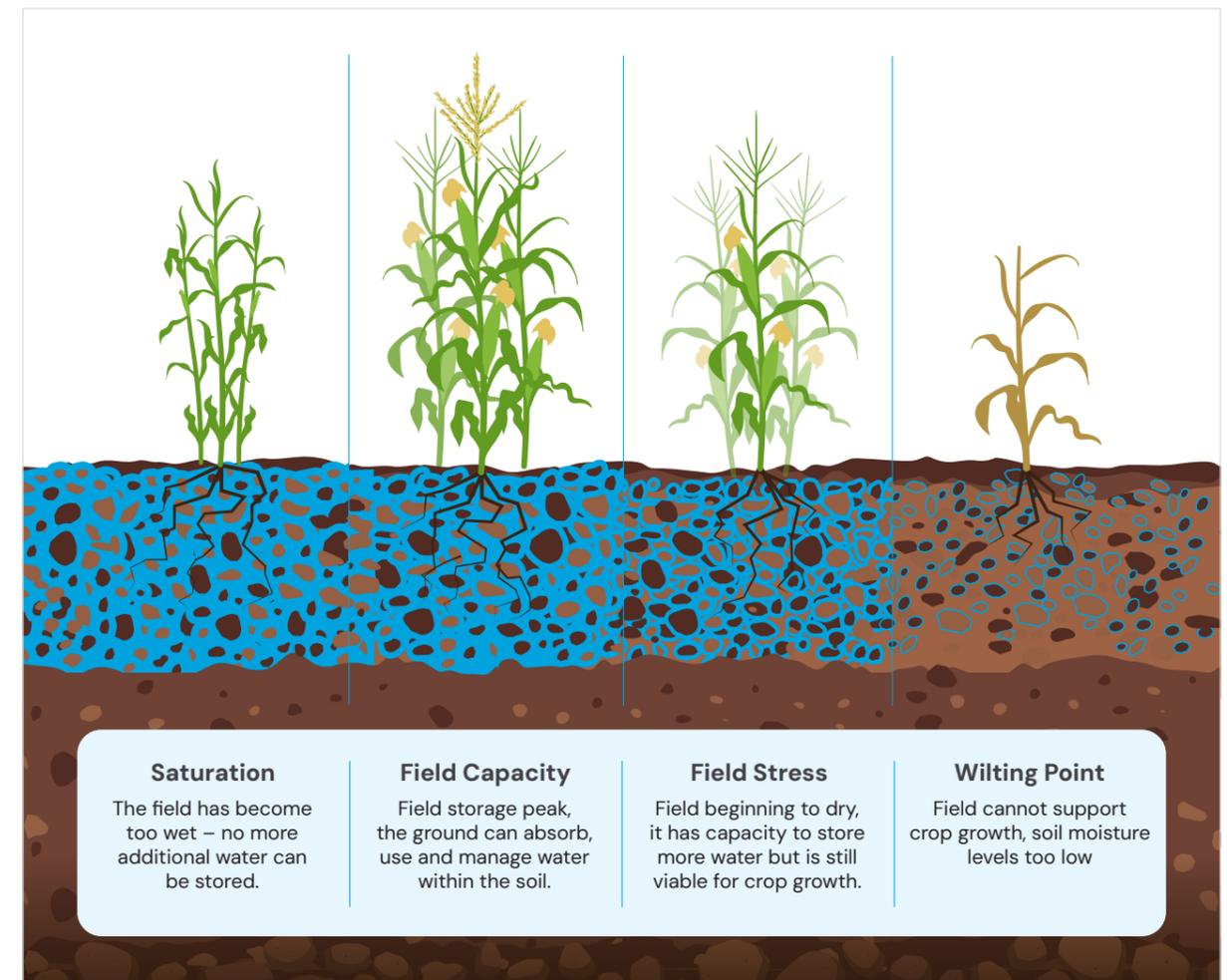


Figure 14: Crop growth under different soil moisture levels.

capacity to absorb the expected rainfall. Irrigating in strong wind is wasteful and should be avoided where possible. It scatters the water, leading to patchy coverage (some dry patches, some puddles). Looking ahead and timing your irrigation for calmer days or times of day will mean irrigation water is applied more evenly.

### Measuring soil moisture

Most irrigation scheduling will rely on understanding the soil moisture deficit. This is simply the amount of water (expressed in mm) required to bring soil moisture content back to field capacity. The soil moisture deficit should be monitored and irrigation triggered before it reaches a critical level. The amount of irrigation that should be applied at any one time is limited by the current soil moisture deficit as well as the infiltration rate of the soil. Irrigation should not be applied at a faster rate than can be accepted by the soil. Irrigating with more water than the soil can accept is not only a cost in terms of energy used and wasted water but can cause run off and erosion.

*The UK Irrigation Association (UKIA) have calculated that "a 10% overestimate in field capacity (e.g. a volume water content 23.4% instead of 21.3%) would mean 30% over watering."* [13]

Overwatering is inefficient and costly, especially when water is scarce. To use water wisely, you need to know exactly how much moisture is in your soil before the crop shows signs of stress. When water is lost through evaporation (from the soil surface) and transpiration (from the plants), you develop a Soil Moisture Deficit (SMD).

Measuring this deficit lets you react quickly and adjust your irrigation schedule, maintaining ideal moisture levels for maximum yield and quality. Don't wait for visible signs of drought.

Seeing these changes quickly lets you adjust your irrigation schedule right away, keeping moisture levels perfect to support a healthy, high-yielding crop. There are a number of ways to calculate this deficit, including physical testing, modelling, and visual assessment.

### Physical testing

There are many kinds of soil moisture sensors and probes all significantly different in cost, accuracy, ease of installation and data retrieval. These include transportable handheld devices, which take single point measurements to more permanent buried remote sensors (at different depths), which can offer real time hourly readings at depth. Some can provide decision support and irrigation scheduling advice too. Fixed sensors come at a higher cost and typically require a subscription payment. Table 7 lists a range of options.



Table 7: Soil moisture sensors and probes for assessing water deficit.

Method	Description	Pros	Cons
<b>Gravimetric</b>	Weigh a wet soil sample, oven dry at 105 °C for 24 hours, then reweigh. % moisture = (Wet weight - Dry weight) / Dry weight × 100 %.	Accurate.	Time consuming and may require lab equipment.
<b>In situ soil moisture sensors / probes</b>	Sensors measure the dielectric constant of the soil, which refers to the speed at which an electromagnetic signal travels/ reflects in the soil. Soil moisture content then determined via a calibration curve. <b>Examples include:</b> Time-domain reflectometry. Frequency domain reflectometry.	Provides real time data and can be connected to local weather stations.	Can be expensive. Technical knowledge required to calibrate across different soil types.
<b>Portable soil moisture meters</b>	Handheld devices pushed into the soil to get instant readings.	More affordable and quick and easy to use.	Less accurate than installed sensors or lab measurements.
<b>Tensiometers</b>	Measures how tightly water is held in the soil. In general, drier soils will have higher tension (more difficult for plants to access water) and wetter soils will have lower tension (where water is more available to plants).	Reusable and can be placed at root depth.	Can be less effective in drier soils.
<b>Remote sensing and satellite data</b>	Soil moisture inferred from satellite imagery or drone mounted sensors.	Large areas covered, less labour intensive, useful for precision agriculture and mapping.	Expensive. Requires technical expertise and specific software/tools to interpret data.

### Soil Moisture Sensors

Good irrigation management requires knowledge of the soil moisture status.

Water is an invaluable and limited resource. The amount and timing of crop irrigation can have a great impact on crop yield and quality.

Soil moisture sensors are used for efficient irrigation scheduling on potato and veg crops.

They are one of the most accurate ways of scheduling efficient irrigation, as they give real time information of moisture in the soil and are linked to weather data to predict evapotranspiration rates, when the next irrigation should be timed, and amount of water required for the crop at that time.

They are self-contained units consisting of a telemetry head, Multi depth soil moisture probe and rain gauge designed to stay in the crop throughout the growing season.

### Advantages

- Up to date information of soil moisture deficit.
- Provide multi depth soil moisture information which can be linked to soil management zones.
- Easier and more precise irrigation scheduling and planning.
- You can see what is happening across all your fields in one App.
- Enable more efficient use of water and help optimise the yield and quality of your crops.
- Very useful after rain events to manage when water is required again and where to start.
- Helpful in potatoes for high common scab risk varieties like Maris Piper at tuber initiation for managing irrigation at the critical time to control common scab but not over apply water which leads to run off and can affect quality.

### Disadvantages

- Extra cost.
- Can be inaccurate if not installed and set up properly.
- Need installing and removing from the crop at busy times of the year.
- May highlight shortages of irrigation capacity.



### Modelling

Predictive models using weather related inputs and crop information are now available, which can help mitigate the impact of water scarcity on your land. These tools can help management decisions on farm, identifying where to prioritise and highlight potential issues, which may occur during the season. The models can forecast yield, and in some areas highlight potential areas, which may need more attention or resources to improve yield. You can use these projections,

alongside moisture measurements to prioritise water distribution to vulnerable or the potentially most viable crops in times of water stress. Speak to your local advisor to discuss different options which may be available for you or you could discuss with your neighbours to see if they have started using prediction models on farm.

### Visual assessment

Whilst models and technology can be the most efficient and accurate method of



measuring soil moisture to work out the water deficit, there is still value in traditional methods of looking and feeling soil regularly to identify soil moisture. Visual assessment of your soil can be a valuable quality assurance step to ensure that the technology you are using is working and the soil moisture levels are similar to what the other systems are reporting. This qualitative assessment is based on the texture, cohesiveness, and appearance of the soil but is subjective, visual and requires experience and interpretation. Visual signs of poor drainage in soils includes the appearance of grey (bleached) horizons where soil minerals have been flushed out and/or soil mottles, which comprise of spots, patches or streaks of contrasting colour within the soil (usually grey, yellow or reddish colour) caused by fluctuating availability of oxygen (oxidation and reduction). In soils that are compacted, there is less pore space for water storage and oxygen availability, which can lead to reduced water holding capacity. Undertaking a visual evaluation of soil structure (VESS) using the [SRUC method](#), provides a simple (and free) approach to identifying whether compacted soil layers are present.

