Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

SOUTHERN NSW Innovation Hub
SUSTAINABLE AGRICULTURE, LANDSCAPES AND COMMUNITIES

# FOREWARNED IS FOREARMED

Forecasting tools for informed decision making

# Workshop Delivery

## Making better tactical decisions using the climate forecast tools

April 2023

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program and developed in conjunction with the Southern NSW Drought Resilience Adoption and Innovation Hub as part of the Drought Resilience Adoption and Innovation Hubs Program, which received funding from the Australian Government's Future Drought Fund – an Australian Government initiative.

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The Forewarned is Forearmed project was supported by funding from the Australian Government, Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program. It was also supported by contributions from a number of project partners.

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The following organisations (including producer/farmer representatives) all contributed to the development of Forewarned is Forearmed extension resources, including reviewing the workbook and/or delivering the pilot workshops, ensuring the FWFA program is relevant and practical for industry:

- Meat & Livestock Australia
- Grains Research and Development Corporation
- Dairy Australia
- South Australian Research and Development Corporation
- Sugar Research Australia
- Wine Australia
- Primary Industries Climate Challenges Centre
- Cotton Research and Development Corporation
- Agrifutures
- Australian Pork
- Agrista
- Local Land Services NSW
- Pinion Advisory
- Enablers of Change

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# Foreword

**The Forewarned is Forearmed (FWFA) project is helping equip farmers to proactively manage the impacts of extreme weather events. Australia has one of the most variable climates of any country in the world. Extreme weather events (such as heatwaves, frost and heavy rainfall) and climate variability have a huge impact on our agricultural production and income.**

The five-year, national FWFA project aims to help farmers by providing forecasts of extremes and equipping them with the information and tools to be forewarned and prepared. As a result, we're aiming to decrease the impacts that extreme climate events have on farm production and on business profit.

The Bureau of Meteorology (known as the BoM or just the Bureau for short) and its project partners have developed forecasts of the likelihood of weather extremes on multi-week and seasonal timescales—beyond the traditional seven-day weather forecast. The tools are focused on heat, cold and rainfall extremes. They help answer questions such as *'What is the likelihood of having an extreme rainfall this spring?'*; *'What is the chance of having a heatwave in the week after next?'*; and *'What is the likelihood of having more heavy rainfall events than usual in the upcoming fortnight?'*. This provides farmers with the first-ever forecasts of weather extremes in the weeks to seasons ahead.

A co-design process included agricultural climate and systems analysis researchers and extension specialists with expertise in the dairy, beef, sheep, grains, sugar and wine industries. They used Bureau outputs and worked directly with farmers and farm consultants to connect the forecasts with agricultural decision-making systems. They developed risk management strategies to help farmers proactively prepare for these events, and communicated the project outputs to farmers and advisors.

Seasonal forecasts provide us with extra information, and as Peter Hayman from SARDI says, "they help you know which way to lean, not jump. They are too good to ignore, but not good enough to be sure!"

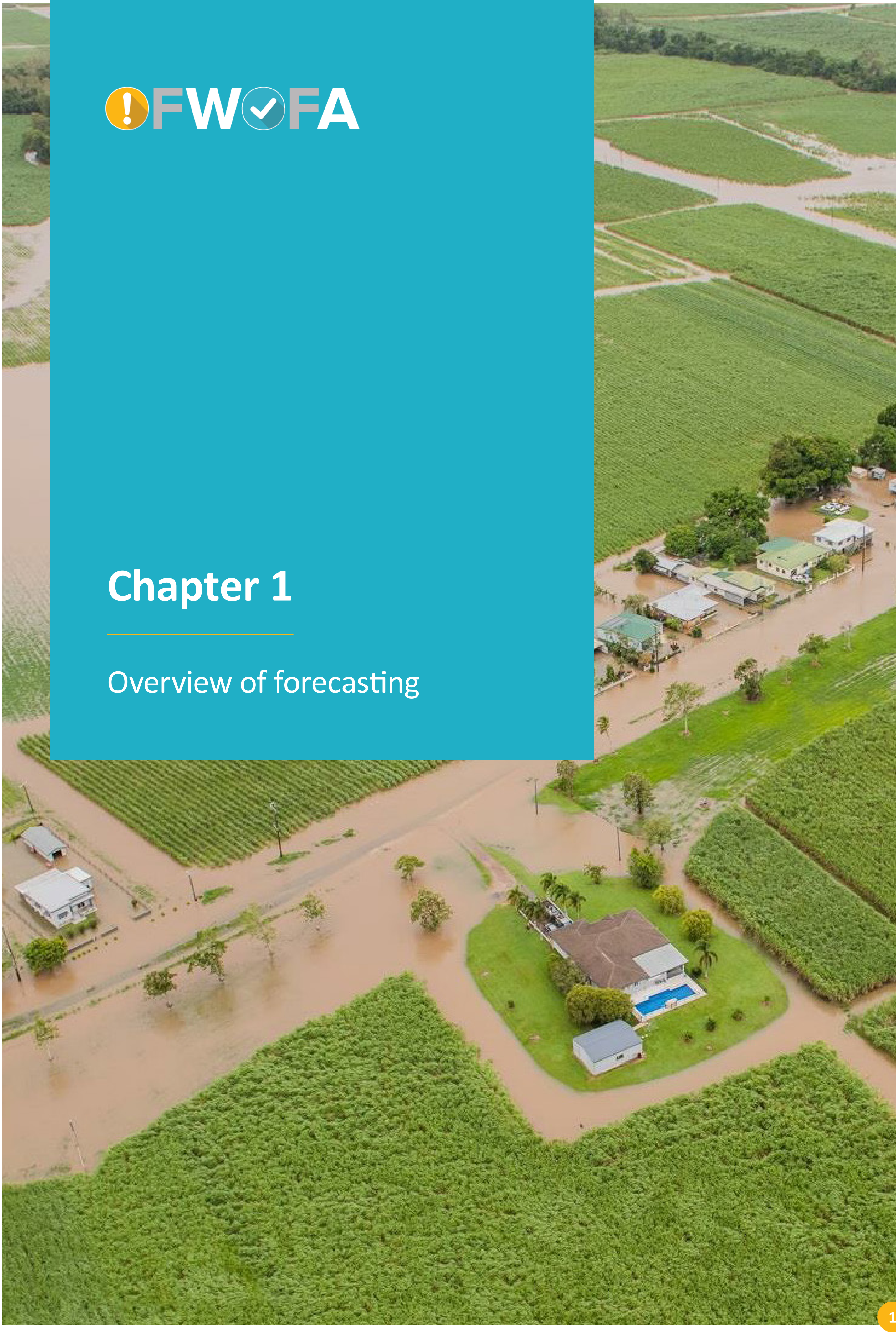
# Contents

# Glossary

| | |
|---|---|
| **Average** | The mean value obtained by adding a set of values and dividing the sum by the number of values. |
| **Binomial** | In Latin it means "having two terms". A binomial probability distribution describes the likelihood of only two possible outcomes occurring (above or below, success or failure, etc.) in each trial or model run. |
| **Box and whisker plot** | A graphical representation of a set of data through its quartiles and outliers, with a box showing the middle 50% of the data and whiskers representing the range of the data outside the box. |
| **Bureau** | The Bureau of Meteorology (BoM), which is the Australian government agency responsible for collecting and analysing data related to weather and climate. |
| **Burst** | A sudden and brief increase in wind speed or rain. |
| **Climate** | The description of the long-term pattern of weather in a particular area. It can be defined as the average weather for a particular region and time period, usually taken over 30+ years. |
| **Climate driver** | A factor or process that influences the behaviour of the climate system, such as solar radiation and ocean currents. |
| **Climate outlook** | A long-range forecast or projection of future climate conditions for a certain region. |
| **Climatology** | The scientific study of climate, including its patterns, variations, and changes over time. |
| **Decile** | A statistical term referring to one element of a dataset that is divided into ten equal parts. |
| **Forecast** | A prediction of future weather or climate conditions based on scientific data and models. |
| **Forecast products as maps** | There are three FWFA forecast products that have a map-based output: above/below median, chance of being in top 2 deciles or bottom 2 deciles and chance of 3-day totals. Apart from the 3-day totals, all of these products can be applied to temperature or rainfall and to different periods (coming weeks, months and 3-month seasons). |
| **Forecast products as location specific graphs** | There are three FWFA forecast products that have a location specific graph - time series (weeks or months), decile bars and probability of exceedance. All of these products can be applied to temperature or rainfall and to different periods (coming weeks, months and 3 month seasons). |
| **Hindcast** | The process of using weather or climate models to simulate past weather or climate conditions for the purpose of testing the accuracy of the models. |
| **Likelihood** | The probability of a certain event occurring, often expressed as a percentage or a fraction. |
| **Median** | The middle value in a set of ordered data, separating the lower 50% of the values from the upper 50%. |
| **Model accuracy** | How well a weather prediction model is able to make accurate forecasts of future weather conditions based on past and current data. |
| **Model resolution** | The level of detail in a weather or climate model, typically expressed as the spatial or temporal scale of the model. |
| **Neutral forecast** | A forecast indicating that the likelihood of all potential outcomes is similar. |
| **Operational decision** | Short term decisions with a planning horizon of 1-7 days that implement the tactics and strategies, and are influenced by weather forecasts. |
| **Probability** | The measure of the likelihood of an event occurring, often expressed as a number between 0 and 1. |
| **Quartile** | A statistical term referring to one element of a dataset that is divided into four equal parts. |
| **Quintile** | A statistical term referring to one element of a dataset that is divided into five equal parts. |
| **Strategic decision** | A long-term decision with a planning horizon of more than a year. |
| **Tactical decision** | A seasonal decision that is responsive to the current state of the farm system such as soil moisture, standing feed, commodity price, and can be guided by seasonal climate forecasts. |
| **Weather** | The state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc. (I.e. the atmospheric conditions being experienced at a moment in time, at a particular place.) |

# Chapter 1

## Overview of forecasting



# 1 The overview of forecasting

## The process of forecasting

**The process of forecasting the short-term weather and the longer-term climate is both an art and a science. In this section, we'll introduce you to the concept of forecasting and help you understand some of the factors that affect it, such as climate drivers.**

### The climate decision gamble – is it like chess, poker, or the pokies?

Australia has a highly variable climate which makes farming decisions difficult. If we knew with certainty that our desired rainfalls and temperatures would occur when we needed them, we could maximise our opportunities and minimise our risks. Often, we think of climate forecasts as having a random chance of happening, like when we play the pokies[1]. We feed our money into the machine and have no idea whether we'll win or lose.

Farming is a risky enterprise, but unlike the pokies the decisions involve degrees of prediction and judgement. So, farming is more like a chess or poker game. In chess the only hidden information is the strategy and supporting tactical moves in the players' heads however, both players see all the chess pieces and their positions on the board. There is no rolling of the dice to make one of the pieces disappear from the board. Losing a chess game is based on poor tactical moves, not bad luck. Poker, on the other hand, is a game of incomplete information—this is decision making under uncertainty. Losing a hand of poker may involve bad luck, but the game involves a high level of skill, as evidenced by the world champion poker players. When we approach our farming decisions, we should be thinking like these poker players.

The first step in making a good farm business decision is to acknowledge that we are dealing with a level of uncertainty. Champion poker players are continually considering probabilities and recognise each decision has a range of possible outcomes; some of which are more likely than others and some carrying more consequence than others. The farming game involves a bit of chess and a bit of poker, but most climate-risk decisions are more like poker. We need to gather the best information available to us at the time and think through the possible outcomes.

**Key messages**

- Australia has a highly variable climate.
- Making climate-risk decisions in farming is like playing poker—it is decision-making under uncertainty.

### Weather versus seasonal climate forecasts

While weather forecasts and climate forecasts are both types of predictions related to atmospheric conditions, they differ in several ways.

Weather forecasts are short-term predictions of atmospheric conditions, usually covering a period of a few hours to several days. The Bureau uses a weather prediction model that runs out to seven days and has a resolution of one to two kilometres. These forecasts provide information about temperature, rainfall, wind, humidity and other weather parameters. Weather forecasts are based on current weather conditions, as well as computer models that simulate how these conditions are likely to change over time. Weather forecasts are constantly updated as new information becomes available, allowing us to make decisions about our daily farming activities.

In contrast, seasonal climate forecasts are longer-term predictions of the average weather conditions for a particular region over a period of weeks to several months. The Bureau uses a physics-based dynamical climate model that runs out to six months and has a 25 km resolution. These forecasts provide information about the likely trends in temperature, rainfall, and other weather parameters, based on historical data and computer models that simulate

[1]Hayman, P., Mudge, B., Stanley, M., Anderson, G., & Grey, D. (2019, August). Agronomic advice in a variable climate; chess, poker or the pokies. In *Proceedings of the 2019 Agronomy Australia Conference* (pp. 25-29).

how the climate system responds to changes in atmospheric conditions. We can use climate forecasts to plan for longer-term activities (such as which crops to plant) and to prepare for potential disasters.

Another key difference between weather and seasonal climate forecasts is their level of uncertainty. Weather forecasts are typically more precise than climate forecasts because they are based on current conditions and predicting the weather in the coming days. By contrast, climate forecasts are based on long-term trends and can be affected by a wide range of factors, such as changes in ocean temperatures, and atmospheric pressure. As a result, climate forecasts are generally less certain than weather forecasts, and are often presented as a range of possible outcomes rather than a single prediction.

The Bureau has recently introduced multi-week forecasts, which are more like short term climate forecasts than long term weather forecasts. They can predict the weather more accurately due to advances in modelling incorporating overarching oceanic climate forces more so than small changes in the weather. The five tools we introduce in the next chapter use this advanced methodology.

In summary, weather forecasts are short-term predictions of atmospheric conditions providing information about daily weather patterns that can be used for planning operational activities. On the other hand, climate forecasts are long-term predictions of average weather patterns over a longer period, used for strategic planning.

**Key messages**

- Weather forecasts are short-term predictions, usually covering a period of a few hours to several days.
- Seasonal climate forecasts are longer-term predictions, covering a period of weeks to several months.

### Forecast versus hindcast

A forecast is a prediction of weather conditions, for a specific time and place, in the near future. It is usually based on current weather observations and the use of computer models to simulate how the atmosphere is expected to evolve over the next few hours to several days. Weather forecasts are important for planning daily farming activities and making operational decisions about what to do. They are updated as new meteorological data becomes available and they become more accurate as the timeframe for the forecast becomes shorter.

Hindcast, on the other hand, considers what the weather was like in the past, usually for a period ranging from a few days to several decades. Hindcasts are used to evaluate the accuracy and reliability of weather and climate models by comparing their simulations to actual weather observations from the past. Hindcasting involves running a computer model backwards in time, using data (such as historical weather observations, atmospheric conditions, and ocean temperatures) to simulate what the weather would have been like for a particular time and place. As a result, hindcasts are useful for improving weather and climate models, verifying past weather events, and understanding how the climate has changed over time.

**Key messages**

- A forecast is a prediction of weather conditions, for a specific time and place, in the near future.
- Hindcast considers what the weather was like in the past, usually for a period ranging from a few days to several decades.

## Climate drivers

Southern Australia's climate is influenced by several climate drivers, which can have a significant impact on farming activities. The Climate Kelpies website depicts these climate drivers as Climatedogs. There are four major Climatedogs (Enso, Indy, Ridgy and Sam), and two minor ones (Eastie and Mojo) which affect weather on a smaller scale. It's important to remember the Climatedogs work together to drive the climate, so we need to look at the combined effect of all the indicators to get a clear idea of what to expect in the future. Watch a short video about the Climatedogs at https://youtu.be/0LWKKtBrQPc.

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### ENSO (Enso)

Enso, the El Niño Southern Oscillation (ENSO) is a climate pattern that occurs in the Pacific Ocean, which can significantly impact rainfall patterns in southern Australia. During a period of El Niño, equatorial trade winds weaken and warm surface water shifts to the eastern Pacific Ocean allowing cool water to upwell in the western Pacific Ocean, which can lead to reduced rainfall and drought conditions across southern Australia. In contrast, during a period of La Niña, the trade winds are stronger than average, moving warm surface waters to the western Pacific Ocean while cool water upwell in the eastern Pacific Ocean, which can lead to increased rainfall and flooding across southern Australia. Watch a short video about ENSO at https://youtu.be/Gy37fGiRO5Q.

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### IOD (Indy)

Indy, the Indian Ocean Dipole (IOD) is a climate pattern that occurs in the tropical Indian Ocean, which can also have a significant impact on rainfall patterns across southern Australia. During a positive IOD phase the tropical west Indian Ocean sea surface temperatures (SSTs) are warmer than usual, which can lead to reduced rainfall and drought conditions across southern Australia. In contrast, during a negative IOD phase, the tropical east Indian Ocean SSTs are warmer than average, which can lead to increased rainfall and flooding across southern Australia. Watch a short video about Indy at https://youtu.be/4E4MOeX9IdQ.