### Good practice

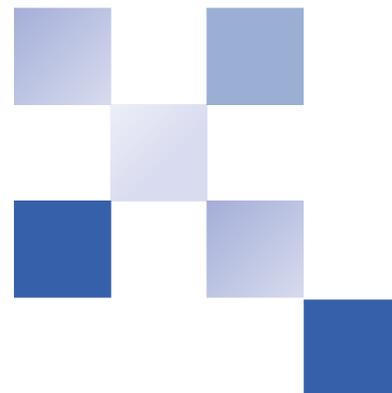
#### Before irrigating, consider good practice, such as:

- Check all equipment is fit for purpose, steel pipes may gradually become rusty and pitted with age. Make sure there are no leaks, and equipment is maintained.
- Undertake a 'Know your risk assessment' to guide irrigation efficiency and identify opportunities for improvement (Section 4 p22-33 – How resilient is your farm business to water scarcity?).
- Do not over irrigate. The aim is to place the right amount of water onto crops in the right place at the right time, with minimal wastage. Use technology and precision agriculture techniques to understand your water requirements for each crop and field.
- Use the correct pipe size and pressure for the length of pipes used, pressure losses are much greater in smaller diameter pipes, for example. Reduce nozzle size, where possible.

- Consider irrigating during a cooler time of day. When the temperatures cool, evaporation is reduced, allowing more moisture to penetrate the soil.
- Implement water saving measures. This could include adapting your irrigation plan to reduce over irrigation or increase soil water holding capacity.
- Consider technique. For example avoid irrigating using a rain gun in windy conditions.
- Think about other watercourse users. Speaking to neighbours and where possible staggering abstraction timings could help to protect the watercourse.
- Use the most efficient system for your business needs that you can accommodate.

Over watering can cause nitrogen loss, which may leach into ground waters, especially if unpredicted rainfall events take place after heavy irrigation. The resultant saturated soils can in turn increase the risk of run-off, soil loss, and erosion, representing another cost to the business.

Having a fixed source of irrigation water, such as a lagoon or borehole will ease decision making during periods of dry weather, helping to futureproof the business in the face of water scarcity. However, water from these sources is limited and should still be used wisely.



### Case study: Haig Hamilton

#### Lothian potato grower reaps benefits of digital irrigation

**Farmer:** Haig Hamilton

**Location:** West Fortune, Drem, East Lothian

**Farm size:** 1,050 ha (2,500 acres), a mix of owned and contract-farmed land

**Enterprises:** Arable farm – potatoes with combinable crops.

**Soil:** Deep sandy loam soils, ideally suited for potatoes and vegetables.

**Rainfall:** Annual rainfall averages 600 mm (24 inches). However, by the end of October 2025, total rainfall was only 350 mm (14 inches).

Potatoes are Haig's main enterprise, and he continues to invest heavily in its success. He grows 240 ha (600 acres) of ware and crisping potatoes – about half on his own land and the remainder on rented land. All the home ground is irrigated, while around 85% of the rented land has irrigation capability. Haig normally plants his potatoes in March and commences lifting in early August. All the

seed for planting is aged through chitting to support crop development.

Without irrigation, the business could not successfully grow potatoes. Irrigation is now essential not only for yield but also to meet increasingly demanding customer quality standards.

#### Recent Investment

The most recent investment involved expanding one of the farm's irrigation reservoirs during spring 2024. The work was carried out by farm staff, with a 360° digger and dozer hired in. The reservoir capacity increased from 2 million to 7 million gallons. A specialist contractor was engaged to install a liner, enabling water to be collected and stored throughout the winter from both a nearby watercourse and a borehole.

**Total cost:** £116,000

- Reservoir liner: £86,000
- Earthworks: £30,000

**Annualised cost over 20 years:** £5,800 per annum

The project was fully self-funded by the business. Although irrigation lagoons may attract funding support for installation (see [Scottish Government RPID Grants](#)) these apply only to new reservoirs, not extensions. The expanded reservoir now provides sufficient capacity to irrigate 40 ha of potatoes with 125 mm of water.

### Adoption of technology

Over the years, the business has invested heavily in technology to improve irrigation efficiency and reduce labour demand, as moving and managing irrigators is traditionally a time-consuming job.

The farm also operates 16 soil-moisture probes, working toward a target of one probe per 15 ha of potatoes. These probes also capture in-field rainfall data, providing valuable information for irrigation scheduling. However, Haig emphasises that manual test digs remain essential to confirm actual soil conditions and validate irrigation decisions.

The farm's irrigation system includes six irrigator reels and automated pumps, all digitally controlled through a mobile app. This system allows Haig to start and stop pumps remotely, adjust water pressure, monitoring water applications in real time. The integration of soil moisture sensors with digital pump control has delivered significant labour savings and improved precision irrigation

management. Recording daily rainfall is an essential part of developing an effective irrigation schedule. The business's automated weather station provides reliable, real-time data that is invaluable for informed decision-making. Coupled with accurate weather forecasts, this information supports timely and efficient irrigation planning.

### Benefits

- **Essential for productivity:** Irrigation remains critical for achieving both yield and quality targets in potato production.
- **Improved water security:** The expanded reservoir provides greater resilience by capturing and storing winter rainfall for use in drier summer months.
- **Operational efficiency:** Digital control systems and sensors have reduced labour needs and improved irrigation accuracy.

### The future

Looking ahead, Haig is planning to expand another reservoir on the farm and is currently progressing through the planning permission process. Continuous investment in irrigation capacity and technology is seen as essential to future-proof the business in the face of increasingly variable weather patterns and climate change.

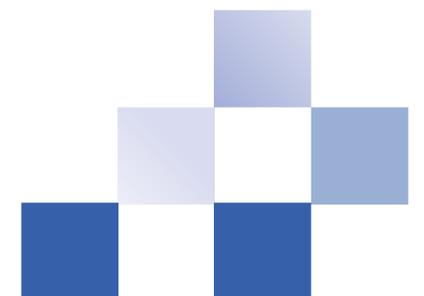
## Working together: Catchment cooperation works

Water is a shared resource. When one water user over-abstracts, others may suffer, either through reduced availability or environmental consequences, triggering tighter restrictions. Fostering a mindset that treats water as a common good can help farming communities develop shared solutions with other water users and reduce risk across entire catchments. Water resilience increases when farms in a catchment coordinate their abstraction practices. By staggering water use or sharing infrastructure, the risk of triggering restrictions is reduced, and environmental harm is avoided.

Catchment-scale cooperation also opens opportunities for shared investment in winter storage or monitoring tools. Local groups, supported by advisory services or environmental organisations, can play a vital role in building trust and ensuring fair access to water.

### Further information and resources

- [The UK Irrigation Association](#) has key resources and materials on irrigation for the UK
- [The Valuing your Soils brochure](#) contains information on improving and protecting farm soils, including the VESS instructions and example soil structure chart
- [The PEPFAA Code](#) is available on Farming and Water Scotland's website



# Section 7

## - Increasing resilience to water scarcity on the farm; steps and strategies

This section considers ways to lessen the impact of water scarcity risk, helping you to increase resilience to water scarcity both now and in the future.

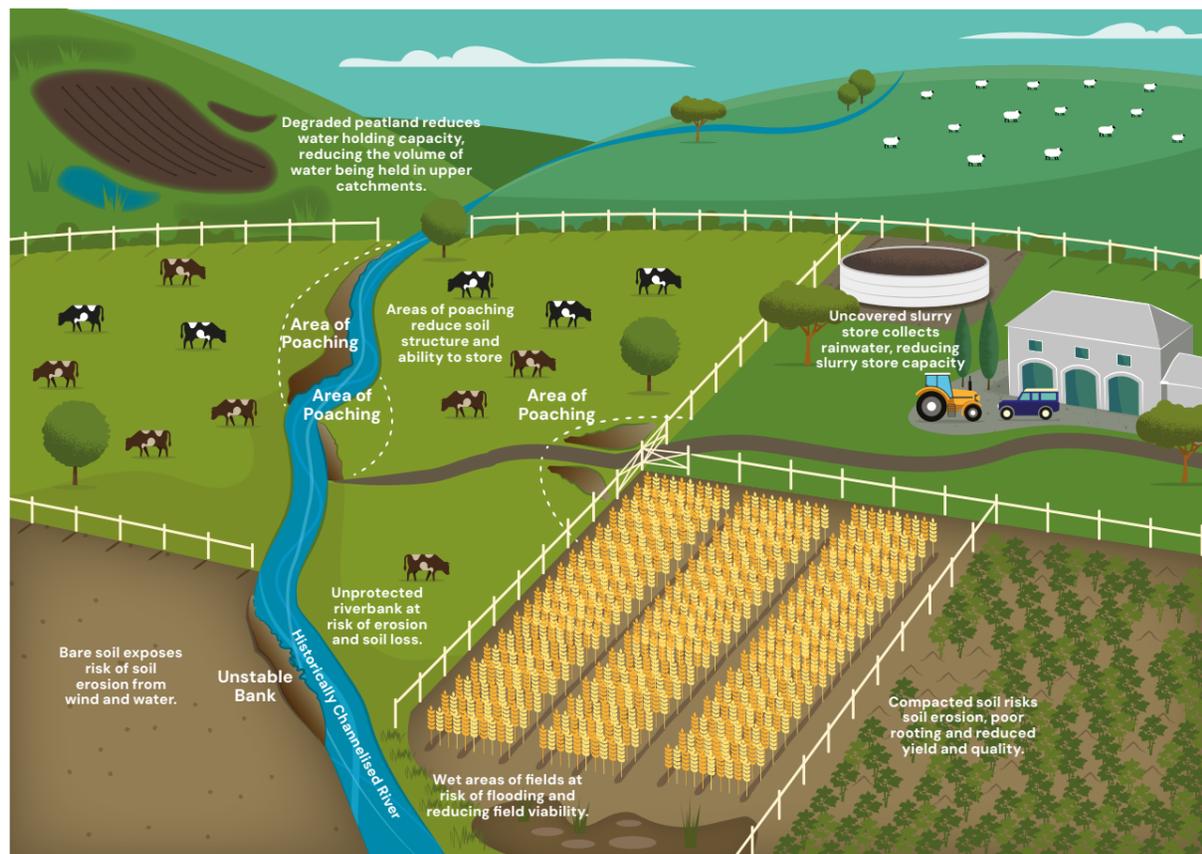


Figure 15: Farm highlighting areas for improved water resilience potential.

Day to day activities can directly affect how well your land can hold and store water. Understanding the impact of routine farming practices can help to build farm resilience.

The following practices can reduce resilience and leave your farm vulnerable to drought, decreasing the farms overall potential for holding water (Figure 15):

- **Poor soil health** – compacted soils, low soil organic matter, poor soil structure.
- **Overgrazing and poaching** – damages soil structure, increases erosion risk and loss of riverbanks, can lead to compaction.
- **Bare soils** – leaves soil exposed to erosion risk, increased runoff/loss of nutrients, increased sedimentation risk, more evapotranspiration.
- **Damaged wetlands** – reduces natural water storage areas, reduces biodiversity.
- **Poor rainwater management** – increased run off leaving your land, little time to percolate through soils and recharge groundwater.

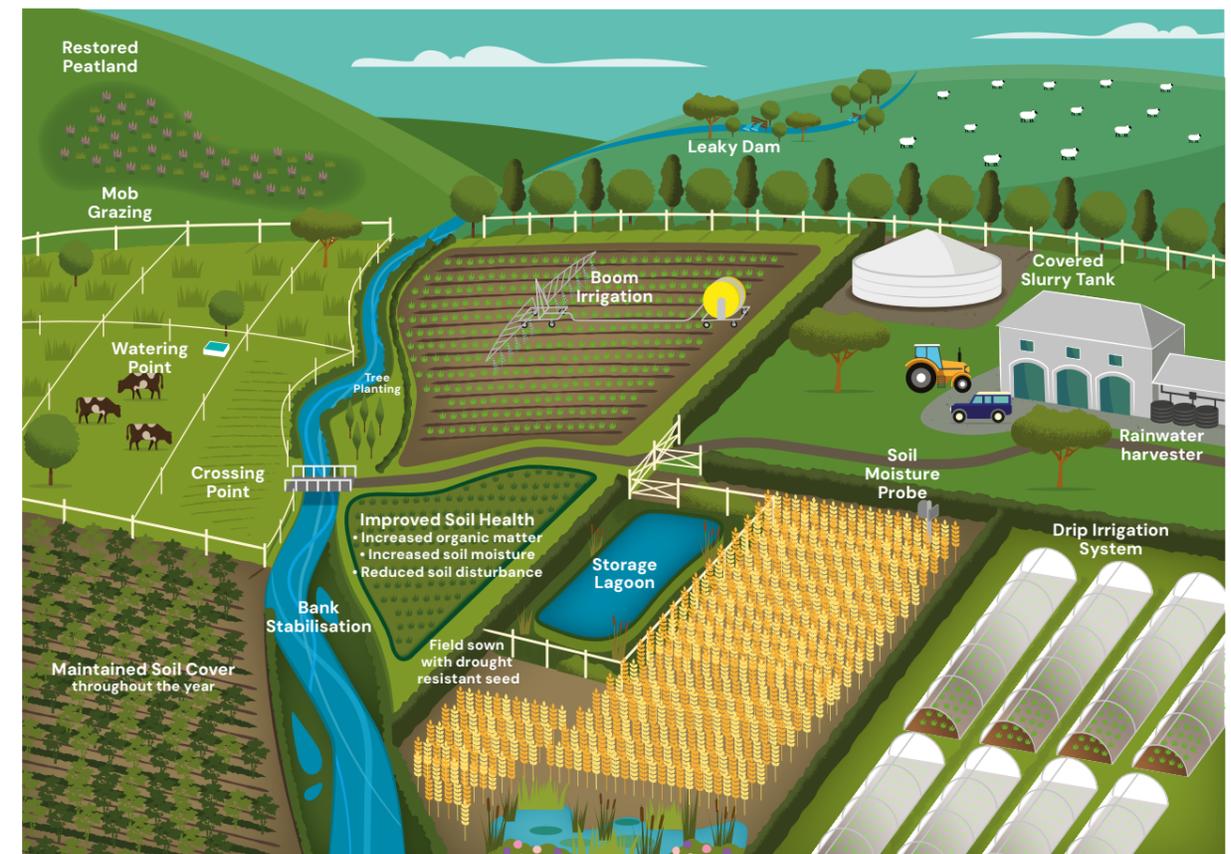


Figure 16: Farm with water resilience measures in place.

Making minor changes, suited to your farm business can make your farm more resilient in times of water scarcity (Figure 16).

**These include:**

- **Slowing the flow** – restoring peatland, leaky dams, creating infield buffers, tied ridging, natural flood management measures, hedge and targeted tree planting.
- **Improving soil health** – maintaining year-round soil cover, optimising soil organic matter levels, avoiding and remedying compaction and careful stock management to reduce poaching and erosion risk.
- **Increasing natural water storage** – this could include wetlands and farm ponds,
- **Improving infrastructure** – for example water harvesting or creation of irrigation lagoons.
- **Improving water use efficiency** – from checks on pumps and pipework to soil monitoring or drip irrigation systems.



**Steps to consider**

Every farm is different, but here are some ideas to consider in the short, medium and longer term, which could help you to improve the resilience of your business year-round and prepare for times of water scarcity.

**Short term (within the year)**

**Monitor and record current water use**

- Monitor and record water use – know how much water you use and when.
- Use meters, logbooks, or apps to track irrigation and total water demand to identify savings (see Appendix 1)

**Identify and minimise losses**

- Look at where you use water, via an abstraction or on mains supply?
- Fit a trigger gun to hoses in the yard, do not leave hoses running.
- Check float switches are operational on water tanks and drinking troughs.
- Check couplings, pipework, and hoses for leaks.
- Check and service pumps; calibrate irrigation equipment.
- Look at your scheduling plan, could you change your plan to become more efficient and effective when using water?

**Understand risk; make a drought plan**

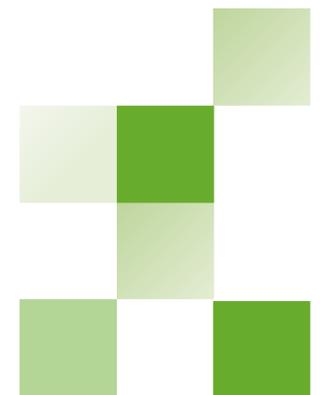
- Carry out a farm drought risk assessment (Section 4/Appendix 1).
- Prioritise crops/fields for irrigation.
- Sign up to SEPA water scarcity alerts.
- Be aware of the conditions in your permit; notice to reduce abstraction volumes in line with the water scarcity situation may already be stipulated.

**Speak to your neighbours**

- Can you schedule irrigation with your neighbours to reduce impact on water sources?
- Can you plan your irrigation at cooler times of the day, during low wind?
- Does a neighbour have spare capacity on their permit that you could use/trade? \*
- Do you have a management agreement with other water uses who rely on the same water source? If you have such an agreement, ensure that you have submitted the written agreement with your permit paperwork to SEPA.

**Identify funding**

- Keep an eye on schemes and grants that could help fund installation of water efficiency measures on the farm, such as changing to more technically efficient irrigation equipment or support towards installing lagoons.



\* Note permit holder needs to ensure that the abstraction volume is within permit conditions and the permit holder is responsible for the submission of the data returns regarding water use.

## Medium term (One to four years)

### Build soils that hold water

- Maintaining/improving soil organic matter will help to hold water in the soil. This could be through organic manures, straw incorporation, or use of green manures/cover crops.
- Regenerative agriculture techniques and/or controlled traffic farming may help you protect and improve soil structure and aid water retention.
- Avoid the use of heavy machinery on wet soils, as this will increase compaction risk.
- Identify and remediate compaction – [The Valuing your Soils brochure](#) has useful guidance around protecting and enhancing farm soils.

### Invest in new technologies

- Soil moisture probes can help improve soil management and allow for more efficient irrigation scheduling.
- Consider using predictive modelling; this can help you to improve and target water distribution throughout the farm.
- Could a change in irrigation equipment/methods help you to become more efficient? (see Section 6)

### Increase on farm water storage and/or consider alternative sources

- Irrigation lagoons can offer water storing facilities on farm to help mitigate dry seasons to ensure crop survival (see Section 5).
- The installation of boreholes, in appropriate locations can offer water availability when other sources are unavailable. However, this source is finite and should be used alongside other water sources (see Section 5).

- Would a rainwater harvesting system work on your farm? Having the opportunity to store water when in surplus can offer respite in times of water scarcity.

### Review crop choices

- Consider more drought resistant/tolerant varieties; seeds, though not always permitted, the use of seeds, which can withstand drier conditions may need to be an option in the future. Speak to your agronomy adviser and/or seed merchant.
- Could you make more use of cover crops to protect soils or deeper rooted multi species swards for livestock grazing?

### Engage in catchment level planning

- Are there strategies or plans within your local catchment to support better water use and shape water use policies in the future? Speak to your neighbours, local fishery trust organisations, or cluster groups established in your area to see if there are any opportunities. You can learn, hear, and plan catchment wide approaches to improve water management with others who rely on the resource. Sharing the cost, learning from experience and plan sustainable actions to improve and safeguard the water environment.
- Is there a management agreement for water abstraction with neighbouring farms, if not, could you set one up?

## Longer term (Four years +)

**Develop a long term weather resilience plan for your business.** An example is provided in Appendix 2 – Creating a weather resilience plan.

### Consider diversification opportunities

- Is there a market to switch away from crops with a high reliance on irrigation?

### Continue to monitor and improve soil health

- Alongside regular soil sampling, targeting optimum nutrient and pH values and improving soil organic matter, the guidance in Valuing Your Soils brochure gives a range of ideas to support farm soils.

### Consider nature-based solutions

- Could targeted riparian tree planting on the farm support water management? Tree planting could also provide shelter and shade for livestock or act as a wind break for crops. [Think the right tree, in the right place.](#)
- Are there opportunities for peatland or wetland restoration?
- Do you have suitable areas which could be used to create wetland/ponds to help increase water retention and 'slow the flow' on your land? These features can also help to recharge groundwater sources.

**Assess** your exposure, make a **plan**, and **invest** where you can. Water is no longer unlimited – treat it as a valuable input.

### Benefits from tree planting

Targeted tree planting can be beneficial for individual farms, and at scale, for wider water retention within catchments. Tree canopies intercept rainfall, slowing the movement of water within a catchment, helping to mitigate potential flood peaks after heavy or prolonged rain. Tree roots help to stabilise soils and encourage water infiltration (therefore reducing surface runoff) which in turn can help groundwater recharge. Leaf litter helps to build organic matter in the soil, further aiding water retention ability. Targeted planting can also support biodiversity and amenity value on the farm, and along with shelter and shade for livestock, certain tree species can also provide additional ad-hoc grazing material with nutritional benefits.