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### STR (Ridgy)

Ridgy, the Sub-tropical Ridge (STR) is a semi-permanent high-pressure system that influences seasonal weather variability across Australia. During summer it is positioned to the south of the continent and brings stable dry conditions, reducing rainfall and increasing temperatures. This can have a significant impact on farming across southern Australia, as it can lead to drought conditions, water shortages and reduced crop yields. We may need to adopt strategies such as irrigation, crop rotation and soil conservation to cope with these conditions. Watch a short video about Ridgy at https://youtu.be/mqHbpgzBQLA.

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### SAM (Sam)

The Southern Annular Mode (SAM) is a climate driver that occurs in the southern hemisphere affecting the strength and position of westerly winds which influence southern Australia's weather patterns. During a positive SAM event, the westerly winds are stronger and positioned further south, which can lead to reduced rainfall and drought conditions across southern Australia. In contrast, during a negative SAM event, the westerly winds are weaker and positioned further north, which can lead to increased rainfall and flooding across southern Australia. Watch a short video about Sam at https://youtu.be/ZQwgosJ_RL0.

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### ECLs (Eastie)

Eastie, the East Coast Low-Pressure systems (ECLs) are intense low-pressure systems that occur off the east coast of Australia, particularly during the autumn and winter months. They bring moisture-laden winds and heavy rainfall to the region, which can cause flooding and waterlogging. While ECLs can benefit agriculture, providing much-needed moisture for crops and pasture, they can also be destructive, causing damage to infrastructure, property and crops. Watch a short video about Eastie at https://youtu.be/m4wKGdZjBBU.

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### MJO (Mojo)

The Madden-Julian Oscillation (MJO) is a tropical weather pattern that can influence rainfall patterns across southern Australia. It is characterised by a band of clouds, rainfall and winds moving eastward across the tropical Indian Ocean into the western Pacific Ocean. When the MJO is in its enhanced phase it can increase the rainfall across southern Australia. However, when the MJO is in its suppressed phase it can reduce rainfall and bring drought conditions across southern Australia. Watch a short video about Mojo at https://youtu.be/AU8-I-IqJZU.

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In summary, these six climate drivers significantly impact the rainfall patterns across southern Australia. Awareness of these drivers and their potential impact on crops, livestock and land will support our management decisions.

### Key messages

- There are six climate drivers that work together to affect the climate.
- We need to look at the combined effect of all the drivers to get a clear idea of what to expect in the future.

## Model accuracy

As well as understanding these drivers, we need to consider the model accuracy (also known as model confidence or model skill) of the computer models that are used by the Bureau to predict the weather and climate. These models use hindcasts to understand the spread of historical events with 99 forecast model iterations run over a three-day period to determine the chance of a modelled forecast occurring. The time of year and location for which these forecasts are made can make a big difference.

### Key messages

- Model accuracy refers to how well a weather prediction model is able to make accurate forecasts of future weather conditions based on past and current data.

## Correctly understanding a daily weather forecast

To understand a daily weather forecast from the Bureau, you need to pay attention to three main aspects: the *forecast icon*, the *chance of any rain*, and the *possible rainfall*.

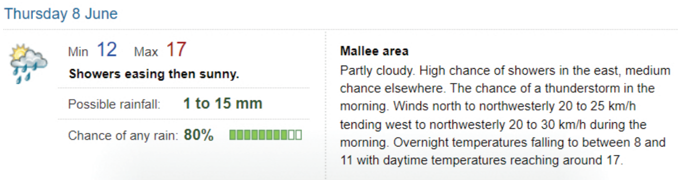


**Figure 1.** An example daily weather forecast.
Source: www.bom.gov.au

The *forecast icon* is a symbol that represents the general weather condition for the day or the hour. For example, a sun icon means sunny weather, a cloud icon means cloudy weather, and a raindrop icon means rainy weather.

The next item to look at is the *chance of any rain*. This is represented as a percentage that tells you how likely it is that *at least 0.2 mm of rain* will fall in your area. For example, if the forecast says there is a 80% chance of rain, that means there is a 80% chance of getting some rain, and a 20% chance of getting no rain at all.

Finally, the *possible rainfall* provides a range between two numbers. However, it's important to note that there is more behind these numbers than meets the eye. The first number is the least amount of rain that is *75% likely*, while the second number is the least amount of rain that is *25% likely*. So, in this example, there is a 75% chance of receiving at least 1 mm, while there's a 25% chance of receiving at least 15 mm.

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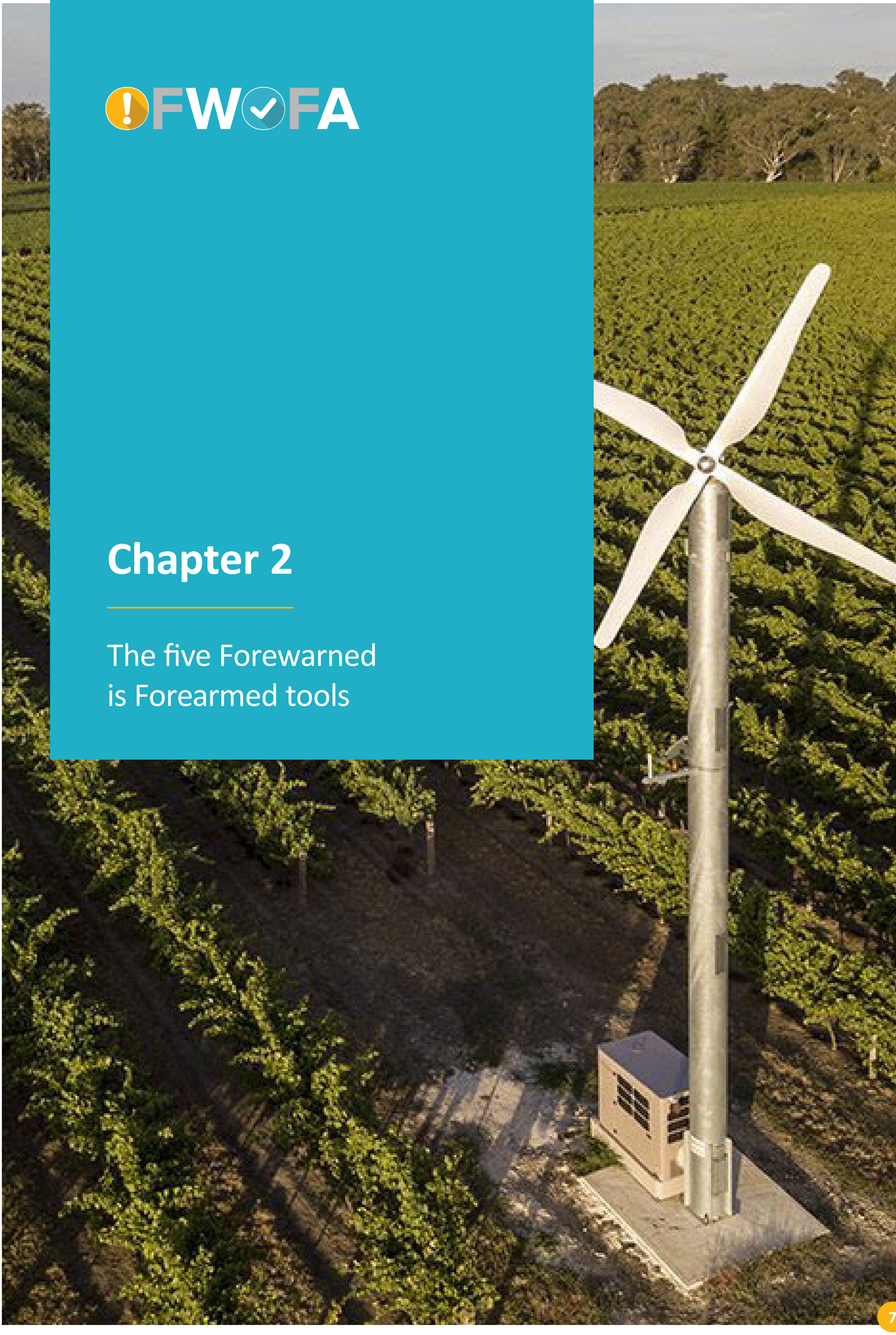
Read more about this on the Bureau's website: https:\media.bom.gov.au\social\blog\209\right-as-rain-how-to-interpret-the-daily-rainfall-forecast\

## Notes



# Chapter 2

## The five Forewarned is Forearmed tools

# 2 The five Forewarned is Forearmed tools

**As part of the FWFA project, the Bureau of Meteorology launched five seasonal climate forecasting tools. These tools provide more insight in predictions, especially when considering the possibility of extreme weather events.**

The tools are:

1. The **chance of extremes maps** for rainfall and temperature.
2. The **chance of 3-day totals maps**.
3. The **decile bar charts** for rainfall and temperature.
4. The **timeline graphs** for rainfall and temperature.
5. The **probability of exceedance graphs** for rainfall.

Before diving further into the tools, let's establish some definitions to guide correct interpretation.

## The four key risks

The four weather extremes of most interest to farmers are heat, cold, wet and dry. Extreme heat refers to defined periods of high temperature and can be accompanied by high humidity. It can affect livestock production, joining, crop growth stage, on farm operations along with increased risk of bushfires in the landscape. Prolonged periods of low temperatures, on the other hand, can affect vulnerable livestock or crop yield and quality. Extended or intense periods of extreme rainfall and wet conditions can disrupt infrastructure at farm-level or supply chain-level. In the case of flooding, livestock and crops can be lost. Finally, prolonged absences of rainfall can lead to periods of drought, often accompanied by scarcity of vital resources, such as feed and water.

Extreme weather events can occur in combination or in isolation. Devastation involved with the effects of extreme weather events often outweigh potential benefits, such as enrichment of soil and regeneration of vegetation after fire or flood. Depending on the level of impact, recovery can have significant temporal, economic and social costs. So understanding the likelihood of an extreme weather event can support our preparation, planning and on-farm responses through better decision making.

## Forecasting terminology

Interpretation of forecasting information can become confused if the terminology is not well understood. Meaningful interpretation of the information presented enables better decision making.

### Medians

The median of a dataset represents the middle value when the data is arranged from lowest to highest value. It is often used as a measure to capture the more central values, especially when a dataset contains outliers (unusual or extreme values). As such, it can provide an understanding of the typical or more representative value of a dataset.

**The median is different from the average, or mean,** because it is less affected by outlier data. An average considers all values, including outliers, by summing all values and dividing that by the number of data points. The average is a mathematically calculated value and may not actually appear in the dataset. The average is a useful value for summarising data into a single, central value, though the value can be skewed by outliers and misrepresent the central value or 'typical' value of a dataset.

After the median of a dataset is determined, other values can be compared to it, and either be *higher* or *lower* than the central value: this is referred to as the dataset being *binomial*. **In the FWFA's tools, the median is used to describe the typical or more representative value of historical weather events at a certain time of year.** An example is shown in Figure 1. The forecasts use the median to explain if we can expect a typical weather event more like the average historical value for that time of year, or if we can expect an unusual weather event, which is much lower or higher than the median historical value for that time of year.

### Deciles and quartiles

While comparing values to the median, we deal with a binomial distribution of the dataset where the values can either be higher or lower than the median. Further detail from a dataset can elaborate on where the 'value of interest' is positioned on the data scale from high to low. For example, if it's not equal to the median, is it much higher, lower, or not that much different?

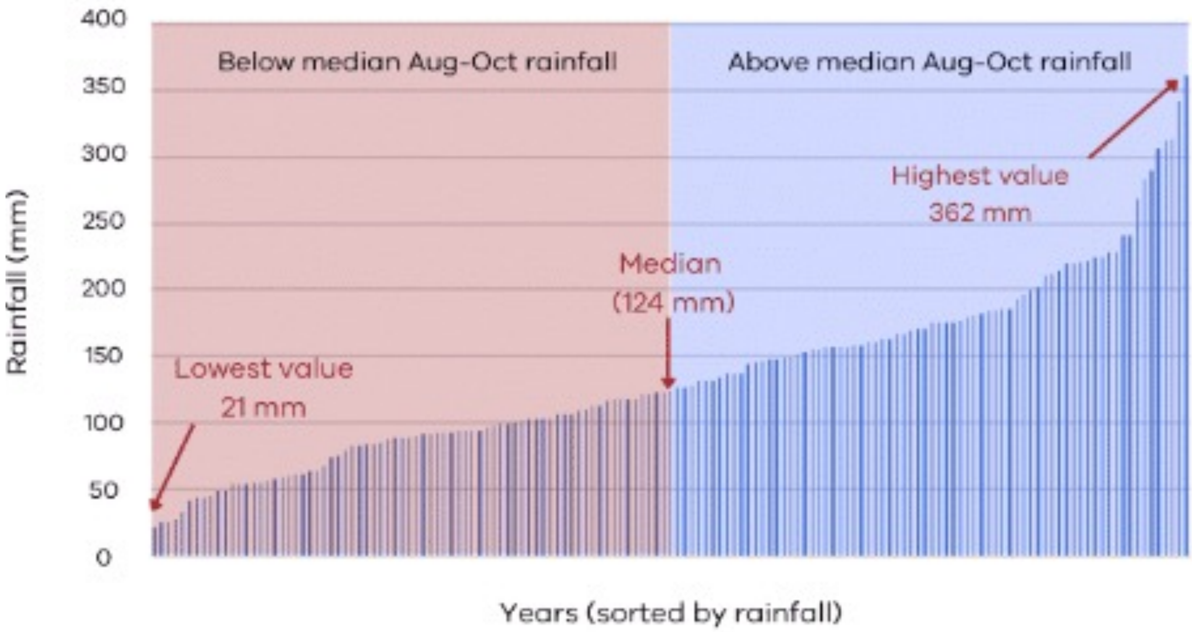



**Figure 1.** The binomial distribution of August – October rainfall for 146 years (1875 – 2021) in Dubbo, NSW. Rainfall is either above or below the median rainfall (124 mm). Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