## Soil management for water scarcity

Soils can provide a vital if temporary store of water, increasing the holding time between rainfall and peak flow in rivers and burns around the farm, helping to reduce flooding risk and increase water infiltration and ground water recharge. A healthy and well-structured soil will also help during times of water scarcity.

### Improve soil organic matter



Managing soil organic matter (SOM) is not always as straight forward as just adding more organic manures and compost.

Specific soil characteristics along with various land management practices all influence the retention and resilience of SOM over time. It is thought that a mixture of different methods for protecting and enhancing soil organic matter would provide more benefits rather than relying on one single management option. Scottish Governments Agricultural Reform List of measures offer potential options to improve SOM such as:

- [Adopting suitable regenerative agriculture practices.](#)
- Continuous soil cover – do not leave soils bare (e.g. winter cover).
- Reduced use of synthetic fertilisers and transition to increase legumes in the rotation, use green manure, use animal manure or livestock grazing, compost and digestate.
- Alternative grazing methods (mob, strip, adaptive multi-paddock grazing) on improved grassland.
- Identify and alleviate soil compaction.

- Diversify crop rotation and break crop rotation period (esp. for root crop) and avoid monocultures through the application of inter-cropping, under-cropping, and mixed cropping (e.g. peas and barley).
- Diverse sward species and herbal leys.
- Introduce animal manure or certified compost.
- Could you introduce trees, hedgerows, or buffer strips to incorporate different rooting depths of plants.
- Retain and enhance field margins and permanent habitat margins and existing nature rich habitats.

Soil organic matter also reduces the risk of drought by reducing soil crusting, increasing water holding capacity, supporting infiltration, and reducing runoff. It is a win-win.

*An increase topsoil carbon in Scotland (and therefore SOM) by 174Mt C could result in an additional 109 billion litres of water stored. <sup>[14]</sup> This is equivalent to 6 mm of rainfall over all cultivated land.*

### Review and assess soil structure

In addition, good soil structure is important for SOM retention and drainage. Examining the shape and size of soil aggregates, the degree of porosity, root distribution, and the presence of compaction layers in the field can be used (through [Visual evaluation of soil structure \(VESS\)](#)) to evaluate structure.

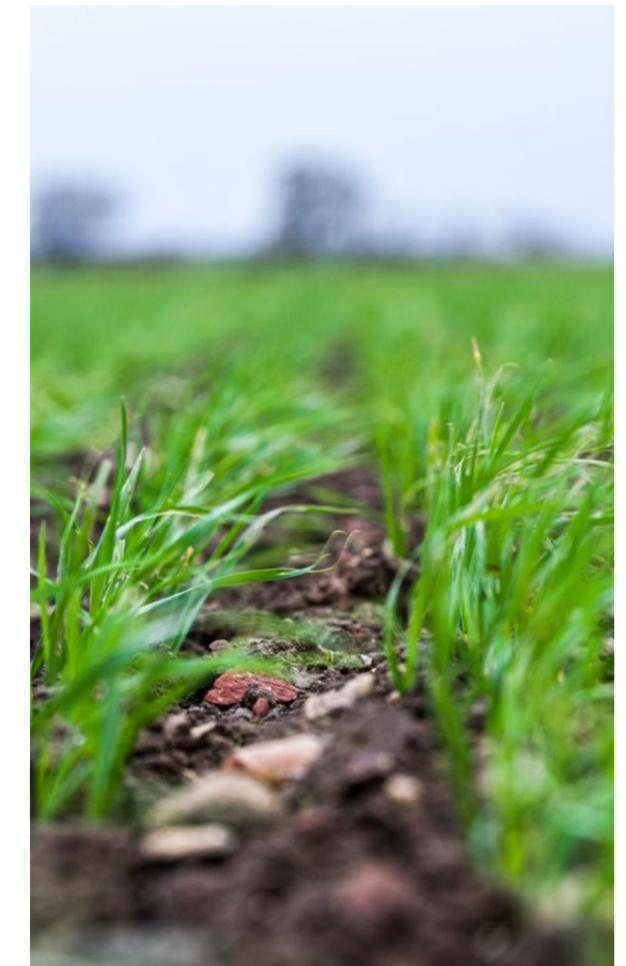
*A silt loam soil with 4% organic matter holds more than twice the water of a silt loam with 1% organic matter. <sup>[15]</sup>*

Poor soil structure, such as soil compaction, occurs when soil layers have been compressed leading to tightly packed soil aggregates and diminished pore spaces, can arise from the use of heavy machinery and/or poaching. Wet weather can exacerbate and speed up the development of soil compaction.<sup>[16]</sup> There is a link between soil compaction and erosion where soils that become compacted have a restricted capacity to store rainfall and generate overland flow more quickly than soils that are not compacted.<sup>[17]</sup> This overland flow can then cause erosion. [Soil risk maps](#) are available, which show areas of soil at risk of erosion, runoff, leaching and both topsoil and subsoil compaction, based on the inherent properties of the soil and the landscape. Identifying and remedying compaction will improve yields through improved rooting depth and access to nutrients, whilst also benefitting soil moisture holding capacity. The greatest driver of soil compaction is machinery weight, which has been increasing over the past few decades, although using wide tyres, dual wheels and low-pressure tyres can reduce the impact.

Farm Advisory Service (FAS) provides a practical guide for [avoiding and alleviating soil compaction](#) which includes:

- The use lower pressure and bigger tyres to avoid compaction from machinery such as high flexion tyres.
- Vary practices, such as cultivation depths.
- Control livestock density to reduce poaching.
- Reduce livestock and vehicle access with fencing.
- Consider location of troughs and feeders.

The vulnerability of soils to compaction are highlighted within Scotland's soil risk maps which are based on the natural soil drainage, soil texture, and organic matter content.





### Case study: Gray Farms Ltd.

Gray Farms is a family farm, farming 1300Ac in the Northeast of Scotland on a mixture of soil types, growing spring barley for malting and high-grade seed potatoes from field generation one (planting mini tubers) through to commercial export across various continents and countries.

Started many years ago by Charlie Senior, and now being run by Charlie Junior and his son Philip, diversification has always been at the heart of the business. In 2007 Gray Composting Services was born and runs alongside the farm taking organic waste streams, including green wastes and food wastes from both the public and industry, and turning them into a high-quality soil improver or compost.

#### The benefits of water retention from applying compost to our farmland

By applying compost to our farmland, we have been able to enhance soil fertility and boost crop productivity. One of the most significant, yet sometimes

overlooked, benefits of compost application is its ability to improve water retention in soil. This capacity for improved moisture management can lead to increased agricultural resilience, particularly in the face of climate variability and water scarcity, particularly while growing potatoes. Potatoes are shallow-rooted crops that require consistent moisture to develop healthy tubers. Compost, rich in organic matter, enhances soil structure by increasing porosity and aggregate stability. This allows the soil to absorb and retain more water, reducing the need for frequent irrigation and protecting plants during dry spells.

---

*For every 1% of soil organic matter, the soil can hold 185 m<sup>3</sup> of plant available water per hectare of soil down to 1ft deep.*

---

#### Increased organic matter content

Organic matter is crucial for water retention because it acts like a sponge. Compost contributes to this by adding stable forms of organic carbon that can persist in the soil for years. As a result, compost-rich soils have a higher water holding capacity, which reduces the need for frequent irrigation and protects crops from drought stress. This improved water retention ensures that moisture is available in the root zone longer, which is critical during tuber initiation and bulking stages – key periods for potato development. Compost also helps prevent water stress, which can lead to issues such as reduced tuber size, misshapen potatoes, or lower yields.

#### Improved Infiltration and reduced runoff

Compost improves soil infiltration – the rate at which water enters the soil. With better infiltration, water can seep into the soil profile instead of running off the surface. This reduces erosion, runoff and nutrient loss while allowing water to penetrate deeper, where it can be stored and accessed by plant roots. The reduced surface runoff also helps to mitigate the risk of flooding and water contamination from agricultural chemicals.

#### Efficient Use of irrigation and rainfall

With enhanced water retention, soils make better use of both irrigation and rainfall. We can irrigate less frequently, leading to reduced water consumption and lower energy costs. During rainfall, more water is absorbed and stored rather than being lost to runoff. This efficiency is particularly beneficial in drier summers such as the one we have just experienced.

#### Increased drought resilience

Climate change is increasing the frequency and severity of dry and wet spells, making water management a critical concern for us. Soil organic matter helps buffer crops against these extremes by maintaining consistent soil moisture levels. During periods of limited rainfall, compost-amended soils can continue supplying moisture to plants, reducing the risk of crop failure and stabilizing yields.

#### Environmental benefits

By improving water retention, compost also contributes to environmental sustainability. Reduced irrigation demand conserves freshwater resources. Lower runoff rates help protect nearby water bodies from sedimentation and pollution. Additionally, healthier soils with improved moisture balance promote microbial activity and biodiversity, further enhancing soil fertility and long-term productivity.

#### Conclusion

Incorporating compost into our farmland has been a powerful, nature-based solution for improving water retention. This practice not only enhances soil health and reduces irrigation needs but also builds resilience against climate-induced water stress.

For farmers facing increasing environmental pressures, increasing soil organic matter offers a sustainable path toward more efficient water use and long-term agricultural sustainability. Gray's farm uses compost, but similar benefits can be made through the uses of farm yard manure for example.

## Soil texture

Soil texture is defined by the mix of sand, silt and clay particles in your soil and will influence how soil behaves, as shown in Figure 17. The quantity of clay minerals in soils influence the adhesive properties between soil and water, particularly through capillary action (water movement in soil pores due to adhesive and cohesive forces e.g., surface tension). Unlike soil structure, soil texture is fixed, but knowing soil texture can help you make decisions about how you manage it.

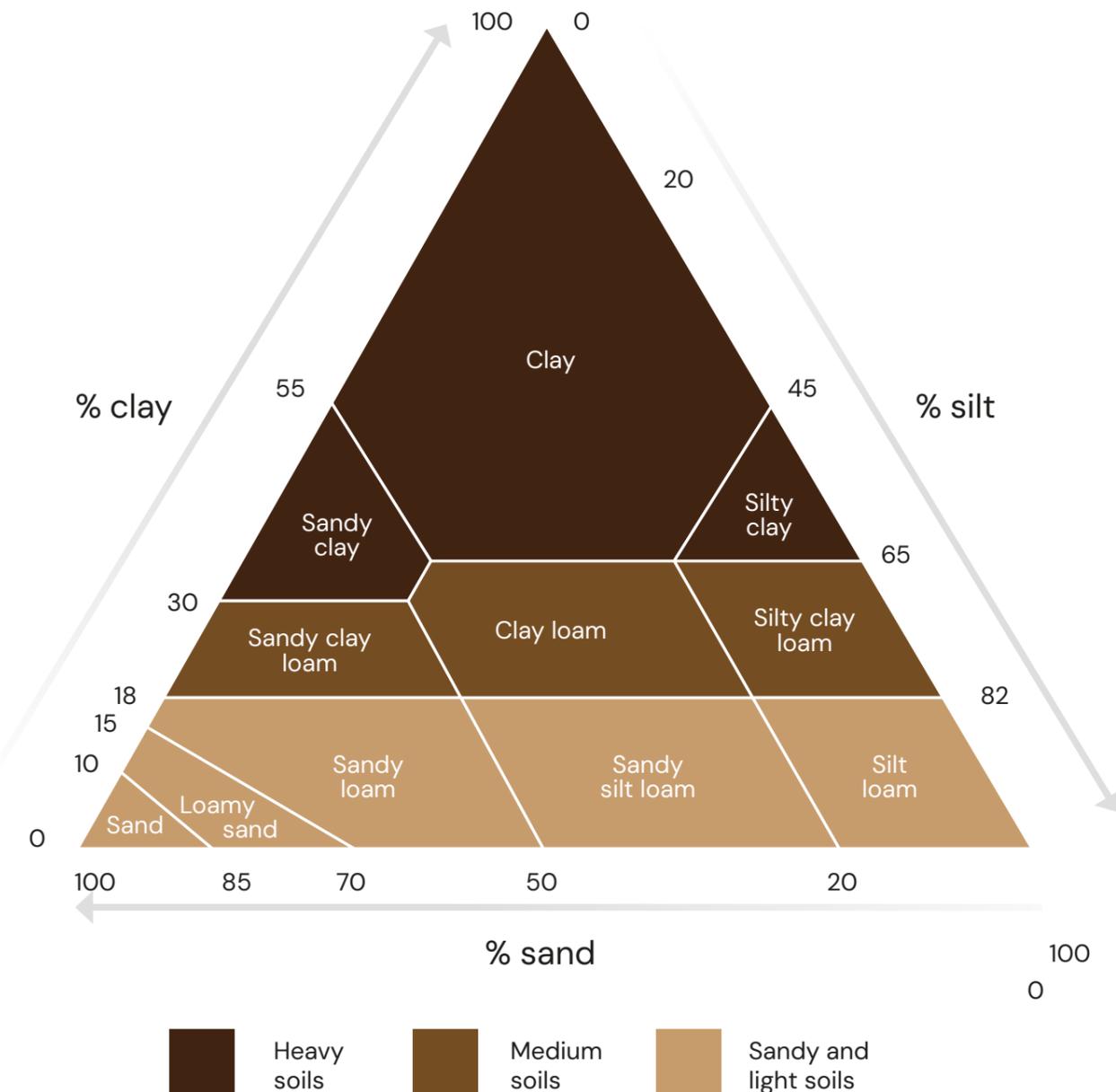


Figure 17: Soil texture triangle

## Explore regenerative agriculture techniques



Regenerative agriculture techniques such as reduced tillage, livestock integration, and use of cover crops (when targeted correctly) can help to protect and improve soil health, increase soils functionality in terms of drainage, improve water holding capacity and retention, and help to support yields. More and more commercial buyers are looking for evidence of regenerative ag techniques as part of routine practice. You can pick, choose, and adapt these principles to fit your farm business. See the further resources section for links to guidance on regenerative agriculture.

### Healthy soils holding water

Not only can this help at times of water scarcity, but also during times of heavy rainfall, helping to reduce potential flood risk.

### Nature-based systems

A variety of nature-based solutions can help you protect and manage your water resources. These measures harness natural processes to reduce surface water runoff, enhance the soil's water holding capacity, and increase infiltrate rates, which in turn supports groundwater recharge.

### Semi-natural habitats

Trees and hedgerows with their deep root systems increase infiltration, reducing surface water runoff and encouraging ground water recharge. The leaf litter from these plants increases soil organic matter enhancing the capacity of soils to store water. Rough grassy field margins, and vegetated buffer strips, help to slow the flow of water during periods of heavy rainfall, giving more time for water to infiltrate into the soils, reducing runoff, and helping to prevent soil erosion. The effectiveness of these features depends on their placement within a farm. Locate them where they intercept natural water flow paths to optimise the benefits. You know your land best and will have a good idea of where runoff occurs during heavy rain.

### Crop and sward diversification

Depending on soil characteristics and frequency of water scarcity events, it may be worth considering drought tolerant/resistant varieties. Additionally, select diverse crops with different water requirements to build resilience to drought. Deep rooted cereal crops such as rye, tolerate dry conditions due to their extensive root systems. Similarly, beans also have a deep rooting system and their ability to fix nitrogen reduces the requirement for inorganic fertilisers. Alternative crops such as these help aerate the soil and improve soil structure, which in turn aids drainage.

In grassland scenarios, multi-species swards or herbal leys provide a mix of grasses, legumes, and herbs. The different root systems of these species mean they can access water at different depth, with the deep tap roots of chicory complementing the shallower roots of white clover. This ensures better water usage and helps to maintain yields during periods of drought. In addition to this, if allowed to flower these swards provide foraging resources for pollinators such as butterflies and bees. Mixed swards require different grazing regimes compared to a typical grass sward, an example would be to leave 4 cm of height throughout the winter to aid persistence of the herbs.

Sowing catch/cover crops into arable stubbles protects soils during winter. Cover crops not only protect soils from erosion but also slows surface water runoff and increase water infiltration. Furthermore, they can increase soil organic matter, either through the dung if grazed by livestock or through incorporating the cover crop in spring. Cover crops, therefore, can increase soil health whilst building resilience to drought.

### Wider benefits

Nature-based solutions are well placed to build on farm resilience to drought, and these interventions also deliver a wide range of other benefits. Crop diversification and multi-species swards increase farm resilience to pests, weeds and disease and market fluctuations. Trees and hedgerows provide shelter and shade reducing heat stress and cold exposure in livestock with positive implications to welfare and productivity. Through reducing water runoff and intercepting sediments and pollutants, hedgerows, cover crops, field margins and buffer strips protect watercourses from diffuse pollution. By enhancing soil health, increasing infiltration, and storing more water in the landscape these interventions provide natural flood management and groundwater recharge. They also create vital habitat for beneficial insects such as natural enemies and pollinators alongside a host of other species including farmland birds, bats, and fungi.

### Further information and resources

- [Farming and Water Scotland](#)
- [Farm Advisory Service \(FAS\)](#)
  - [Using organic matter to alleviate water scarcity](#)
  - [Soil organic matter practical guide](#)
  - [Organic matter and soil erosion](#)
  - [Soil structure and compaction \(FAS\)](#)
  - [Making sense of soil carbon](#)
  - [Reducing Surface Runoff and Erosion with 'Magic Margins'](#)
- [The Rural Payments and Services website](#) provides information on potential funding opportunities which may be available to you.
- [AHDB](#) has information on Soil health and water supply which can be found on their website



Balruddery Farm: Tied Ridger © A Christie

# Appendix 1: Know your risk assessment

This section expands on and outlines information to conduct a risk assessment on water scarcity from Section 4 of the main document. It is a step-by-step process, which requires the use of [DRAT tool](#). Following Figure 7 p23 this section intends to break down each step to allow a risk assessment to be produced.



## Step 1 – Understand the local hazard

Hazard is the likelihood that your area will face dry weather and low river/groundwater levels long enough to limit water for farming. In Scotland, drought is typically when river flows are very low (around the bottom 5% of normal) for a prolonged period, often 30+ days. That's when restrictions and crop stress become likely.

### A. Build your local baseline (look-back 5–7 years)

Create a simple record of past dry spells and restrictions for your farm's catchment.

#### 1. SEPA Water Scarcity status history (May–Sept, each year)

- Note how often your area reached Alert, Moderate, or Significant Scarcity. More frequent/earlier escalations = higher hazard. [SEPA publishes weekly updates in season](#).

#### 2. Restrictions history

- Record any **temporary suspensions or limits** on abstraction (e.g., 2022 suspensions in the Eden, Fife). These are strong indicators of a high-hazard catchment.

### 3. Seasonal timing

- Mark when conditions typically tighten locally: **April–May** (establishment/early growth) and **late Aug–Sept** (grain fill/veg finishing) are increasingly vulnerable windows.

### B. Quick weekly monitoring routine (15 minutes a day, May–Sept)

A short, repeatable process helps you spot trouble early.

#### 1. Check [SEPA's weekly Water Scarcity Report](#) for your region. Log the status (Early Warning, Alert, Moderate, Significant). If the level rises two weeks in a row, treat it as a trigger to prepare (e.g., top up storage, tighten scheduling).

#### 2. Open [SEPA's Drought Risk Assessment Tool \(DRAT\)](#)

- Look at consecutive low-flow days for your local river. Rising run lengths signal increasing hazard even before formal restrictions. Note the trend week-to-week. DRAT is a near real time source of information and can vary over time. Therefore, regular checks with this tool, especially during the irrigation season can help inform the potential hazard risk.

### [Drought risk assessment tool \(DRAT\)](#)

To use this tool, please click the link. You will see a map of Scotland with interactive dots within the 'Map' tab. The dots are central points for areas. Please select the dot which represents the area your farm falls within. You will get a pop up which will show you the name of the local station for your area.

Please switch view to the 'Report' tap and scroll to your local station name. You will then be able to find information on mean flow, low flow threshold.

### 3. Local rainfall and soil moisture

- Note your 7–14 day rainfall and any soil moisture readings. Two dry weeks in spring/late summer with rising evapotranspiration = mounting hazard in catchments.

### 4. Neighbour intel

- Speak with nearby irrigators or your agronomist. If small burns are dropping fast or intakes are "near the stones," assume hazard is high for small sources.

### C. Interpreting SEPA categories (and what to do)

SEPA's levels are your "traffic lights." Use them to time actions.