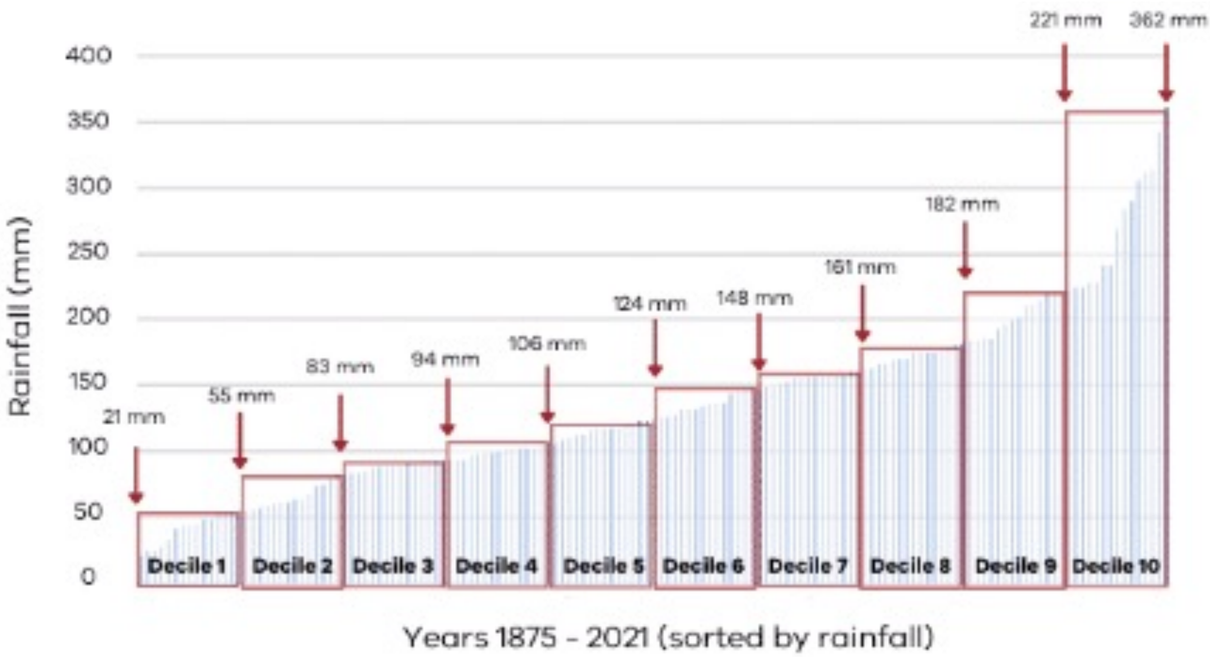
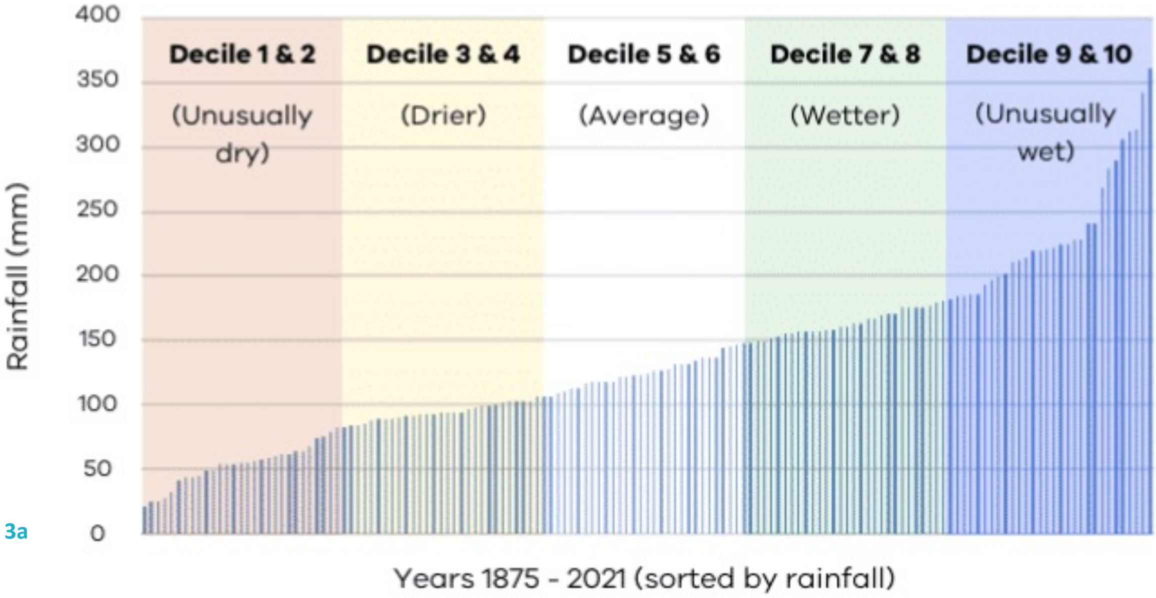
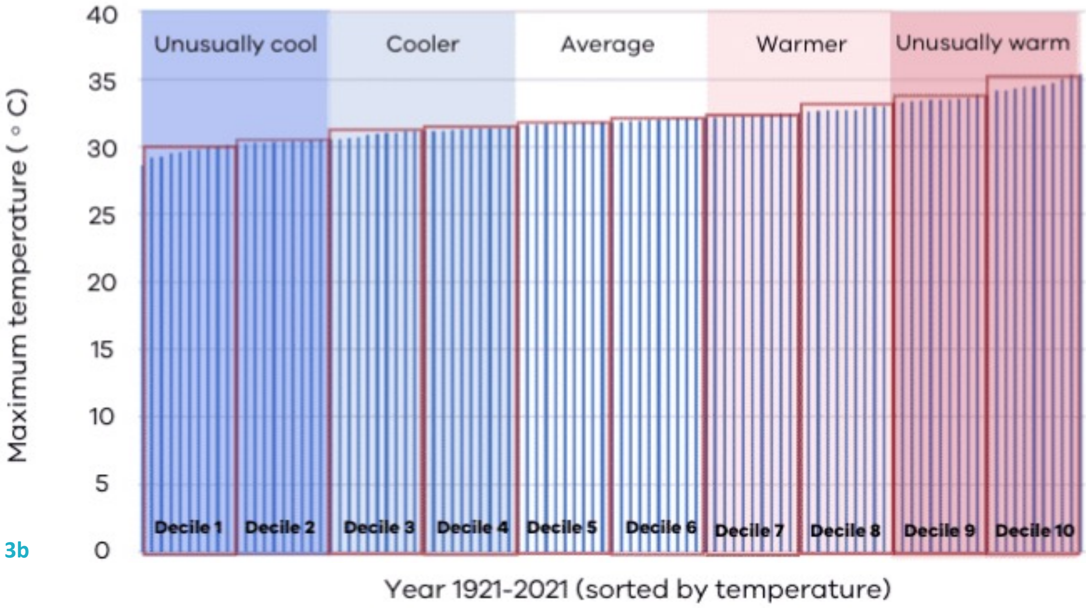



**Figure 2.** Decile bar graph showing August – October rainfall for 146 years (1875 – 2021) in Dubbo, NSW. Rainfall is divided in 10 equal groups of data (deciles) each with a lower and upper value defining the decile. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

Instead of dividing the dataset into two groups and creating a binomial distribution (higher and lower), the dataset can be divided into 10 equal groups, referred to as ***deciles***. Each decile contains a group of data that explains 10% of the dataset, with a lower and an upper value defining the decile, as shown in Figure 2.

As such, we can understand the context of and refer to the value as being (for example) in decile 9 (significantly higher than the median but not quite the most extreme value measured) or in decile 5 (not that far off the median, but a little lower).




**Figures 3a and 3b.** Decile bar graphs showing August – October rainfall for 146 years (3a at top) and December – February maximum temperatures for 101 years (3b) in Dubbo, NSW. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

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In the FWFA tools, this concept is used to describe rainfall (Figure 3a) or temperature (Figure 3b) as summarised in Table 1. These tools visually combine two deciles (referred to as a ***quintile***) which describes 20% of a dataset, or one of five equal groups of data. Another common term used to group data is quartile, where a dataset is divided into four equal groups and each ***quartile*** explains 25% of the dataset.

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A short video about understanding percentiles in climate data can be viewed at https://youtu.be/e3ak-ognuTU.

**Table 1.** Decile descriptors for rainfall and temperature used in the Bureau of Meteorology climate outlook and forecasting tools.

| | Rainfall | Temperature |
|---|---|---|
| **Decile 1 & 2** | Unusually dry | Unusually cool |
| **Decile 3 & 4** | Drier | Cooler |
| **Decile 5 & 6** | Average | Average |
| **Decile 7 & 8** | Wetter | Warmer |
| **Decile 9 & 10** | Unusually wet | Unusually warm |

### Probabilities

A probability is a measure of the likelihood (or chance) of an event occurring. It is calculated by determining the number of times an event has happened, divided by the total number of events and expressing the outcome as a value between 0 and 1, or 0% and 100%. Probability is often used to explain the likelihood of future events based on historic information.

When referring to deciles, there is a 20% chance of a historic rainfall or temperature value falling in any of the decile groupings. For the purpose of climate forecasts, we are focused on the chance of a decile 1 & 2, or a decile 9 & 10 event. The FWFA tools present this chance for us.

### Box and whisker plots

A box and whisker plot graphically summarises the distribution of a dataset, as shown in Figure 4. It displays the data distribution including the median, quartiles and outliers. It consists of a box and two 'whiskers' extending from above and below the box. The box represents the middle 50% of the data, with the bottom of the box delineating the first quartile (Q1) and the top of the box delineating the third quartile (Q3). The median, or second quartile (Q2), is typically represented by a line within the box.

The whiskers represent the minimum and maximum values of the data which are not considered outliers (outliers are sometimes represented as individual points or circles beyond the whiskers). The length of the box and whiskers are dependent on the distribution of the dataset. If the data is evenly distributed, the box will be longer and the whiskers shorter. If the data is skewed, the box and whiskers will be shorter on one side and longer on the other.

### The neutral forecast

As previously explained, a forecast places probabilities of certain forecast model runs occurring in the deciles that describe the hindcast weather data for a particular point in time. If a particular extreme weather event occurs, then the data input from climate drivers and weather patterns might influence the forecast model outcomes, implying a high chance of an extreme event. If the majority of forecast model runs suggest a high chance of a particular extreme event occurring, the chance of the event not occurring remains, because not all model runs would have generated the same outcome.

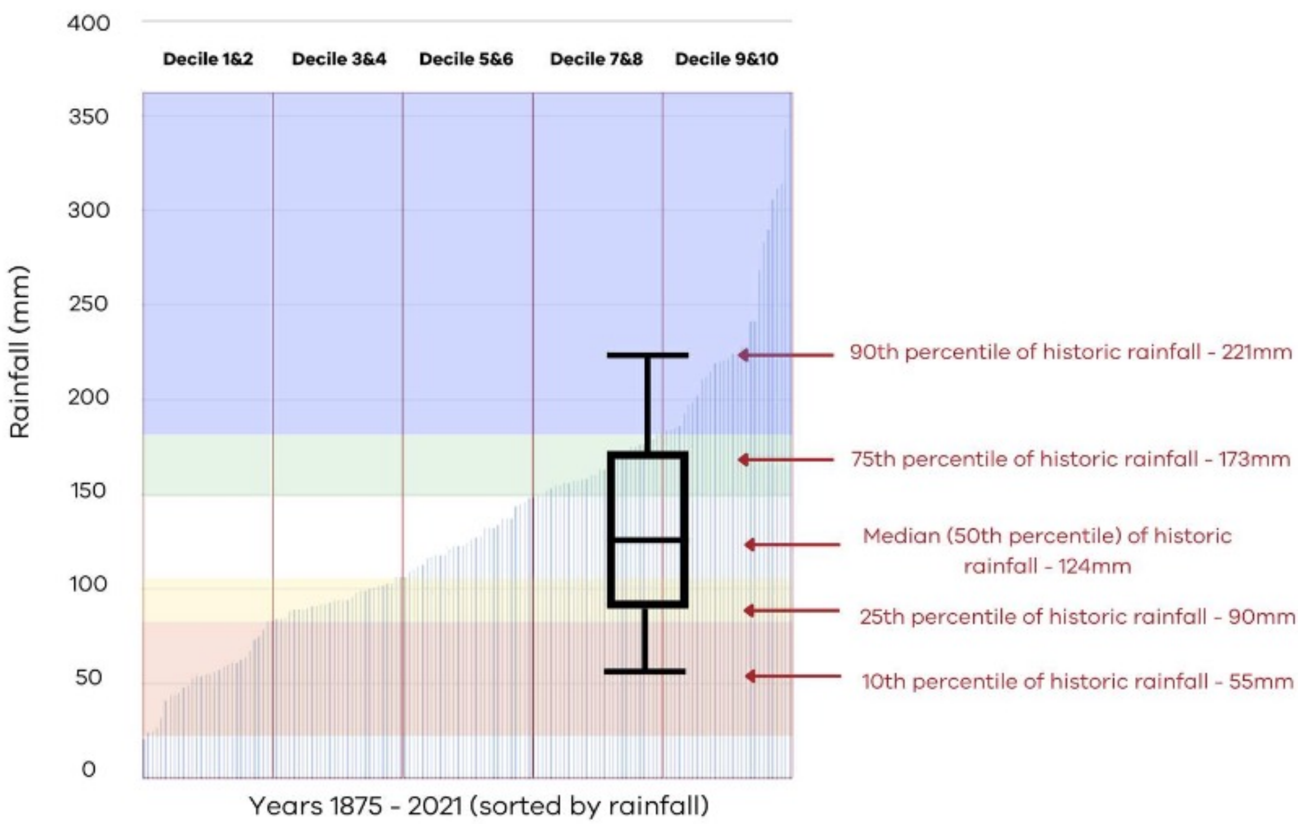



**Figure 4.** A box and whisker plot explained. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 2.** Summary of FWFA tools.

| FWFA tool | Format | Parameters | Time frame/s | Limitations | Best use |
|---|---|---|---|---|---|
| **Chance of extremes** | Australia-wide map | Rainfall and temperature | 1 week,<br>2 week,<br>1 month,<br>3 months | • Not location specific, so need to zoom in on the map.<br>• No information about heatwave or extended cold period. | • Simple, quick overview, for all timeframes, to highlight if can expect something unusual or average. May provide a prompt to dig deeper with the other tools. |
| **Chance of 3-day totals** | Australia-wide map | Rainfall only | 1-2 weeks | • Not location specific (which might be expected), so need to zoom in on the map.<br>• Most useful for northern Australia. | • Northern Australia - monsoon and heavy rain forecast. Start of wet season prediction.<br>• Southern Australia – autumn break indication. |
| **Decile bar chart** | Location-specific | Rainfall and temperature | 1 week,<br>2 week,<br>1 month,<br>3 months | | • Next level up from chance of above median map – provides some more detailed information. Often helps with understanding of *above median* maps and *chance of extremes* map.<br>• Easier to understand. |
| **Timeline graph** | Location-specific | Rainfall and temperature | 4-weeks,<br>5-months | • Categorised rating for accuracy. | • Box and whisker plots shape and size is visual and provides information about the confidence in the model runs.<br>• Provides recent history as well. |
| **Probability of exceedance** | Location-specific | Rainfall only | 1 week,<br>2 week,<br>1 month,<br>3 months | • More complex to understand. | • In-depth understanding (essentially all of the information in other tools in one); most suitable for deliverers. |

So, in essence, the more forecast model runs that align, the higher the chance of the forecasted outcome. In some instances, the distribution of forecast model outcomes can be so spread there is no skew to the outcomes and any outcome is just as likely to occur as another. This is referred to as a ***neutral forecast***. Examples are a 20% chance of all quintiles occurring, or a 50% chance of exceeding the median. In such situations, any outcome can be expected because all outcomes are equally possible.

## The tools

Most of us might already be familiar with the *Chance of above median* tool from the Bureau, or at least have seen it featured in farm journals, webinars or Landline (Figure 5). This tool tells us if we can expect above or below median rainfall, for a selected period of time.

However, the Bureau's five FWFA tools provide us with an  opportunity for more context than simply 'above' or 'below' the median, which we now understand to be a simple binomial result. The Bureau's climate outlook and forecasting tools provide additional context to forecasts by including the decile distribution of forecast model runs and the likelihood of them occurring, based on 99 model runs over weeks, fortnights and months. So essentially the FWFA tools can be described as short-term climate forecasts. They are not as accurate as a seven-day weather forecast, but they give us a better understanding of the climate outlook over a shorter time frame (one week to three months). The tools provide insight by presenting the range of forecasted outcomes in multiple ways and can help you plan operations past the seven-day weather forecast. Using the FWFA tools in combination with seven-day weather forecasts provides more confidence in interpreting and using the information to make decisions.

There are two types of tools: maps and location-specific graphs. Clicking on a location on a map or entering the location in the search function will bring up the location-specific graphs.

In this chapter, we present the five tools and show how you can use them to gain insight into the chance of an extreme weather event occurring.

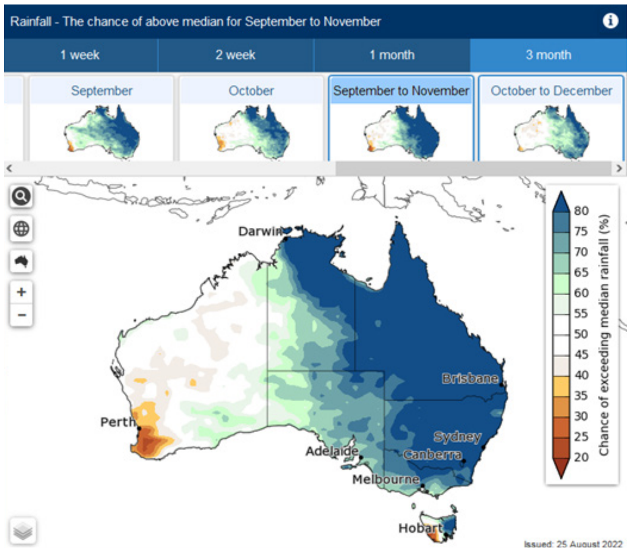



**Figure 5.** An example of the *Chance of above median* tool from the Bureau for a three-month outlook (September - November), issued at 25 August 2022. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

### Chance of extremes

The *chance of extremes* maps show the predictions for unusually high and low rainfall or temperatures over one week, two weeks, one month or three months. These maps are an extension of the *chance of above median* maps.

The colouring in the maps indicates the chance or likelihood of experiencing extremes in rainfall or temperature as shown in Figure 6. The increasing intensity of colours used in the maps correlates to increasing chance of rainfall or temperature in extreme deciles. In a neutral forecast, the likelihood of any outcome is 20%. As such, the likelihood of an extreme dry or cold (decile 1 & 2) or extreme wet or hot (decile 9 & 10) is also 20%, and no distinct indication can be drawn from the forecast model results. Areas without data are represented in grey.

In the example in Figure 6, the map shows an above 80% chance of rainfall being in decile 9 & 10 of historical data for central Queensland. This means the likelihood of extremely wet conditions is four times higher than the chance of median rainfall typical for that time of year.

The *chance of extremes* map can show the likelihood of extreme cold events, however, it can't indicate a frost. Minimum temperatures may give an indication of frost potential at certain times of the year, and this can be explored further using other Bureau tools and seven-day forecasts.