- Normal:** Planning and/or post-event evaluation  
*Do now:* Routinely implement water saving measures; use recent experience to consider modification to operating practice; create/review contingency plan for future events.
- Early Warning:** Conditions trending dry.  
*Do now:* service pumps, fix leaks, check meters; review contingency plan, start topping storage when flows allow.
- Alert:** Risk is increasing; low flows possible.  
*Do now:* schedule irrigation at out with the hottest part of the day and when the wind is not strong; coordinate with neighbours to **stagger abstraction**; prioritise fields/crops.
- Moderate Scarcity:** Restrictions likely/possible.  
*Do now:* reduce non-essential use; ensure compliance with licence conditions; prepare for rotations or temporary suspensions if directed.
- Significant Scarcity:** Severe stress; suspensions may be imposed.  
*Do now:* follow SEPA instructions immediately; activate your priority plan (save highest-value crops, switch sources if available). **Record impacts** for future planning.

## D. Quick “hazard rating” for your farm (do this before Step 2)

Give **1 point = low, 2 = medium, 3 = high** for each line. Add them up.

Item	1 (Low)	2 (Med)	3 (High)	Score
<b>SEPA history (last 5–7 yrs)</b>	Rarely above Alert	Often at Alert	Regularly at Moderate/ Significant	
<b>Restrictions record</b>	None	Once	≥2 times	
<b>Source type</b>	Large river/ lochs or resilient aquifer	Mid-size burn or mixed sources.	Small burn/ spring or shallow well	
<b>DRAT trend (this season)</b>	Stable/short low-flow runs	Rising some weeks	Rising ≥2 weeks and lengthening	
<b>Seasonal timing risk</b>	Little spring/ late-summer stress	One window at risk	Both <b>Apr–May</b> and <b>Aug–Sept</b> often dry	
<b>Total Score:</b>				

### Totals

- **5–7 = Lower hazard** → keep watch, proceed to exposure/ vulnerability steps.
- **8–11 = Moderate hazard** → prepare to ration, ready storage/rotations.
- **12–15 = High hazard** → assume restrictions likely, act early on storage and scheduling.

> Less than  
 ≥ Equal or less than  
 < Greater than  
 ≤ Greater or equal to

Please note this assessment is to inform you of your risks, it is not an official requirement by SEPA.

### Take home messages for step 1

- **Make hazard visible:** keep a weekly log (status + DRAT + rainfall).
- **Watch the windows:** **April–May** and **Aug–Sept** are now the danger periods in many east-coast catchments.
- **Treat rising DRAT runs + Alert/Moderate as an early action trigger.**



## Step 2 – Assess your exposure

Exposure is how dependent your farm is on water (how much, when, and where you need it) and how tightly your operations are tied to a single source. In Scotland, farm water typically comes from rivers/lochs, private supplies (springs, small burns, rainwater/ ponds), groundwater boreholes, mains, and on-farm storage. High-value irrigated crops (potatoes, veg, soft fruit) occupy a small share of land but a large share of income, so exposure can be high even if the area irrigated is modest.

### A. Make a one-page ‘sources & uses’ map

Sketch or digitally produce a map of your farm blocks and note for each:

- **Water source** used (river/burn, borehole, spring/private supply, mains, storage).
- **Connection details** (pump, pipe run, head/ elevation, access point).
- **Main use** (irrigation, stock water, dairy/ parlour, washdown, produce washing, spraying).
- **Backup** (e.g., storage tank, secondary source, tanker point).

This gives you a clear picture of where dependence is concentrated. (Private supplies and shallow springs are often the most fragile under drought; borehole availability is site-specific across Scotland’s geology.)

### B. Do a fast water audit

- **Meter** key lines (irrigation pump, borehole, main stock line).
- **Irrigation volume:**
  - $m^3 = mm \times ha \times 10$ .
  - Example: 25 mm over 10 ha = **2,500 m<sup>3</sup>** per application; over 5 days ≈ **500 m<sup>3</sup>/day**.
- **Livestock/parlour:** confirm daily totals and short **peak flows** (bursts after milking).
- Identify **peak season** (often Apr–May; late Aug–Sept) and **peak hour** constraints (pump, pipe, elevation).

### C. Reality-check permissions and kit

- If abstracting **>10 m<sup>3</sup>/day**, ensure your **licence rate and total calculated peaks** and that you can comply under low-flow conditions.
- Check **pump and pipe sizing** against peak flow and lift (head); under sizing is a common hidden limiter.
- Plan to **buffer peaks** with storage: pump steadily into lagoons/tanks, draw off to meet irrigation bursts.

## D. Quick exposure score (do this before Step 3 – vulnerability)

Give 1 = low, 2 = medium, 3 = high. Add them up.

Item	1 (Low)	2 (Med)	3 (High)	Score
Share of income from irrigated/ high-water crops	<15%	15–40%	>40%	
Number of independent sources (incl. storage)	≥2	1 + backup via mains/tanker	1 only	
Peak-day demand vs. licenced/available rate	≤60%	60–90%	>90%	
Daily peak flow vs. pump/ pipe capacity	Comfortable	Tight at peaks	Frequently short	
Distance/head to main fields	Low	Moderate	High/awkward	
<b>Total Score:</b>				

### Totals

- **5–7 = Lower exposure** – Good baseline; improve measurement & keep storage topped up.
- **8–11 = Moderate exposure** – Consider storage, peak-shaving (what time of day are you irrigating, wind conditions), and backup.
- **12–15 = High exposure** – Prioritise storage/backup, review cropping pattern, and coordinate abstractions.

### Take-home for Step 2

- **Measure what matters:** meters on main lines pay for themselves by finding leaks and confirming peaks.
- **Match peaks with buffering:** storage + correct pump/pipe sizing turns a fragile system into a robust one.
- **Reality-check the paperwork:** ensure licence limits and conditions align with your **calculated** peak needs before the season starts.



## Step 3 – Assess your vulnerability

Vulnerability is how well your farm can cope when water is scarce. Two farms with the same drought hazard and the same exposure can fare very differently depending on their buffers (storage), backups (alternative sources), soils, crop mix, and how efficiently they use the water they have. Lower vulnerability means you can keep priority crops/stock supplied for longer, comply with any restrictions, and avoid costly emergency measures.

### A. Your biggest lever: storage days of cover

- Days of cover = usable storage (m<sup>3</sup>) ÷ peak daily demand (m<sup>3</sup>/day).
- Benchmarks: ≥21 days = low vulnerability; 7–20 = medium; <7 = high.
- If low, consider winter-fill storage, modular tanks, and peak shaving (what time of day are you irrigating, wind conditions, fix leaks, modifying scheduling).

### B. Redundancy and soils

- Backup sources you can switch to in hours (storage/mains/borehole).
- Soils/rooting: light/sandy soils need tighter intervals; improve structure and organic matter to raise available water.

### C. Business and efficiency

- Avoid >40% gross margin dependent in July–Aug irrigated crops.
- Check distribution uniformity and pressure; fix leaks; recalibrate nozzles; rotate sets to match priority fields.

### D. Constraints, kit, people

- Understand licence conditions (e.g., hands-off flows); plan actions by SEPA level.
- Backup power/pump; spares kit (nozzles, filters, clamps).
- A one-page drought plan with named roles, switching steps, and contacts.



### E. Quick vulnerability score (use once you know your exposure)

Give 1 = low, 2 = medium, 3 = high for each item. Add them up.

Item	1 (Low)	2 (Med)	3 (High)	Score
Storage days of cover (start of July)	≥21	7–20	<7	
Independent sources (incl. storage)	≥2	1 + credible backup	1 only	
Soil & rooting	Medium/heavy or deep roots	Mixed	Light/sandy + shallow roots	
Business dependence on irrigated crops	<15%	15–40%	>40%	
System efficiency (uniformity, leaks)	Verified good	Some issues	Poor/unknown	
Licence constraints in dry summers	Rare	Occasional	Frequent	
Power/hardware backup	Generator + spares	Partial	None	
People & plan	Written plan + trained	Informal	None	
<b>Total Score:</b>				

#### Totals

- **8–11 = Lower vulnerability** – Keep good practice, revisit annually.
- **12–17 = Moderate** – Target 2–3 improvements (storage, fixes, plan).
- **18–24 = High** – Prioritise storage/backup, system fixes, and a written plan now.

#### Take-home for Step 3

- **Know your buffer:** days of cover is the single clearest indicator of vulnerability.
- **Redundancy beats hope:** a second source or proper storage is worth more than a “normal” summer.
- **Tighten the system:** efficient, well-maintained kit turns limited water into saved crops.
- **Make decisions quicker:** a simple drought plan and priority list cuts losses when restrictions arrive.



### Step 4 – Build your drought risk profile

Pull your **hazard (H)**, **exposure (E)**, and **vulnerability (V)** into one picture so you can:

1. see your **overall drought risk**.
2. agree **clear triggers** for action.
3. prioritise **investments**.

#### A. Convert your Step 1–3 scores into bands

- **Hazard:** Low (5–7), Medium (8–11), High (12–15).
- **Exposure:** Low (5–7), Medium (8–11), High (12–15).
- **Vulnerability:** Low (8–11), Medium (12–17), High (18–24).

#### B. Choose an overall risk method (pick one)5

Method 1 – Simple “risk grid” (fast and visual)

1. Plot **Exposure (x-axis)** vs **Vulnerability (y-axis)** on a 3×3 grid (Low/Med/High).
2. Use Hazard to tint the box:
  - a. Hazard **Low** = pale; **Medium** = amber; **High** = red outline.
3. Read your overall risk from the box colour/shade:
  - a. **Low** (bottom-left area), **Medium** (middle belt), **High** (top-right).

Method 2 – Weighted index (still simple; gives a number)

Turn bands into numbers (**Low=1, Med=2, High=3**), then:

$$\text{Overall Drought Risk Index (ODRI)} = H + 2 \times E + 2 \times V$$

(Min = 5, Max = 15; we weight exposure/vulnerability more because you can act on them.)

- **Low risk** = 5–7.
- **Medium risk** = 8–11.
- **High risk** = 12–15.

(Use Method 1 if you like visuals; Method 2 if you want one number.)

#### C. Set clear triggers linked to real actions

Agree these before the season; keep them simple and automatic.

Trigger type	Example trigger	What you do the same day
SEPA status	Area moves to Alert	Top storage on higher flows; shift irrigation to cooler times of day, low wind; check leaks and filters
River signal	DRAT low flow run lengthens 2 wks	Start neighbour rota; reduce non-priority sets by 20–30%; prepare to switch intakes
On-farm buffer	Storage < 14 days cover	Pause non-priority fields; activate backup source/mains for parlour; confirm tanker point
Licence/ condition	Hands-off flow close	Move to storage only; implement priority list and record volumes

**D. Fill a one-page “Drought Risk Profile Card”** An example has been provided below. You can adapt the form to your needs and actions. Downloadable version [here](#).