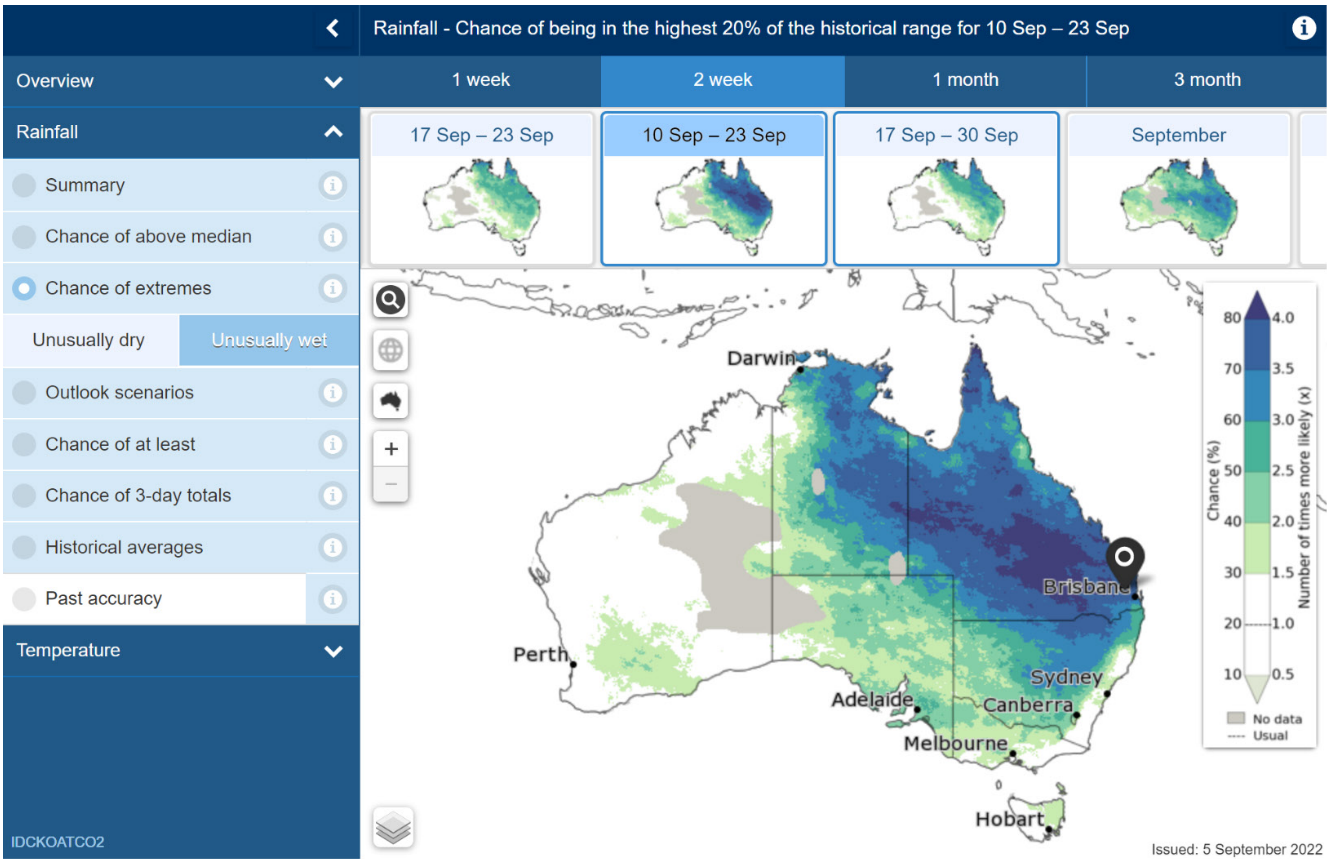



**Figure 6.** An example of the Climate Outlook Map forecasting unusually wet conditions issues during September 2022 for the two weeks between 10 – 23 September across eastern Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

## Notes

## Chance of 3-day totals

The *chance of 3-day totals* forecast maps show the chance of receiving 'at least' a given amount of rainfall total over three consecutive days. Forecasts are available for 15 mm, 25 mm, 50 mm and 75 mm of rain during a one-week or two-week period. Historic data (1960 – 2019) for *chance of 3-day totals* is available and accessible. Figure 7 shows a *chance of 3-day totals* map for the period 21 March to 3 April 2023.

SCAN ME

Dr Tim Cowan, USQ, demonstrates using the rainfall burst forecast map in a short video (2min 11sec) at https://youtu.be/I5iqDl3qlr8.

SCAN ME

Dr Chelsea Jarvis, USQ, discusses the application of the rainfall burst forecast tool in the cotton, livestock and sugar industries in a short video (2min 32sec) at https://youtu.be/u8_je1NC3r4.

Note that the location-specific graphs in the *chance of 3-day totals* map do not present probabilities or deciles on a three-day timeframe. Instead, the location-specific graphs present data on the outlook for either one week or two weeks when selected in the *chance of 3-day totals* map, as with the *chance of extremes map.*

## Decile bar charts

The location-specific decile bars for rainfall and maximum and minimum temperature show the forecasted probability of a given range of rainfall or temperature outcomes. The chart can be accessed by selecting a location on the map or entering a location in the search function.

The forecasted probability of a given range of rainfall or temperature outcomes is compared with the typical probability of 20%, indicated as the dotted grey line in Figure 8. In this example, the forecast shows that 38 from 99 forecast model runs fell into deciles 1 & 2 (unusually dry weather) which is nearly twice more likely than the likelihood of median rainfall for that time of year. However, note that the likelihood of the other ranges remains. For instance, there are still 11 out of 99 model runs that fell into deciles 9 & 10 (unusually wet weather) which means other outcomes (besides deciles 1 & 2) are still possible.

The tool's infographic includes the historical median rainfall, which in this example is a historic median rainfall of 61 mm for Clear Lake (VIC) during the

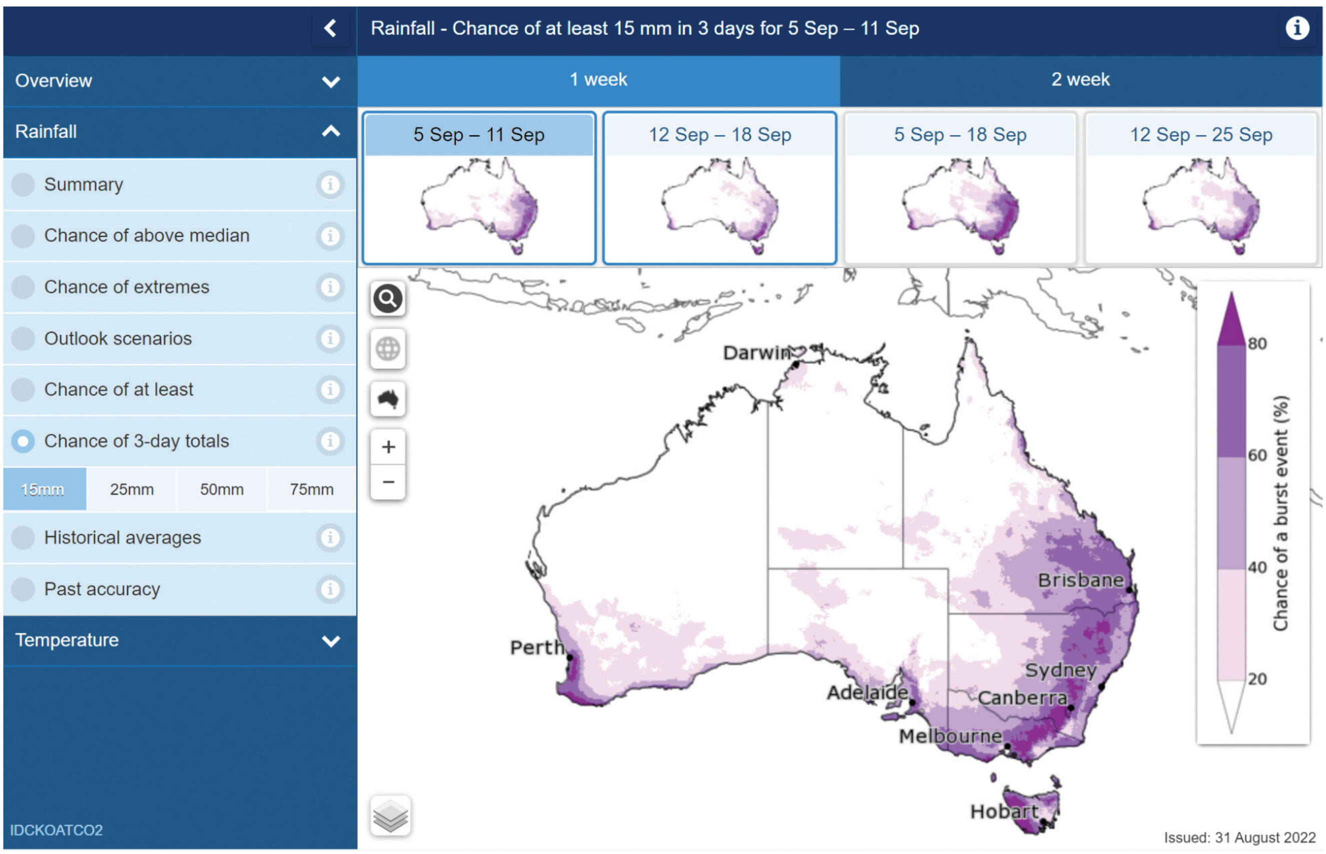



**Figure 7.** *Chance of 3-day totals* map for Australia for the period of 21 March – 3 April 2023. Source: www.bom.gov.au 16/3/23.

period February – April. In some locations the median rainfall can be 0 mm at certain times of the year. In those instances, the range of likelihood of rainfall falling in a certain historic range for the given period is not that meaningful.

The star ratings beside the likelihoods indicate the past accuracy of the outlook. If the model has been reasonably successful at forecasting for this location and time during the past, it receives three out of three stars — a highly accurate result. Two out of three stars indicates medium past accuracy, and one out of three stars indicates low past accuracy.

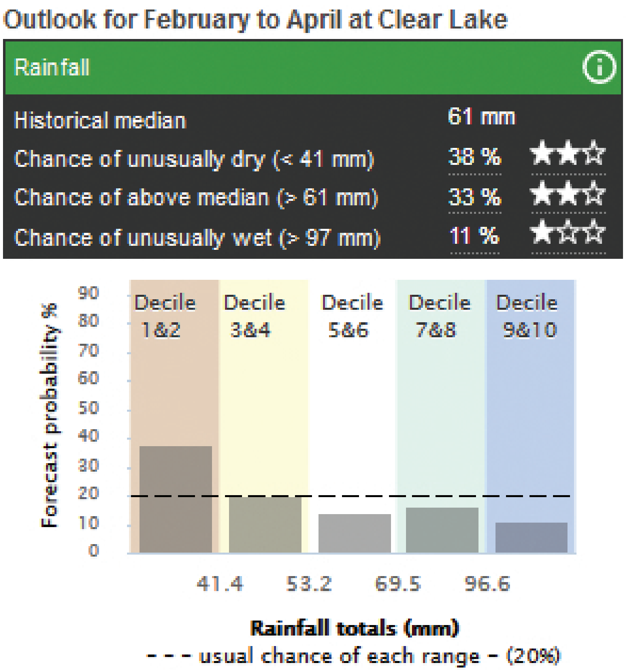



**Figure 8.** Decile bars for the rainfall outlook at Clear Lake, Victoria, for February – April 2022. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

## Timeline graphs

Timeline graphs display a timeline of recent climatic observations from the previous weeks and months, against historic averages, to illustrate what might happen in the future. The box and whisker plots show the variability of the 99 model runs for the four weeks or five months ahead. To make it easier, the shading of the graph aligns with the markers of the box and whisker plot to show the recent rainfall deciles (recent average rainfall indicated by the solid black line) and the predicted deciles (predicted medians indicated by the dotted black line) as illustrated in Figure 9 (on the following page). The timeline graph can be accessed by selecting a location on the map or entering a location in the search function.

As with the decile bar charts, the timeline graph includes star ratings to indicate past accuracy for the outlook. The length of the whiskers and size of the box indicate the range of predictions. So, if most of the 99 model runs are within a tight range (compact box and shorter whiskers, e.g. July in Figure 9), it provides greater confidence in the prediction. However, as we've seen with the decile bar charts, any outcome is still possible.

## Probability of exceedance

The *probability of exceedance* is a graph with lines representing the forecasted and historical data of a certain location for a particular rainfall total as shown in Figure 10. The graph can be accessed by selecting a location on the map or entering a location in the search function.

The red line in Figure 10 shows the likelihood of the chosen location receiving the median rainfall over the specified timeframe. In the example, Murray Bridge typically has a 60% chance of receiving 18.6 mm rainfall, 40% chance of receiving 27.6 mm and 20% chance of receiving 40.8 mm during October. A drier time of year would typically show a steeper red line, whereas a wetter time of year would decrease the slope of the red line.

The blue line in Figure 10 represents the forecast. It shows how often the 99 model runs exceed a range of rainfall values. A blue line below the red line would indicate a drier outlook. A blue line above the red line, as shown in Figure 10, indicates a wetter outlook.

Note the shading of the graph aligns with the defined deciles for rainfall summarised in Table 1 and Figure 3a. Hovering over the graph brings up the percentage chance for the corresponding rainfall.

### Key messages

- The four weather extremes of most interest to farmers are heat, cold, wet and dry.
- Meaningful interpretation of forecasting information enables better decision making, which is why it is important to understand the involved terminology.
- The Bureau's five climate outlook and forecasting tools provide additional context to forecast results by including the decile distribution of forecast model runs and the likelihood of them occurring, which helps you plan operations past the seven-day weather forecast.
- There are two types of tools: maps (the *chance of extremes* and the *chance of 3-day totals*) and location-specific graphs *(decile bar charts, timeline graph* and *probability of exceedance).*

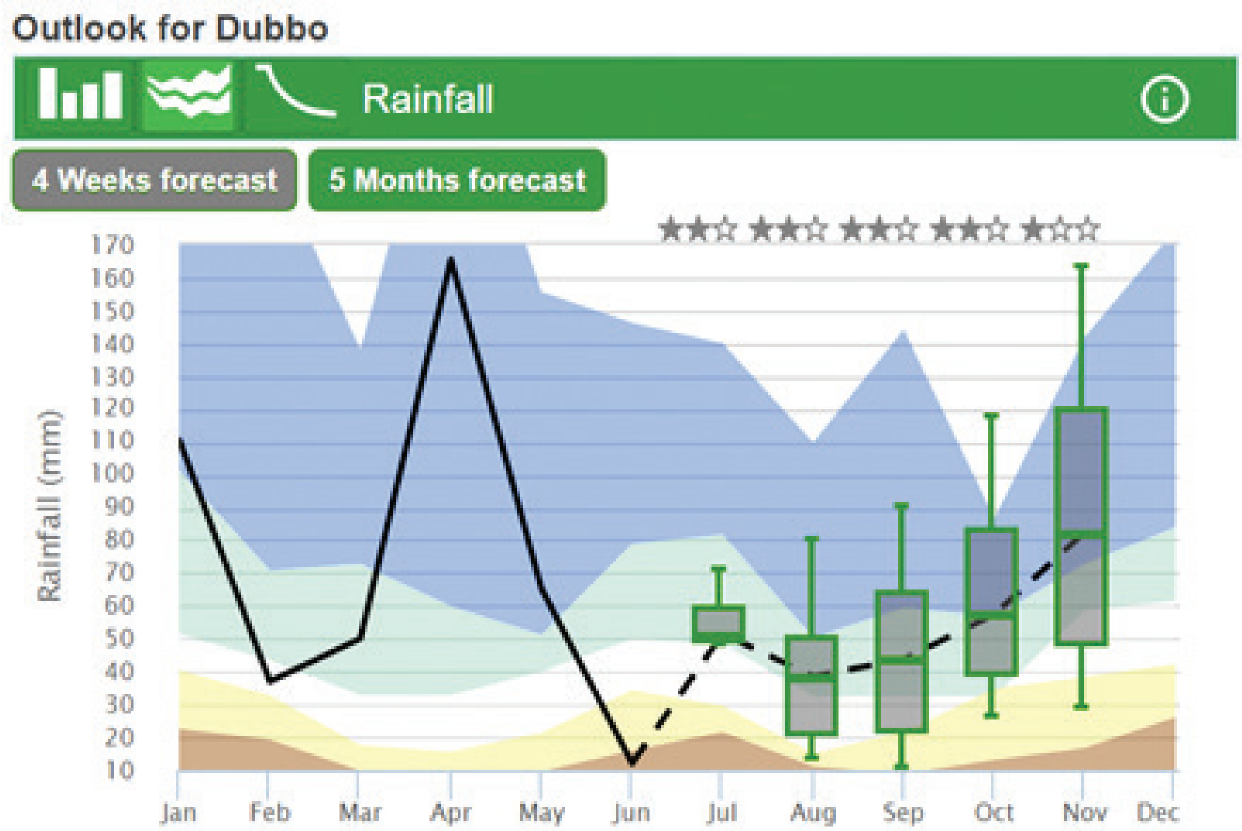



**Figure 9.** Five-month timeline graph for predicted rainfall in Dubbo, NSW. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

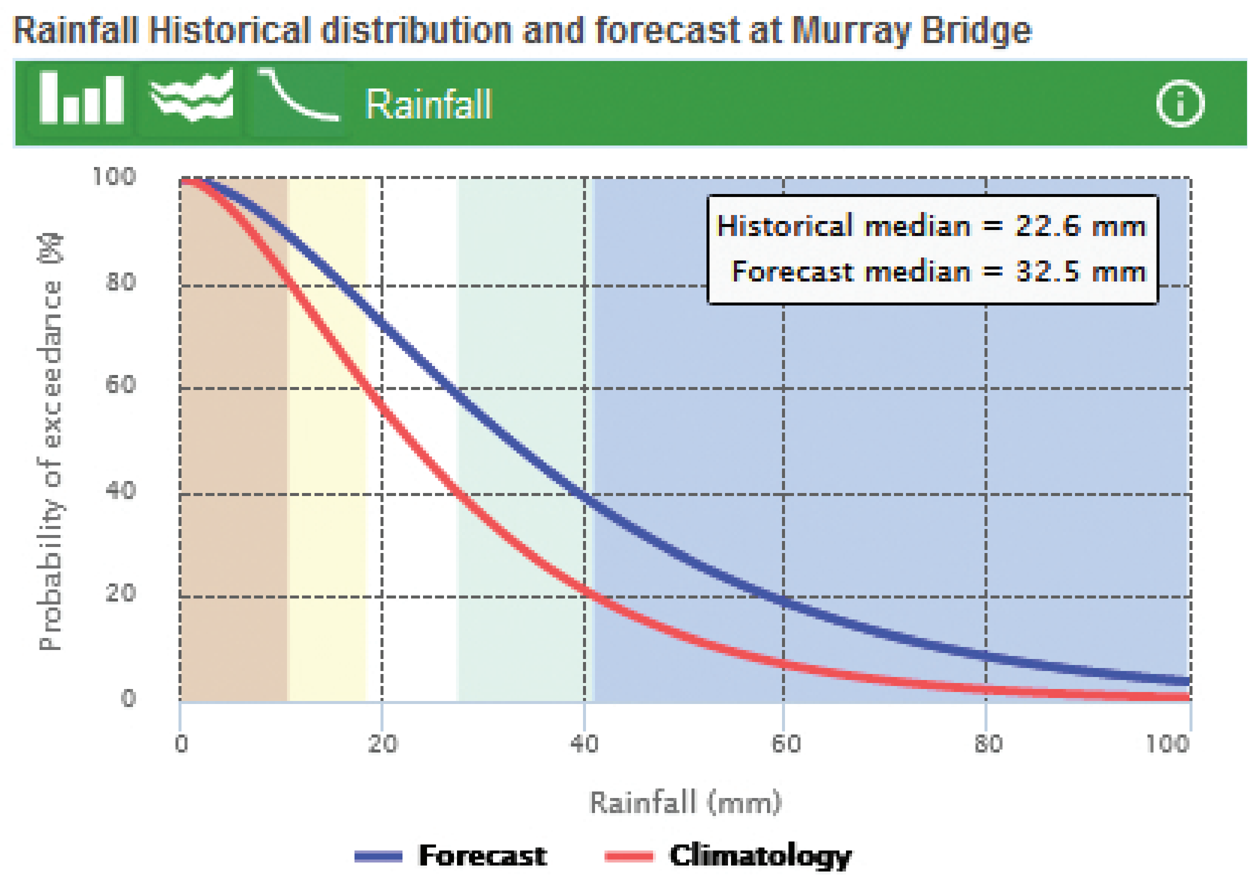
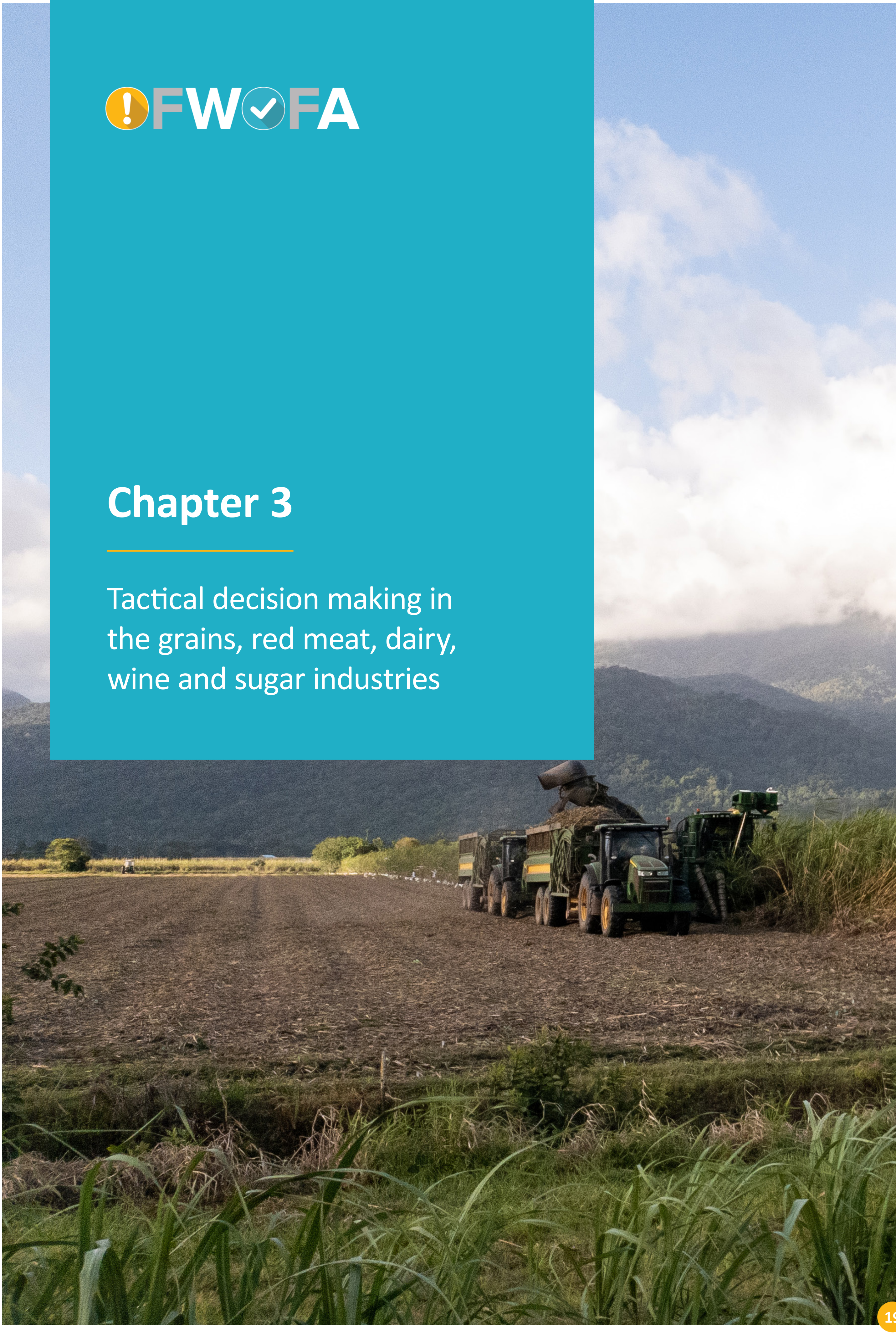



**Figure 10.** Rainfall outlook for the month of October 2022 at Murray Bridge, SA. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

# Notes



# Chapter 3

## Tactical decision making in the grains, red meat, dairy, wine and sugar industries

# 3.1 Tactical decision making

## Decision making

Decisions are made daily in a farming business. Some decisions relate to day-to-day operations, such as when to spread fertiliser or start harvest, selling weaners, and prioritising spraying jobs. This is operational decision making. Decisions made for the longer term of the business are strategic decisions and examples include deciding whether to invest in capital items, setting targets (such as return on investment and gross margin targets), and optimising labour use efficiency. Tactical decisions and plans are designed to achieve the longer term strategy, usually with a medium-term view (1 – 12 months). Examples of tactical decisions for a farming business might include scheduling of harvest around crop maturity, feed budgeting, or nutrient budgeting.

A tactical climate sensitive decision is one where the time frame is within the season and the ideal decision depends on the weather. Examples include nitrogen application rate, when to drain rice fields, whether to leave a field for fallow or plant cotton, and investing in additional harvest resources such as contracting.

Information from FWFA is most relevant to tactical or operational decisions, however, long-term or strategic decision making can be the most cost-effective way to manage extreme events. Examples include investing in hay making equipment and storage, planting shelterbelts, or altering the enterprise mix. Determining the costs and benefits of these decisions requires historical climate data and climate change projections on the frequency and severity of rare events. Historical climate data can be accessed via the Bureau's website: http://www.bom.gov.au/. Under *Our services, Climate and past weather*, the rainfall and temperature records are available under *Rainfall history* and *Temperature history*.

Farmers deal with weather variability daily, influencing their operational decision making. This type of decision making is something we are more familiar (and comfortable) with, than those decisions around less frequent, but more impactful, extreme events. Working with a number of Research and Development Corporations (RDCs) as part of the FWFA project, the Bureau developed five tools to support short-term and medium-term decision making regarding extreme climate risks. As these tools focus on a seasonal timeframe, they are most suited to supporting on-farm operational and tactical decision making.

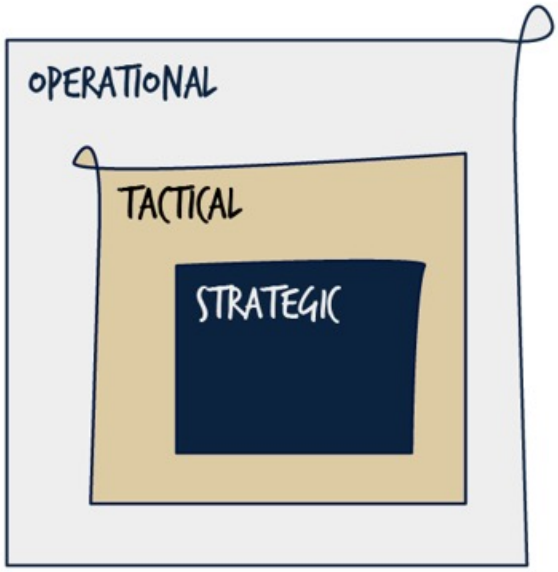



**Figure 1.** The three types of decisions (from Dairy Australia – Our Farm Our Plan)

Before you can use these tools effectively in your business you need to fully understand the operations and assets that can be affected by an extreme event. While we often focus on the risks of these events, it's important to realise they may also create opportunities. Following are some examples of tactical decisions that can potentially mitigate these risks or capitalise on the opportunities. These are not designed to operate in isolation from a whole enterprise risk assessment and management plan, but rather to complement them.

**Key messages**

- A tactical climate-sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the weather.
- FWFA tools are best used to support tactical and operational decision-making for managing extreme weather events.

## Key risks

A business' calendar of operations usually considers the seasonality of activities relevant to the location of the farm. Extreme weather events are highly likely to disrupt these operations.

The four extreme events of most concern to farmers are extended dry periods (drought), extreme high temperatures (heatwaves), extreme low temperatures (including frosts) and extended wet periods. These can affect yield and quality, infrastructure and soil condition and health, cashflow, animal health and performance and social wellbeing. Each of these impact areas will be affected to different degrees by extreme events (e.g. extreme low temperatures may be of particular concern during flowering, extreme wet may be more disruptive during lambing/calving or harvest), and may require different tactical responses. Some tactical responses are more relevant in cases when the duration of the extreme event is prolonged.

Extreme events can disrupt business cashflow and have  flow-on effects on commodity prices. There are a range of possibilities that may create risks for some businesses and opportunities for others(e.g. if production in one region is impacted by drought, this may drive up prices, meaning regions unaffected by the drought will benefit).

Tools such as farm management deposits or budget contingencies for unforeseen costs can aid a business' financial security. Planning for these allowances can be part of a business' strategic and tactical decision making. Ensuring ways of staying up to date with the availability of industry and government funding for extreme events is another way to manage some of the financial risks. These opportunities may involve funding for improving infrastructure, mitigating impacts of future extreme weather events, or recovery after an extreme event. These funding sources often lag an event or are not immediately accessible and can take time to move through regulatory processes. Such funding should not be relied on, and sound financial management with contingencies should be built into management of the business.

Social wellbeing is another area that can be impacted by extreme events. Mental fatigue from dealing with challenging circumstances, particularly when these events are extended, is not uncommon. Enduring losses or traumatic experiences related to an extreme event can impact mental health and affect relationships. Seeking support early, by being aware of your emotional wellbeing and the wellbeing of people around you, is invaluable.

Extreme events can also cause workplace health and safety issues by affecting conditions in the workplace, including new hazards following extreme conditions. For example, a heatwave can impact both livestock and those having to work outside in extreme heat. Tactical responses such as early starts or finishes to the workday can circumvent the need to work during the hottest time of day, reducing the risk of heat stress. Ensure machinery is serviced so air conditioning is working.  Leveraging the Bureau's extreme event tools to allow prioritising repairs and maintenance in the lead-up to a heatwave can make a difference. Extreme weather relating to bushfire risk can also influence work practices with some tasks, such as grain harvesting, not able to safely continue under high fire risk weather conditions. Other safety issues could involve the location of livestock, and potential escape routes, in case of bushfire (or floods). Having emergency policies and procedures in place, communicated, and understood by all staff can help mitigate risks and keep people safe during an extreme weather event.

Understanding the extreme weather events your location and industry are susceptible to, is critical in planning and preparing responses for those extreme events. Establishing thresholds or triggers for your business can provide early warning to implement an extreme weather response ahead of its occurrence, and can potentially mitigate or reduce the impact.

### Key messages

- The extreme events of most concern to the farming businesses are drought, heatwaves, extreme cold (including frost) and extended wet periods.
- Sound financial management with contingencies should be built into the business.
- Be aware of impacts on mental well-being - seeking support early for yourself or encourage those around you to do likewise.
- Use emergency procedures, communicated to, and understood by, staff, to help keep people and animals safe during an extreme event.
- Be aware of the extreme weather events your location and industry are vulnerable to, and establish triggers or thresholds for response.

## Drought

Periods of extended dry weather, more commonly referred to as droughts, impact availability of resources such as water and feed for livestock, limit growing season rainfall and deplete soil moisture. Growing seasons can be significantly reduced or absent altogether during periods of drought.

Historical records can help to form a picture of the likely annual and growing season rainfall for a district. Utilise this knowledge to make strategic decisions about the types of enterprises to run or decisions about investing in major infrastructure, (e.g. water storage, irrigation equipment, silos or barns). Considerations such as the frequency with which droughts have occurred in the past, and their duration, can aid strategic decision making and ensure the business' continued viability.

Albeit at different scale, less-frequent or shorter dry spells or droughts can still cause considerable challenges to a business. For example, the lack of an autumn break (an opening rain sufficient to establish crops or a winter feed wedge for livestock) can mean that despite adequate subsoil moisture crops can fail to establish or may not be sown at all if the break does not come. Actions such as maintaining stubble cover, changing fertiliser strategies and placement or supplementary feeding, can all help to make the most of a moderate break when (and if) it occurs. Droughts can cause crop failure or quality issues and may require tactical responses such as cutting for fodder or grazing crops rather than harvesting. Drought can also mean increased prices for feedstock and bedding materials in piggeries.

Disruption to water supplies and reduced likelihood of rain is likely to require tactical responses to manage limited water supply. Actions such as finding alternative water sources and managing existing water sources will lessen the risk of fully depleting water supplies, and optimises catchment capacity to make the most of water in the event of rain. Prioritising the use of irrigation water on crops may also become necessary, for example avoiding extended the frequency between irrigations during flowering of cotton. In a water scarce year where growing rice may result in reduced returns, a tactical decision could be to participate in the water trading market, or planting an alternative crop, instead of growing rice. Ensuring irrigation systems are operating at optimum efficiency should be conducted regularly to ensure water is always being used efficiently.