**Farm & Catchment**

- Holding/catchment: \_\_\_\_\_ SEPA area: \_\_\_\_\_
- Main sources:  River/burn  Borehole  Spring  Mains  Storage
- Licence summary (rate/volume/conditions): \_\_\_\_\_

**Scores & Bands**

- Hazard: \_\_\_\_\_ (Low/Med/High)
- Exposure: \_\_\_\_\_ (Low/Med/High)
- Vulnerability: \_\_\_\_\_ (Low/Med/High)
- Overall (grid or ODRI): \_\_\_\_\_

**Key Numbers**

- Peak-day demand (m<sup>3</sup>/day): \_\_\_\_\_
- Storage **days of cover** at start of July: \_\_\_\_\_ days
- Priority crops/uses (by margin per m<sup>3</sup>): 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

**Top 3 Weak Points**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

**Triggers & Actions**

- **Trigger A (seasonal):** First SEPA Alert → Top up storage; irrigate at cooler times; leak check
- **Trigger B (local):** DRAT low-flow run ↑ two weeks → Stagger with neighbours; switch to storage for priority blocks
- **Trigger C (on-farm):** Storage < 10 days cover → Priority-only irrigation; secure backup source

**Contacts**

- Neighbour abstraction rota (names/numbers): \_\_\_\_\_
- Pump/pipe repair contact: \_\_\_\_\_
- SEPA—local office contact: \_\_\_\_\_

**F. Link risk band to an investment plan**

- **If overall risk = Low:** keep meters/maintenance tight; review annually.
- **If overall risk = Medium:** add **buffer/storage** (tanks/lagoon), fix bottlenecks (pump/pipe sizing), and formalise neighbour rota.
- **If overall risk = High:** plan **winter-fill storage** or a **second source**, redesign set-up for irrigation at cooler times of day and priority delivery, and review crop mix/contract exposure.

**Take-home for Step 4**

- Put your three bands on **one page** with **triggers** and **priority ladder**.
- Use either the **method 1**, the **grid**, or **method 2** the **ODRI** to label overall risk (Low/Med/High).
- Tie the risk level to **specific actions and investments** you’ll make **before** the season, so decisions in July are fast and calm.



**Step 5 – Test your resilience**

You scored hazard, exposure, vulnerability. Now pressure-test your set-up. Run short drills and “what-if” scenarios to see if your plan, storage, licences, pumps, and people actually hold up. Fix the weak points you find.

**A. Pick 3–5 realistic scenarios (one page each)**

- **Two-week irrigation ban (July)** on your main river/burn.
- **Spring stops for 10 days (Aug);** stock water at risk.
- **Hands-off flow triggers:** nights-only pumping for 14 days.
- **Pump failure** (48 hours); **power cut** (12 hours).
- **Filter clogging/algae** at low flows; application rate drops 25%.

For each scenario, write: **assumptions, what you will do today, who does what, and what success looks like.**

**B. Do a 60-minute tabletop drill**

Work the first **24–48 hours** hour-by-hour: triggers, priority list, switching steps, compliance, calls, repairs. **Pass** if you can meet **priority crops/stock** within licence and storage limits for the scenario window.

**C. Run one short live drill (2–3 hours)**

- **Night-set rehearsal; source-switch** to storage; start **backup pump/generator**.
- Time each step; update kit list and instructions.

#### D. Simple water-budget stress test

- **Net change (m<sup>3</sup>/day) = inflow – priority demand.**
- If negative, **days of cover shrink**; reduce demand (pause non-priority, lengthen intervals on deeper soils) or increase inflow (night pumping if allowed).

#### E. Rationing rules that work

- Night/early-morning irrigation only.
- Pause non-priority uses (washdown to rainwater/mains).
- Rotate sets for **“just enough”** on priority fields.
- Fix leaks and pressure (uniformity up = depth down for same effect).

#### F. Pass/fail scorecard (per scenario)

Score **0 = fail, 1 = partial, 2 = pass**:

Element	0	1	2	Score
Priority crops supplied	<70%	70–90%	≥90%	
Stock/parlour continuity	Break	Short disruption	Continuous	
Licence compliance	Breach risk	Tight	Compliant	
Switching speed	>4 h	1–4 h	<1 h	
Comms & rota	None	Ad-hoc	Clear/used	
Storage trajectory	Collapses	Flat	Stable/recovering	
<b>Total Score:</b>				

≥9 = **acceptable**. If lower, fix two weakest items and re-run.

**[Note for expansion]** Add a “go-bag” checklist (spares, tools, contacts) and a one-page scenario sheet template.

#### Take-home for Step 5

- **Carry out a drill over winter, not in July.** One tabletop + one short live drill exposes most issues.
- **Budget your water daily.** Track storage vs demand and act early.
- **Make it easy for people.** Clear rationing rules, a priority ladder, and a neighbour rota turn stress into a routine.

Cranfield University have produced a tool to allow farmers to build a farm drought risk assessment. This tool is advanced, but the following steps have been created to help you use the software. Please note that the tool is UK wide, so some steps below have highlighted sections which need to be taken to ensure that the data is relevant to Scotland.

**D-Risk** is a free, web-based tool that estimates the **probability of irrigation shortfalls (deficits)** and **licence headroom** and lets you **test storage/reservoir options** under different weather sequences. It runs a monthly water balance using local agro-climate (PSMD) and your farm inputs (crops, soils, licences, storage). It also includes a **D-Risk Reservoir** explorer for indicative sizing/costing (for scoping only you would still require professional design).

D-Risk uses hundreds of plausible weather sequences (**the MaRIUS event set**) to build **probability distributions** and an **uncertainty envelope** (average/driest/wettest series), rather than relying on a handful of historic droughts.

Step by step guidance is below:

#### Quick run sheet (inputs → outputs → decisions)

##### 1. Gather your inputs (15–30 min)

- **Location:** select Scotland and the nearest catchment gauge inside D-Risk.
- **Crops & soils:** irrigated areas by crop; soil type.
- **Licences:** SEPA daily/annual limits; any **hands-off flow (HOF)** threshold.
- **Storage:** usable capacity (m<sup>3</sup>) across lagoons/tanks. (Tip: meters/records from Step 2 make this quick.)

##### 2. Choose climate period

- **Baseline (1975–2004)** reflects observed climate; Near-future (**2020–2049**) represents a high-emissions trajectory. Start with **Baseline** for today’s decisions.

##### 3. Scotland-specific switches

- Leave **“Include emergency drought restrictions (S57)” off** (that’s an England/Wales mechanism). Use SEPA alerts/DRAT for live triggers.

##### 4. Run scenarios

- **A. No flow constraints** (licence + storage only).
- **B. With flow constraints** (adds HOF/river conditions). D-Risk outputs **probability curves** for **deficit** and **headroom**; it also shows uncertainty bands based on multiple weather sequences (MaRIUS event set).

##### 5. Explore storage (optional)

- Open **D-Risk Reservoir** and test +20–50% storage. Note the **risk reduction per £**; treat costs as **indicative only**.

##### 6. Cross-check with live Scottish data

- **SEPA DRAT** (daily): consecutive **very-low-flow days** → early warning of escalating scarcity.
- **UKCEH Hydrological Outlook** (monthly): one to three month river-flow outlook to plan staffing/inputs.

## How to read the D-Risk graphs (deficit & headroom)

### What you'll see:

- Curves showing the **cumulative probability** of exceeding a given **annual irrigation deficit** (m<sup>3</sup>) and the **probability distribution of licence headroom** (% of licensed volume unused).
- Two versions: **without** and **with flow constraints** (HOF/river limits). Use the **with-constraints** curves for real-world planning.

### Rules of thumb for decisions

- **If the 1-in-5-year (80th percentile) deficit > 0** → plan extra **storage/backup** and a **priority ladder** (Step 4).
- **If headroom ≈ 0%** at common probabilities → daily/annual **licence or pump/pipe capacity** is the pinch point; improve scheduling and/or upsize critical bottlenecks.
- **If adding flow constraints shifts curves sharply right** → **river-flow limits** drive risk; invest in **winter-fill storage** and **neighbour rotas** timed to higher flows.

### Common pitfalls and how to avoid them

- **Forgetting flow constraints:** Always compare **with vs. without** constraints; in dry summers, HOF/river limits often dominate risk.
- **Over-trusting reservoir costs:** D-Risk Reservoir costs are **indicative**; confirm with professional design and site investigation.
- **Assuming today's climate only:** Start with **Baseline**, then sanity-check **Near-future** to see how risk might shift.
- **Using S57 in Scotland:** Leave it **off**; rely on SEPA's weekly updates and DRAT for triggers.

### What to paste into your Step-4 Profile Card (from D-Risk)

- **ODRI evidence:** "D-Risk (with flow constraints), 80th percentile deficit = \_\_\_ m<sup>3</sup>; headroom (80th) = \_\_\_%."
- **Storage case:** "+ \_\_\_ m<sup>3</sup> storage → deficit curve improves by \_\_\_ m<sup>3</sup> at 80th percentile (scoping only)."
- **Trigger link:** "If DRAT low flow run → two weeks or SEPA **Alert** issued → activate night sets, rota, and switch to storage per plan."

# Appendix 2: – Creating a weather resilience plan

Our climate is becoming less predictable, and we are seeing more extremes, often out of season. Creating a longer-term weather resilience plan will be bespoke to your farm, however, the following outlines sections for consideration:

## Section 1 – Soil management

- Are your soils in good condition? Adapting regenerative agriculture techniques could support farm soils. [‘The Valuing Your Soils’](#) booklet provides a useful reminder of soil management strategies and how to improve and protect farm soils.

## Section 2 – Crop and livestock adaptation

- How robust are your cropping choices? Do you need to consider more crop types to spread risk or experiment with planting smaller areas of drought tolerant varieties?
- Do you have grazing plans in place to accommodate wet or dry years? Are there shelter and shade for livestock?
- Integrating trees could be one way to provide shelter and shade for livestock, reduce wind damage for crops, and/or protect watercourses.

## Section 3 – Financial and business strategy

- Do you have adequate insurance? This could be for infrastructure, livestock losses, or crop failure.
- Are there other diversification opportunities that could help you spread risk?
- Do you have emergency plans in place, for example if the business lost power, was cut off by storms or experienced flooding?