An unusually dry period has varying impacts depending on the previous seasonal conditions and time of year, therefore risk mitigation responses need to vary accordingly. The *Chance of extremes – unusually dry* tool indicates the chance of rainfall being in the lowest 20% of the historical range for a specified time (ranging from a week to three months). A dry outlook for spring might prompt a livestock business to secure supplementary feed early, in anticipation of increased demand during summer. A dry outlook during winter could trigger reassessment of the planned inputs for a grain crop. An example of such a dry outlook for late autumn is shown in Figure 2.

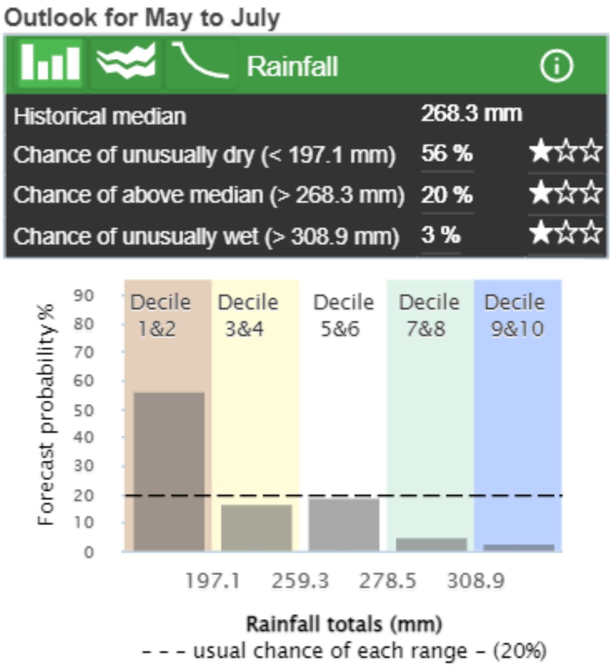



**Figure 2.** Example of the decile bar chart tool, showing the probability of an extreme dry (decile 1&2) event for a location between May and July. Reproduced from www.bom.gov.au.

There are a range of potential challenges regarding the impact of drought, which may differ for different enterprises, summarised in Table 1, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

**Table 1.** Summary of challenges and responses associated with the impact of drought.

| Potential challenges | Tactical response |
|---|---|
| Crop failure | Grazing or cutting for fodder to recoup some value |
| | Reducing inputs as season progresses |
| | Summer fallow management to store moisture for spring crop use |
| Lack of opening rains | Alter variety choice to ensure appropriate maturity timing |
| | Reduce area of higher risk crop types in favour of low risk options or fallow |
| | Reduce area of higher risk crop types in favour of low risk options or fallow |
| Soil erosion or degraded pasture base | Maintain stubble cover on vulnerable soil types |
| | Reduced or no grazing of stubbles; containment feeding |
| | Sacrifice paddocks |
| | Destocking early (e.g. agistment, sales) |
| Water supply | Alternate water source |
| | Monitor and manage water provision proactively |
| | Consider water trading |
| | Avoid extending frequency of irrigation during flowering of cotton |
| Quality issues | Cleaning or blending grain to meet delivery standards |
| | Sale to alternative markets, such as feedlots |
| Feed or fodder deficit | Feed budgeting to estimate feed supply and feed demand |
| | Planning for supplementary feeding (feed stores available and feeding logistics) |
| | Manage competition from feral and native animals |
| | Destocking early (e.g. agistment, sales) |
| Stock loss (mortalities) | Monitor animal condition and health |
| | Ensure feed supply meets feed demand (supplementary feed stores sufficient and animals fed to meet their requirements) |

## Key messages

- Drought can be an issue for farms whether it's for an extended period, or for shorter periods at important times of the year, such as the autumn break.
- There are a range of tactical responses to managing challenges posed by drought.
- Managing a drought and its impacts can occur over multiple seasons as challenges like soil cover and residual herbicide carryover, or degraded pasture base can persist after the drought has broken.

## Extended wet

Periods of extended wet weather can derail planned activities on the farm, affect livestock wellbeing, affect the ability to complete paddock operations in a timely manner, and disrupt supply chain logistics.

Flooding and soil waterlogging commonly result from an extended wet period. Flooding or waterlogging may occur at farm-level across multiple paddocks for an extended period of time, and/or on a larger scale across a wider region. As such, the range of issues associated with extended wet periods may vary, depending on scale and impact. Hence, the responses to these issues will also need to vary.

At a farm-level, one of the primary issues of waterlogged paddocks is the potential for denitrification and loss of crop or pasture vigour. Flow-on effects from this can be increased weed competition, nitrogen-deficient crops, potential disease issues, reduced feed quality and plant survivability. Another flow-on effect could be the need for increased weed control post-flooding.

Examples of potential responses to these issues include selecting waterlogging-tolerant crops for vulnerable paddocks, altering the timing of nitrogen applications, and potentially sowing longer season varieties early to increase early root growth and grow a larger root system. To maintain timeliness of paddock operations during periods of waterlogging aerial spreading or spraying may be considered if a ground rig is not practical.

Extreme wet weather can also have impacts on the crop with increased disease pressure. Tactics to manage this risk can include growing resistant varieties, and the use of protective fungicide programs.

For businesses running livestock, examples of potential responses to mitigate these issues include early destocking, by either selling off stock or sourcing agistment in an unaffected area. Destocking would need to occur before larger scale impacts, such as transport logistics breakdown (e.g. if roads and laneways become too wet for trucks to access the property). Short-term lot-feeding in a sacrifice paddock on drier ground could ensure livestock are safe from flood waters, allow better stock monitoring and feed management, and reduce pugging and damage to waterlogged areas. In years of high water availability, the opportunistic growing of a rice crop where paddocks are accessible for planting could be an option.

The Bureau's timeline graph in combination with the *chance of 3-day totals* tool could indicate the probability of exceeding median rainfall and highlight the chance of the three-day total rainfall exceeding, for example, 50 mm. Being a step ahead of a potential extreme weather event provides the opportunity to complete any upcoming operations on waterlogging-prone paddocks, make any preparations for vulnerable crops, hay or machinery in flood prone storage locations, or move livestock while the farm is still trafficable. Figure 3 and Figure 4 provide an example of what an extreme wet event looks like using the *probability of exceedance* tool (Figure 3) and the *chance of 3-day totals* tool (Figure 4).

There are a range of potential challenges regarding the impact of extended wet weather, which may differ for different enterprises, summarised in Table 2, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

### Key messages

- Extended wet weather can present operational challenges as well as impact crops and livestock through increased disease.
- Different tactical responses can be implemented at different times of the season depending on the soil water profile, and the time of the year with respect to the animal or plant production cycle.

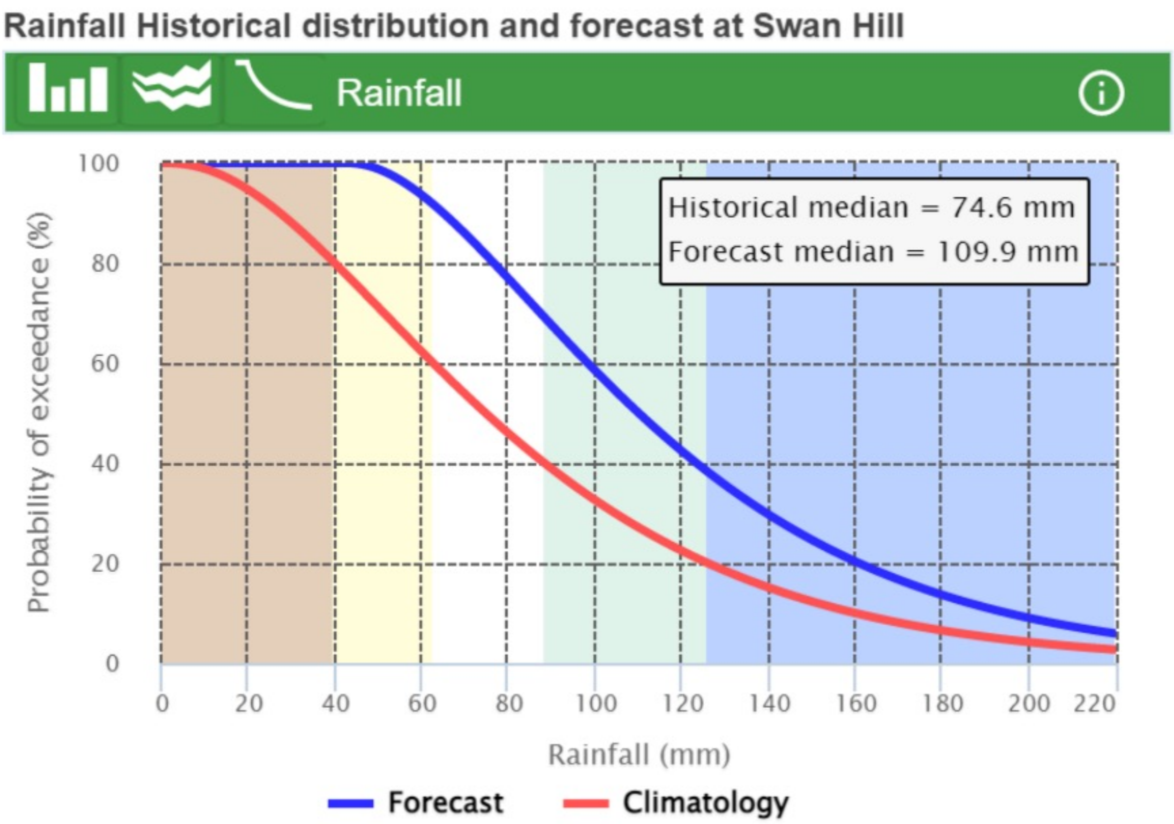



**Figure 3.** Example of the *probability of exceedance* tool, showing an extreme wet outlook for Swan Hill. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

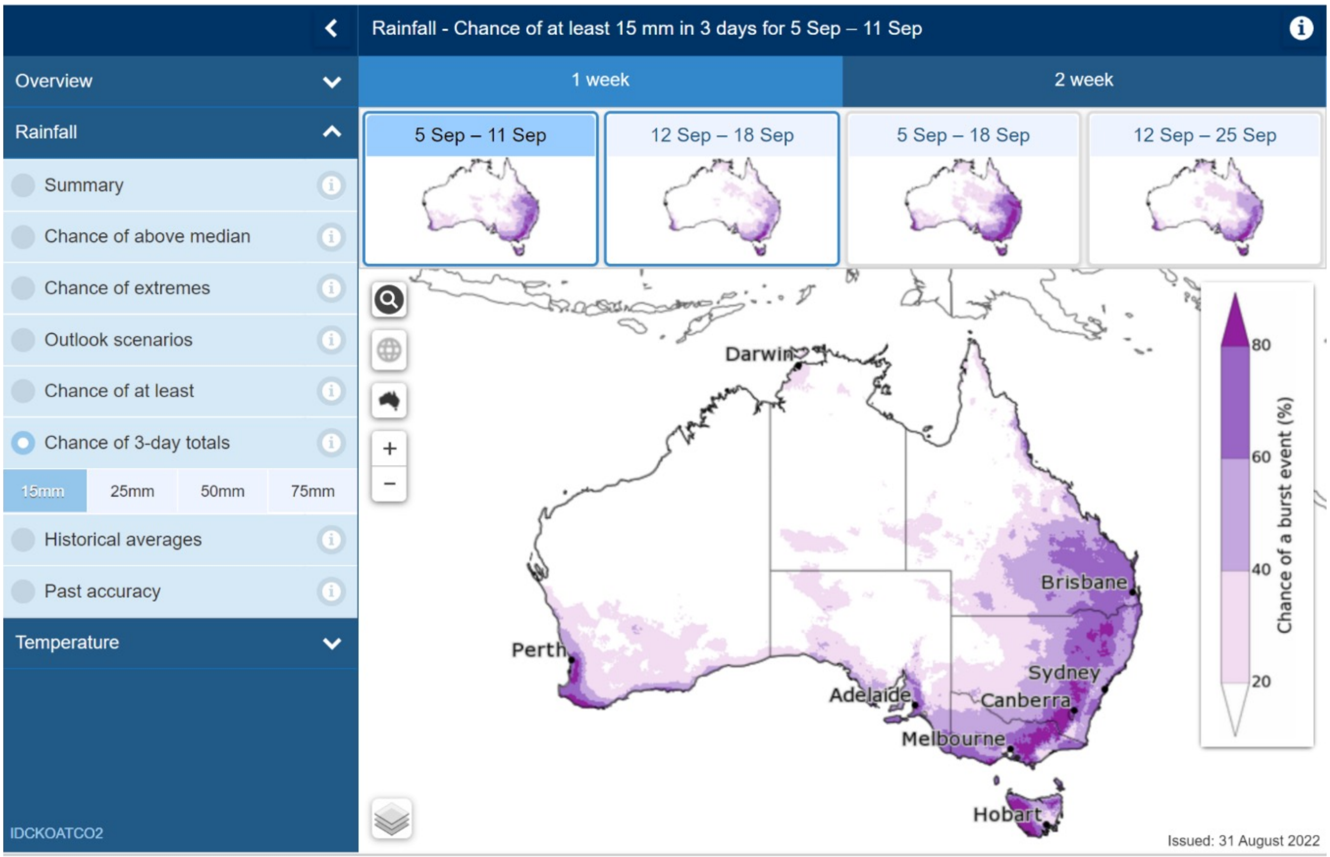



**Figure 4.** Example of the *chance of 3-day totals* tool, showing the chance of a burst event of at least 15 mm in three days between 5 Sep and 11 Sep 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course *'Using seasonal climate prediction tools'*.

**Table 2.** Summary of challenges and responses associated with extended wet weather.

| Potential challenges | Tactical response |
|---|---|
| Waterlogging | Sow water-logging tolerant crops |
| | Timing of nitrogen applications to reduce denitrification |
| | Row orientation to improve drainage |
| | Aerial spraying or spreading to maintain timely operations |
| Increased disease pressure (crops) | Canopy management to improve airflow |
| | Protectant fungicide use and/or proactive fungicide program |
| | Disease-resistant varieties |
| Animal health challenges | Monitor animal condition score and health |
| | Ensure access to (natural) shelter |
| | Ensure lambing/calving/farrowing animals are moved to sheltered and drier areas if possible |
| Minimal spraying days available to complete program | Use of contractors if available, prioritise spraying jobs |
| Tracks and paddock access impacted | Well maintained multiple access points for paddocks |
| Bogged machinery | Stand-off areas for feeding |
| | Develop an emergency procedure that includes postponing work until conditions improve. |
| | Consider aerial spraying for crop protection |
| Lack of resources to hit operational windows | Use of contractors if available |
| | Earlier start date or increased labour or shift length to cover more country |
| | Reallocate labour and hire additional casual labour if required |

### Heatwaves

Periods of extreme high temperatures, otherwise known as heatwaves, can cause shock to the farm management system and the underpinning biological systems. A combination of a prolonged dry event and a heatwave also can increase the bushfire risk.

The Bureau's *chance of extremes* maps indicate the chance of temperatures being in the highest 20% of the historical range for a specified time, ranging from a week to three months ahead. Such notice could allow you to prioritise tasks related to water infrastructure to secure water availability, or to muster and relocate stock to areas with more shelter available. It could also enable the scheduling of harvest activities.

For cropping businesses, yield potential can be impacted following a heatwave during the growing season. Knowing when a heatwave is predicted gives the opportunity to prepare and minimise risk. Examples of actions include preparing to cut hay on paddocks that might fail or reconsidering late-season inputs, such as nitrogen, fungicides or the use of growth regulators. Heatwaves can also have operational impacts, reducing the available time to effectively control summer weeds and preserve moisture, or forcing harvest operations to stop due to fire danger risk.

Pasture can be lost following a heatwave by direct radiative burning, dehydration, root burn and death due to hot soils, or from fire damage in the event of a bushfire. Livestock are impacted in heatwaves through increased heat stress. Examples of heat wave management for livestock include keeping livestock in areas where shade and water are readily accessible without too much walking required, and ensuring the water supply will keep up with increased demand on hot days.

Bushfires pose a serious risk to livestock and crops. Having in place an over-arching bushfire plan, which can be reviewed when heatwaves are forecast, enables livestock locations and escape routes to be identified early. As an additional precautional valuable or vulnerable stock could be relocated early to areas at lower risk (e.g. with low biomass, or close to infrastructure that is likely to be defendable and protected). Establishing fire breaks is also an option with enough notice.

The FWFA tools cannot indicate the occurrence of a heatwave as well as a weather forecast. However, the *chance of extremes* map for unusually warm temperatures for both maximum and minimum temperatures can provide an insight into periods when unusually warm conditions may be expected. An example of an unusually warm outlook is shown in Figure 5.

There are a range of potential challenges regarding the impact of heatwaves, which may differ for different enterprises, summarised in Table 3, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

## Key messages

- Heatwaves can impact both yield and quality of crops and animal health, as well on-farm operations.
- Fire danger is a key concern during heatwaves, which can affect paddock operations and require re-location of livestock.

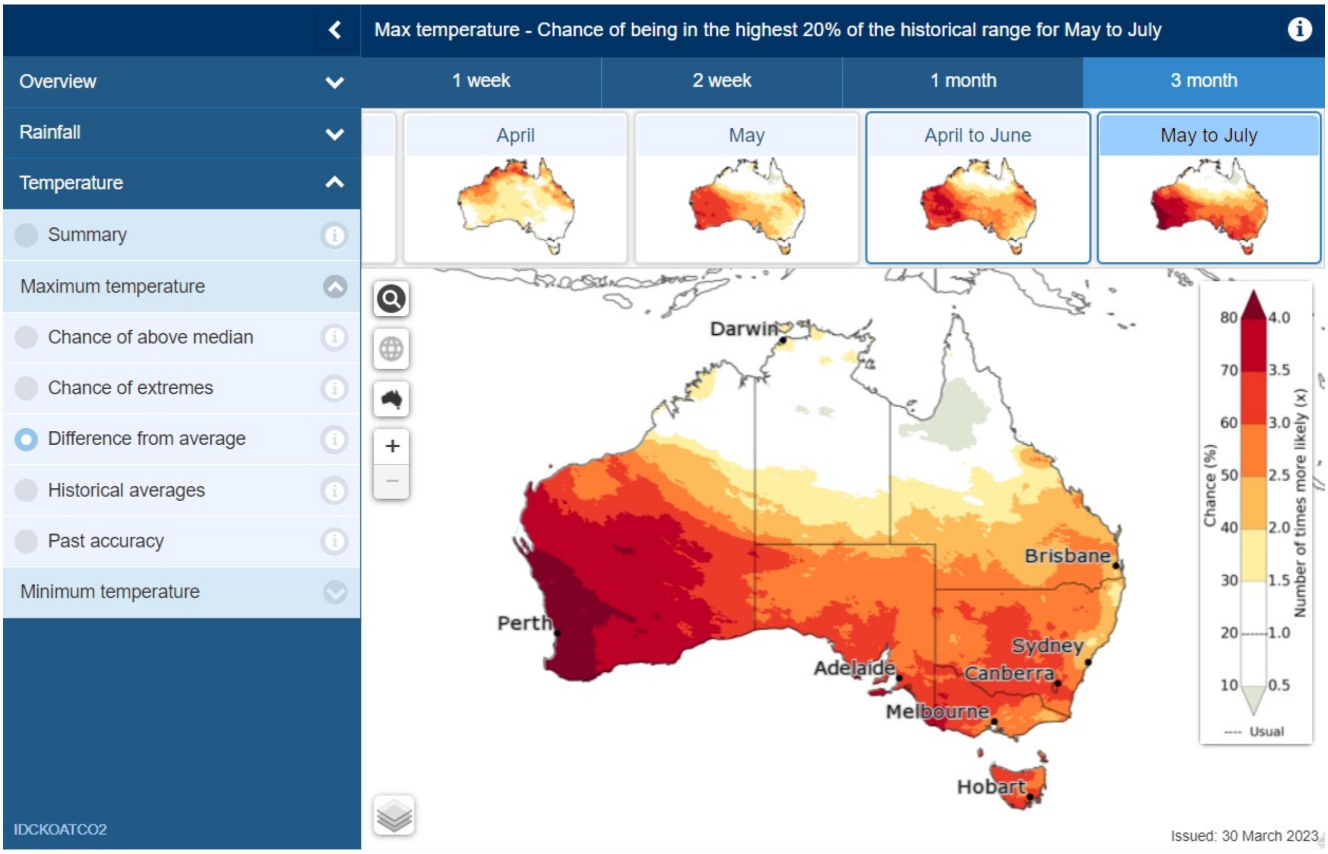



**Figure 5.** Example of the *chance of extremes* map for maximum temperatures in the period between May and July 2023 for Australia. Source: www.bom.gov.au 4/4/2023.

**Table 3.** Summary of challenges and responses associated with the impact of heatwaves.

| Potential challenges | Tactical response |
|---|---|
| Quality reduced | Consider applying growth regulators for high VGR in cotton |
| | Blend or clean grain to meet required specifications |
| | Seek alternative markets (e.g. feedlots) |
| Water supply | Alternative water source |
| | Monitor and manage water provision proactively |
| Reduced spraying opportunities | Employ contractors to assist with summer spraying programs |
| | Commence summer spraying during harvest if opportunities arise |
| Risk of bushfire – stock mortality, disruption to harvest | Bushfire response plan prepared, updated and ready to go |
| | Move livestock to safer locations |
| | Establish fire breaks in key locations |
| | Increase harvest operations during periods of suitable weather |
| | Utilise grain storage on-farm to increase harvesting capacity in suitable weather conditions and reduce reliance on bulk handling system |
| Heat stress impacting animal health, with risk of stock mortality | Monitor livestock condition and health |
| | Monitor and manage water provision proactively |
| | Diet changes such as higher fat content |
| | Wet concrete flooring and/or spray pigs with water |

## Extreme cold events, including frost

Periods of extreme low temperatures, in particular frosts, can have a severe impact on crops at different times of the year and cause significant yield loss. A complex combination of crop type and crop stage, moisture conditions, position in the landscape and low temperature influences the impact of frost in any given situation. The financial impacts on a cropping or horticultural business due to frost can be severe, as frost damage often occurs at a point in the season when most of the inputs have already been applied (e.g. spring).

Yield potential and quality can be impacted following a frost at various stages during the growing season, for example, plant death during severe vegetative frosts early in the season, stem frost through the early reproductive stages, sterility from a frost during flowering, or bolls opening prematurely in cotton crops if not defoliated before the first frost. Different crop species and varieties vary in their susceptibility to frost and environmental factors, such as stubble load or soil type, also play a role. The presence of extremely low temperatures remains the most important weather-related factor in damaging frosts.

Managing frost-prone landscapes often requires some strategic actions, such as changes to enterprise mix, or investment in hay equipment and infrastructure, however, knowing when an extreme cold period (with associated frost-risk), can be expected opens up some tactical opportunities that can be implemented to prepare and minimise risk. Examples of such actions include preparing to cut hay on affected paddocks, considering harvest arrangements to blend grain, considering grazing options, re-assessing grain marketing options and reconsidering late-season inputs, such as nitrogen or fungicides.

Extreme cold conditions, including frosts, can also have operational impacts. For example, some herbicides are sensitive to extreme cold conditions from either a crop safety or efficacy perspective. Knowing when a period of extreme cold is likely can help you prioritise jobs in the spray program.

The *chance of extremes* maps for unusually cool minimum temperatures can provide insight as to whether there is an increased risk of frost events occurring. For more accurate prediction of frosts, the FWFA *chance of extremes* map can be used in combination with 7-day weather forecasts. The *chance of extremes* map for cool temperatures presents the chance for both minimum and maximum temperatures. Using them in conjunction with each other can provide some insights as to whether a frost might be expected with a longer outlook than a weather forecast. An example of the *chance of extremes* map for unusually cool maximum temperatures is shown in Figure 6.

There are a range of potential challenges regarding the impact of frost events, which may differ for different enterprises, summarised in Table 4, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

## Key messages

- Frosts can have severe impacts on crop yield and quality, and profitability.
- Being prepared to graze or cut hay from frost affected cereal paddocks is a sound way to recover some income.
- Closely monitoring forward contracts and estimated yields during extreme cold conditions is critical to reduce risk of contract washouts.

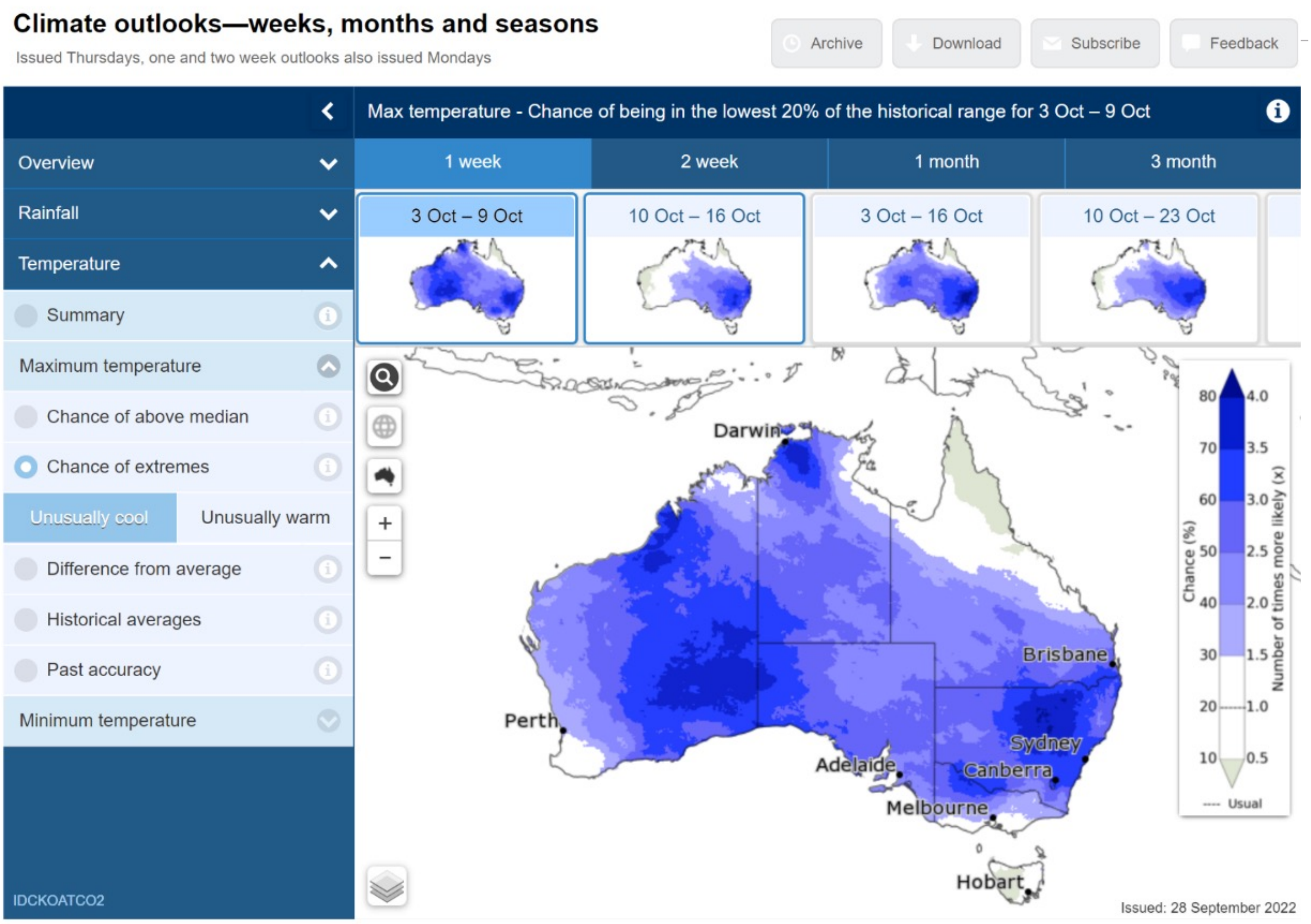



**Figure 6.** Example of the *chance of extremes* map for unusually cool maximum temperatures between 3 oct and 9 Oct 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 4.** Summary of challenges and responses associated with the impact of frost.

| Potential challenges | Tactical response |
|---|---|
| Reduced crop yield | Choose varieties and sowing times to spread the crop across different frost windows |
| | Cut hay from affected paddocks to recover income |
| | Graze affected paddocks to recover income |
| Marketing position exposed | Regularly evaluate crop yield potential to reduce risk of contract washouts, with thorough monitoring of crop damage |
| Reduced crop quality | Be conscious of quality specifications on contracts |
| | Blend or clean grain to meet required specifications |
| | Seek alternative markets, such as feedlots |
| Spray efficacy or crop safety compromised | Prioritise sensitive spray jobs during periods of optimal spraying weather |
| Damage to vine tissue or to blossom or fruit of horticultural crops | Maintain clear moist soil or short grass in the interrow |
| | Employ fan or helicopter protection |
| | Employ irrigation protection |
| | Consider introducing heat through strategically placed heating |
| | Consider protectant sprays |

## Notes

# 3.2 Tactical decision making in the grain industry

## Decision making

Decisions are made daily in a farming business. Some decisions relate to the day-to-day operation of the grain business, such as when to spread fertiliser or start harvest. This is operational decision making. Decisions made for the longer term of the business are strategic decisions and examples include deciding whether to invest in capital items, setting targets (such as return on investment and gross margin targets), and optimising labour use efficiency. Tactical decisions and plans are designed to achieve the longer term strategy, usually with a medium-term view (1–12 months). Examples of tactical decisions for a grain business might include determining nitrogen rate, harvesting grain vs cutting for hay, and crop variety selection.

A tactical climate sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the weather. Examples include nitrogen application rate, grain marketing decisions, and investing in additional harvest resources such as contracting.

Information from FWFA is most relevant to tactical or operational decisions, however, long-term or strategic decision making can be the most cost-effective way to manage extreme events. Examples include investing in hay making equipment and storage, altering the enterprise mix, and changing seeding equipment to better handle dry seeding. Determining the costs and benefits of these decisions requires historical climate data and climate change projections on the frequency and severity of rare events. Historical climate data can be accessed via the Bureau's website: http://www.bom.gov.au/. Under *Our services, Climate and past weather*, the rainfall and temperature records are available under *Rainfall history* and *Temperature history*.

Farmers deal with weather variability daily, influencing their operational decision making. This type of decision making is something we are more familiar (and comfortable) with, than those decisions around less frequent, but more impactful, extreme events. Working with the GRDC and other RDC's as part of the FWFA project, the Bureau developed five tools to support short-term and medium-term decision making regarding extreme climate risks. As these tools focus on a seasonal timeframe, they are most suited to supporting on-farm operational and tactical decision making.

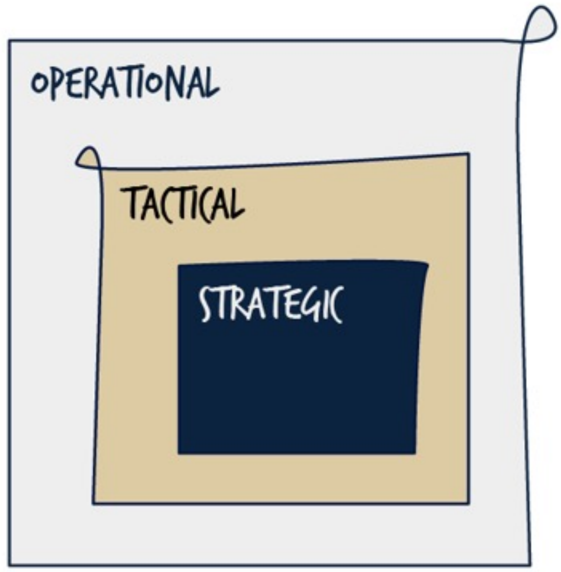



**Figure 1.** The three types of decisions (from Dairy Australia – Our Farm Our Plan)

Before you can use these tools effectively in your grain business you need to fully understand the operations and assets of your business that can be affected by an extreme event. While we often focus on the risks of these events, it's important to realise they may also create opportunities. Following are some examples of tactical decisions that can potentially mitigate these risks or capitalise on the opportunities. These are not designed to operate in isolation from a whole enterprise risk assessment and management plan, but rather to complement them.

### Key messages

- A tactical climate-sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the weather.
- FWFA tools are best used to support tactical and operational decision-making for managing extreme weather events.

## Key risks

A grain business' calendar of operations usually considers the seasonality of activities relevant to the location of the farm. Extreme weather events are highly likely to disrupt these operations.

The four extreme events of most concern to grain producers are extended dry periods (drought), extreme high temperatures (heatwaves), extreme low temperatures (including frosts) and extended wet periods. These can affect grain yield and quality, soil condition and health, cashflow and social wellbeing. Each of these impact areas will be affected to different degrees by extreme events (e.g. extreme high temperatures may be of particular concern flowering and grain fill) and may require different tactical responses. Some tactical responses are more relevant in cases when the duration of the extreme event is prolonged.

Extreme events can disrupt business cashflow. Additionally, extreme weather events can have a flow-on effects on commodity prices, with a range of possibilities that may create risks for some businesses and opportunities for other businesses (e.g. if production in one region is impacted by drought, this may drive up prices, meaning regions unaffected by the drought will benefit).