## Section 4 – Technology and skills

- Many precision agriculture techniques and technologies are available, from controlled traffic farming to soil moisture sensors. Could additional technology benefit the farm business?
- Everyone can learn new skills or gain new knowledge. Take advantage of farmer meetings, discussion groups and catchment initiatives.

# Glossary of terms

**Available water (AW):** capacity is described as the difference between the field capacity (FC) and wilting point (WP).

**Climate water balance:** The difference between rainfall and evapotranspiration.

**Drought:** Prolonged period of abnormally low rainfall, leading to water scarcity and environmental stress.

**Evapotranspiration:** refers to the total amount of water evaporating and transpiring from the Earth's surface.

**Fertigation:** application of water-soluble fertiliser along with water through an irrigation system.

**Field capacity (FC):** is associated with moist soils. Described as how much water the soil can hold after the excess drains off. It displays the balance of water and air in the soil's pores.

**Soil available water capacity:** The amount of water that different soils can store and make available to crops.

**Soil organic matter (SOM):** the organic material fraction within soil. Plays a key role in soil physical structure and biological activity.

**Transpiration:** the process through which water moves from the soil through plants and into the air, is also part of the evapotranspiration system.

**Water budget/balance:** balance between precipitation, evapotranspiration, and runoff.

**Water scarcity:** A long-term imbalance between water supply and demand in a region (or in a water supply system).

**Water scarcity index:** SEPA metric using a combination of rainfall and river flow data, soil moisture deficit and rainfall forecast to assess severity of water scarcity and when to act.

**Wilting point (WP):** is associated with dry soils. Described when water is held by the soil matrix so tightly that roots cannot absorb it in periods of dry conditions.

## References

1. WWF (2019): The Economic Impact of Extreme Weather on Scottish Agriculture [www.wwf.org.uk/sites/default/files/2021-04/Impact\\_of\\_extreme\\_weather\\_on\\_Scottish\\_Farmers\\_2018\\_FINAL.pdf](http://www.wwf.org.uk/sites/default/files/2021-04/Impact_of_extreme_weather_on_Scottish_Farmers_2018_FINAL.pdf)
2. Miriam Glendell, Kirsty Blackstock, Kerr Adams, Jack Brickell, Jean-Christophe Comte, Zisis Gagkas, Josie Geris, David Haro, Mohamed Jabloun, Alison Karley, Laure Kuhfuss, Kit Macleod, Shaini Naha, Eleanor Paterson, Mike Rivington, Chloe Thompson, Kirsty Upton, Mark Wilkinson, Kirsten Williams (2024). Future predictions of water scarcity in Scotland: impact on distilleries and agricultural abstractors. CRW2023\_05. Centre of Expertise for Waters (CREW). Available online at: <https://www.crew.ac.uk/publication/water-scarcity-impacts-distilleries-agricultural>
3. Gosling, R., Halliday, S.J., Brown, I., Black, A., and Hendry, S. (2024). Climate Crisis: informing Scotland's actionable mitigation and adaptation response to water scarcity. CRW2022\_07. Centre of Expertise for Waters (CREW). Available online at: <https://www.crew.ac.uk/publication/mitigation-adaptation-response-to-water-scarcity>
4. Moran & Dann (2008) The economic value of water use: Implications for implementing the Water Framework Directive in Scotland <https://doi.org/10.1016/j.jenvman.2007.01.043>
5. E.K Weatherhead, J.W Knox, J. Morris, T.M Hess, R.I Bradley, C.L Sanders (1997) Irrigation Demand and On-Farm Water Conservation in England and Wales [https://www.researchgate.net/publication/246544337\\_Irrigation\\_Demand\\_and\\_On-Farm\\_Water\\_Conservation\\_in\\_England\\_and\\_Wales](https://www.researchgate.net/publication/246544337_Irrigation_Demand_and_On-Farm_Water_Conservation_in_England_and_Wales)
6. Loris (2004) Allocation and Abstraction of Water in Rural Scotland [https://www.researchgate.net/publication/273938380\\_Allocation\\_and\\_Abstraction\\_of\\_Water\\_in\\_Rural\\_Scotland](https://www.researchgate.net/publication/273938380_Allocation_and_Abstraction_of_Water_in_Rural_Scotland)
7. Rey D., Holman, I.P., Daccache, A., Morris, J., Weatherhead, E.K., Knox, J.W. (2016): Modelling and mapping the economic value of supplemental irrigation in a humid climate <https://www.sciencedirect.com/science/article/pii/S0378377416301342>
8. Knox, J. W., Weatherhead, K., & Loris, A. A. R. (2007). Assessing Water Requirements for Irrigated Agriculture in Scotland. Water International, 32(1), 133-144. <https://doi.org/10.1080/02508060708691970>
9. IK Mathieson, JW Knox, EK Weatherhead, J Morris, DO Jones, AJ Yates. Optimum use of water for industry and agriculture dependent on direct abstraction - best practice manual. Environment Agency R&D Technical Report W157, produced by WS Atkins and Cranfield University. 2002 <https://dspace.lib.cranfield.ac.uk/items/81bc1301-c2c0-4166-bd03-7717897b0466>
10. Rivington and Jabloun (2023) Summary of the Climate Trends, Future Projections and Extremes in Scotland. Available online <https://www.hutton.ac.uk/wp-content/uploads/2024/03/Executive-Summary-of-Climate-Trends-Projections-and-Extremes-in-Scotland-and-implications-for-Natural-Capital-and-Policy-Published-11-7-23.pdf>
11. Hollis J.M., Lilly, A., Higgins, R. Jones, R. J. A, Keay, C.A., Bellamy, P. (2015) Predicting the water retention characteristics of UK mineral soils <https://doi.org/10.1111/ejss.12186>
12. Gagkas, Z., Lilly, A., Baggaley, N. (2018). Comparison of available water capacity predictions in Scotland from different PTFs: implications for modelling [https://www.researchgate.net/publication/327470717\\_Comparison\\_of\\_available\\_water\\_capacity\\_predictions\\_in\\_Scotland\\_from\\_different\\_PTFs\\_implications\\_for\\_modelling](https://www.researchgate.net/publication/327470717_Comparison_of_available_water_capacity_predictions_in_Scotland_from_different_PTFs_implications_for_modelling)
13. Hess, T. M., Knox, J.W., and Kay, M.G. (2008). Managing water better. The agronomic, economic and environmental benefits of irrigation scheduling. An information booklet produced for Defra Innovation Network and the Environment Agency. Cranfield University. <https://www.ukia.org/docs/booklets/Managing%20Water%20Better.pdf>
14. Lilly, A and Baggaley, N.J (2021) Scoping study to identify current soil organic carbon stocks and the potential for increasing carbon sequestration in Scottish soils. <https://www.gov.scot/publications/scoping-study-identify-current-soil-organic-carbon-sequestration-scottish-soils/>
15. FAS (2024) Using Organic Matter to Alleviate Water Scarcity <https://www.fas.scot/article/using-organic-matter-to-alleviate-water-scarcity/>
16. Farming and Water Scotland: Soil Compaction <https://www.farmingandwaterscotland.org/resource/soil-compaction/>
17. Lilly A., Baggaley, N., Loades, K., McKenzie, B., Troldborg, M. (2018) Soil erosion and compaction in Scottish soils: adapting to a changing climate <https://www.climatechange.org.uk/projects/soil-erosion-and-compaction-in-scottish-soils-adapting-to-a-changing-climate/>

**Published by CREW** – Scotland’s Centre of Expertise for Waters. CREW connects research and policy, delivering objective and robust research and expert opinion to support the development and implementation of water policy in Scotland. CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes. The Centre is funded by the Scottish Government.

This document was produced by:

*Fiona Salter<sup>1</sup>, Rebecca Audsley<sup>1</sup>, Gavin Prentice<sup>1</sup>, Kirsten Williams<sup>1</sup>, Jack Zuill<sup>1</sup>, Sarah Buckingham<sup>1</sup>, Lorna Cole (SRUC)<sup>1</sup>, David Haro Monteagudo (The University of Aberdeen)<sup>2</sup>, Kerr Adams (The James Hutton Institute)<sup>3</sup> and Jim Booth (Scottish Agricultural Organisation Society)<sup>4</sup>*

<sup>1</sup>SRUC, Peter Wilson Building, Kings Buildings West Mains Road, Edinburgh, EH9 3JG;

<sup>2</sup>School of Geosciences, University of Aberdeen, Old Aberdeen Campus, Elphinstone Road, Aberdeen;

<sup>3</sup>James Hutton Institute, Craigiebuckler, Aberdeen AB15 9QH;

<sup>4</sup>Rural Centre, West Mains, Ingliston, Newbridge, EH28 8NZ.

CREW Project Manager: Rebekah Burman

Please reference this guidance as follows: Fiona Salter, Rebecca Audsley, Gavin Prentice, Kirsten Williams, Jack Zuill, Sarah Buckingham, Lorna Cole, David Haro Monteagudo, Kerr Adams and Jim Booth (2026). Planning for Water Scarcity: Practical guidance for Scottish farmers and growers. CRW2024\_05. Centre of Expertise for Waters (CREW)

Available online at: [crew.ac.uk/publications](http://crew.ac.uk/publications)

ISBN: 978-1-911706-44-1

**Dissemination status:** Unrestricted

**Copyright:** All rights reserved. No part of this publication may be reproduced, modified, or stored in a retrieval system without the prior written permission of CREW management. While every effort is made to ensure that the information given here is accurate, no legal responsibility is accepted for any errors, omissions, or misleading statements. All statements, views and opinions expressed in this paper are attributable to the author(s) who contribute to the activities of CREW and do not necessarily represent those of the host institutions or funders.

**Acknowledgements:** The guidance document was funded by CREW at the request of SEPA. We are grateful to CREW, SEPA, Nature Scot, Scottish Government and NFUS for comment on draft versions.

All photography in this document is courtesy of SRUC.

We gratefully acknowledge case study farmers, and those participants to our questionnaire and review of drafts.





## Centre of Expertise for Waters

James Hutton Institute  
Craigiebuckler  
Aberdeen, AB15 8QH  
Scotland, UK

[www.crew.ac.uk](http://www.crew.ac.uk)

CREW publications can be accessed here:  
[www.crew.ac.uk/publications](http://www.crew.ac.uk/publications)



@crew-waters.bsky.social    CREW-scotland

CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes and Research Institutes. The Centre is funded by the Scottish Government.