Tools such as farm management deposits or budget contingencies for unforeseen costs can aid a business' financial security. Planning for these allowances can be part of a business' strategic and tactical decision making. Ensuring ways of staying up to date with the availability of industry and government funding for extreme events is another way to manage some of the financial risks. These opportunities may involve funding for improving infrastructure, mitigating impacts of future extreme weather events, or recovery after an extreme event. These funding sources often lag an event or are not immediately accessible and can take time to move through regulatory processes. Such funding should not be relied on, and sound financial management with contingencies should be built into management of the business.

Social wellbeing is another area that can be impacted by extreme events. Mental fatigue from dealing with challenging circumstances, particularly when these events are extended, is not uncommon. Enduring losses or traumatic experiences related to an extreme event can impact mental health and affect relationships. Seeking support early, by being aware of your emotional wellbeing and the wellbeing of people around you, is invaluable.

Extreme events can also cause workplace health and safety issues by affecting conditions in the workplace, including new hazards following extreme conditions. For example, a heatwave can impact those having to work outside in extreme heat. Tactical responses such as early starts or finishes to the workday can circumvent the need to work during the hottest time of day, reducing the risk of heat stress. Ensure machinery is serviced so air conditioning is working. Leveraging the Bureau's extreme event tools to allow prioritising repairs and maintenance in the lead-up to a heatwave can make a difference. On a grain farm extreme weather relating to bushfire risk can also influence work practices with some tasks, such as harvesting, not able to safely continue under high fire risk weather conditions. Other safety issues can involve the accessibility of sheds and equipment in case of floods following an extreme wet event. Having emergency policies and procedures in place, communicated, and understood by all staff can help mitigate risks and keep people safe during an extreme weather event.

Understanding the extreme weather events your location and industry are susceptible to, is critical in planning and preparing responses for those extreme events. Establishing thresholds or triggers for your business can provide early warning to implement an extreme weather response ahead of its occurrence, and can potentially mitigate or reduce the impact.

### Key messages

- The extreme events of most concern to the grain industry are drought, heatwaves, extreme cold (including frost) and extended wet periods.
- Sound financial management with contingencies should be built into the business.
- Be aware of impacts on mental well-being - seeking support early for yourself or encourage those around you to do likewise.
- Use emergency procedures, communicated to, and understood by, staff, to help keep people safe during an extreme event.
- Be aware of the extreme weather events your location and industry are vulnerable to, and establish triggers or thresholds for response.

## Drought

Periods of extended dry weather, more commonly referred to as droughts, often involve limited growing season rainfall and depleted soil moisture in general. Growing seasons can be (extremely) shortened or even be absent altogether during periods of drought.

Historical records can help to form a picture of the likely annual and growing season rainfall for a district. Utilise this knowledge to make strategic decisions about the types of enterprises to run or decisions about investing in major infrastructure, (e.g. water storage, irrigation or seeding equipment to hit optimal seeding windows). Considerations such as the frequency with which droughts have occurred in the past, and their duration, can aid strategic decision making and ensure the business' continued viability.

Albeit at different scale, less-frequent or shorter dry spells or droughts can still cause considerable challenges in a business. For example, the lack of an autumn break (an opening rain sufficient to establish crops) can mean that despite adequate subsoil moisture crops can fail to establish or may not be sown at all if the break does not come. This can lead to increased erosion risk on fragile soils. Actions such as maintaining stubble cover, dry sowing appropriate crops and paddocks, and changing fertiliser strategies and placement can all help to make the most of a moderate break when (and if) it occurs.

Droughts can cause crop failure or quality issues, and may require tactical responses such as cutting hay or grazing crops rather than harvesting grain,

**Table 1.** Summary of challenges and responses associated with the impact of drought relevant to Australia's southern grains industry.

| Potential challenges | Tactical response |
|---|---|
| Crop failure | Grazing or cutting for hay to recoup some value |
| | Reducing inputs as season progresses |
| | Summer fallow management to store moisture for spring crop use |
| | Grain marketing approaches modified to reduce washout risk |
| Lack of opening rains | Alter variety choice to ensure appropriate maturity timing |
| | Reduce area of higher risk crop types in favour of low risk options or fallow |
| | Dry sowing appropriate paddocks and crop types |
| Soil erosion | Maintain stubble cover on vulnerable soil types |
| | Reduced or nil grazing of stubbles |
| | Use of cover crops if conditions allow |
| | Careful consideration of pre-emergent herbicide strategy if dry sowing to reduce crop damage risk |
| Grain quality issues | Cleaning or blending grain to meet delivery standards |
| | Sale to alternative markets, such as feedlots |
| Poor weed control as herbicide efficacy affected | Crop-top to reduce seedset of weeds, or cut affected areas for hay |
| Residual herbicide carryover | Use of tolerant varieties the following season |

and adjusting grain marketing strategies to suit the season. Herbicide performance can be affected by dry conditions that stress crops and weeds, and residual herbicides can cause issues in subsequent crops and seasons from inadequate rainfall to break down residues. An example of what an unusually dry event might look like using the decile bar chart is shown in Figure 2.

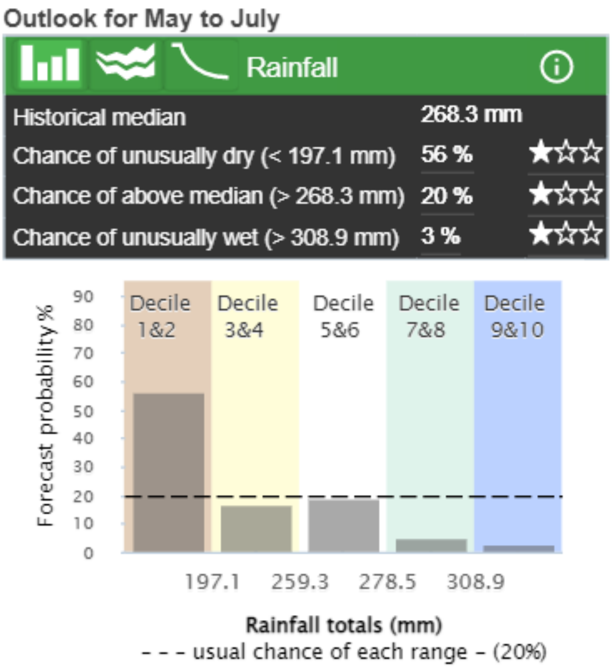



**Figure 2.** Example of the decile bar chart tool, showing the probability of an extreme dry (decile 1&2) event for a location between May and July. Reproduced from www.bom.gov.au.

Grain producers identified a range of challenges regarding the impact of drought, as summarised in Table 1, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

### Key messages

- Drought can be an issue for grain farms whether it's for an extended period, or for shorter periods at important times of the year, such as the autumn break.
- Tactical responses to managing crop failure can include grazing crops or cutting for hay to recoup income.
- Managing a drought and its impacts can occur over multiple seasons as challenges like soil cover and residual herbicide carryover can persist after the drought has broken.

## Heatwaves

Periods of extreme high temperatures, otherwise known as heatwaves, can cause shock to the farm management system and the underpinning biological systems. A combination of a prolonged dry event and a heatwave also can increase the bushfire risk.

Grain yield potential can be impacted following a heatwave during the growing season. This can either be through increased water use as the plants try to cope with the heat, or by other plant responses such as shortening flowering windows, floret sterility reducing grain number, flower loss in pulses and canola, or shortened grain-fill periods impacting on quality. Knowing when a heatwave is predicted gives the opportunity to prepare and minimise risk. Examples of actions include preparing to cut hay on paddocks that might fail, re-assessing your grain marketing position and reconsidering late-season inputs, such as nitrogen or fungicides.

Heatwaves can also have operational impacts, reducing the available time to effectively control summer weeds and preserve moisture, or forcing harvest operations to stop due to fire danger risk.

The FWFA tools cannot indicate the occurrence of a heatwave as well as a weather forecast. However, the *chance of extremes* map for unusually warm temperatures for both maximum and minimum temperatures can provide an insight into periods when unusually warm conditions may be expected. An example of an usually warm outlook is shown in Figure 3.

Grain producers identified a range of challenges regarding the impact of heatwaves, as summarised in Table 2, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

### Key messages

- Heatwaves can impact both grain yield and quality, as well on-farm operations.
- Fire danger from paddock operations is a key concern during heatwaves, which can affect operations.

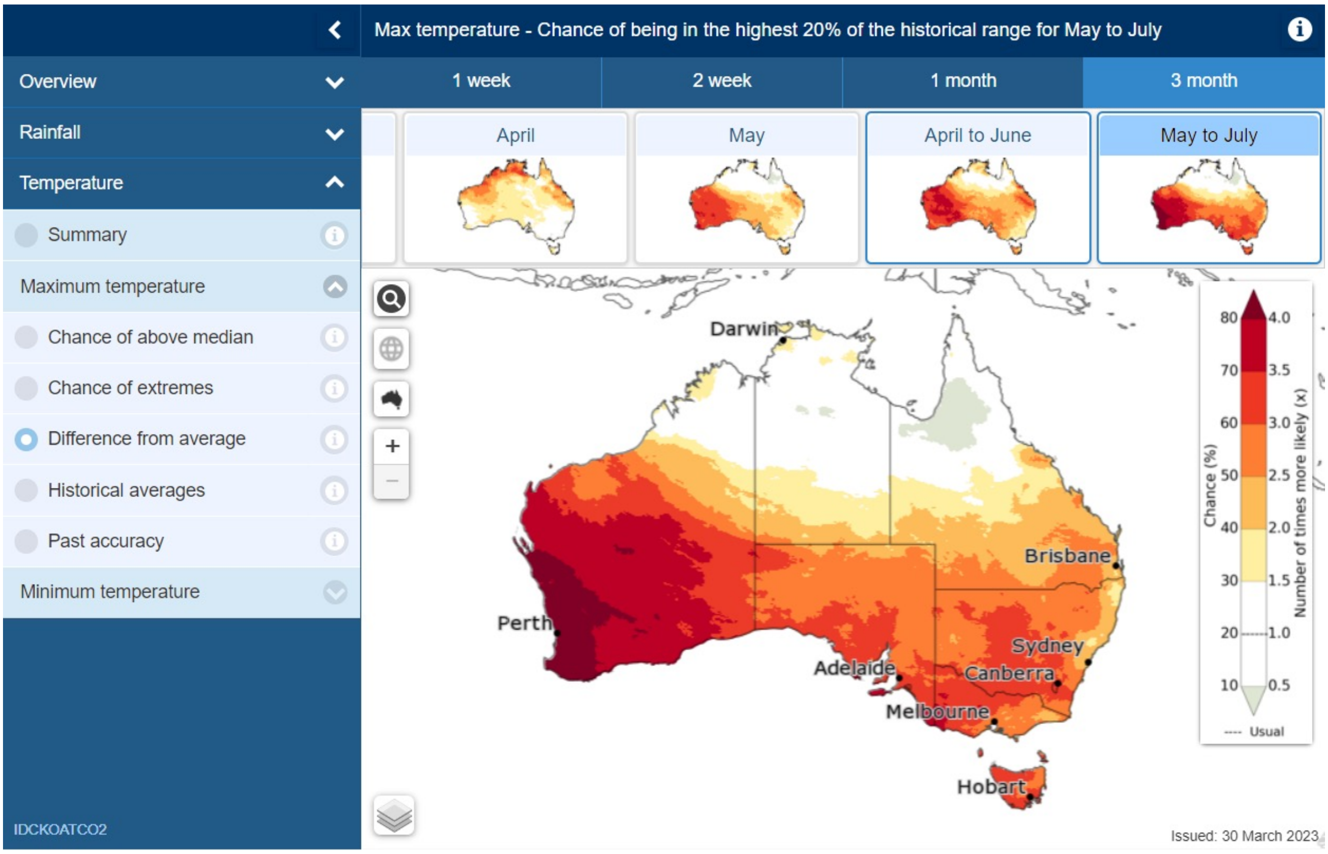



**Figure 3.** Example of the *chance of extremes* map for maximum temperatures in the period between May and July 2023 for Australia. Source: www.bom.gov.au 4/4/2023.

**Table 2.** Summary of challenges and responses associated with the impact of heatwaves relevant to Australia's southern grains industry.

| Potential challenges | Tactical response |
|---|---|
| Reduced flowering period | Use varieties and sowing times to avoid likelihood of flowering window coinciding with heatwaves |
| | Preserve soil moisture for critical spring period |
| Grain quality reduced | Be conscious of quality specifications on grain contracts |
| | Blend or clean grain to meet required specifications |
| | Seek alternative markets (e.g. feedlots) |
| Harvest delayed due to fire danger | Increase harvest operations during periods of suitable weather |
| | Utilise grain storage on-farm to increase harvesting capacity in suitable weather conditions and reduce reliance on bulk handling system |
| Reduced spraying opportunities | Employ contractors to assist with summer spraying programs |
| | Commence summer spraying during harvest if opportunities arise |

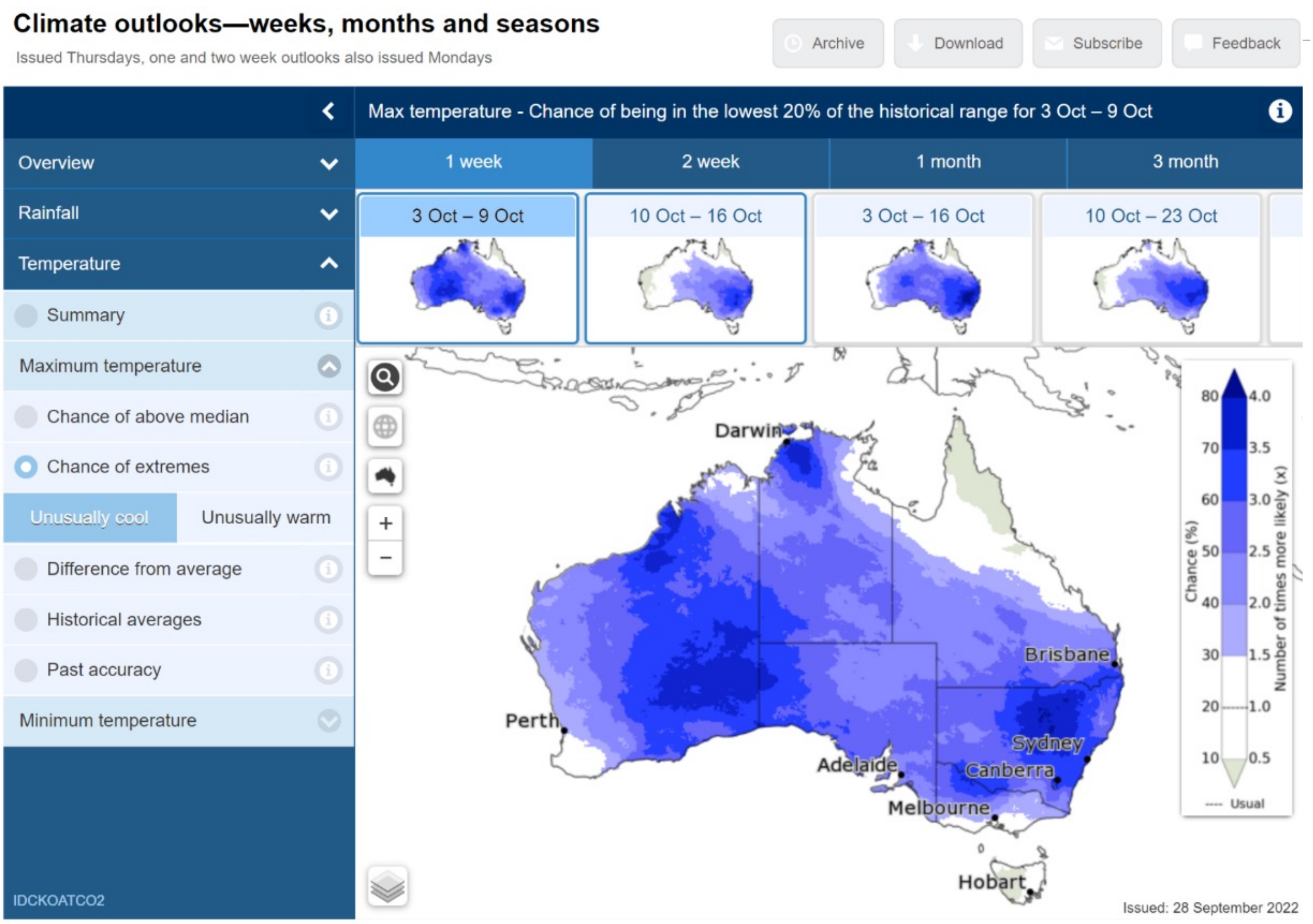



**Figure 4.** Example of the *chance of extremes* map for unusually cool maximum temperatures between 3 oct and 9 Oct 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 3.** Summary of challenges and responses associated with the impact of frost relevant to Australia's southern grains industry.

| Potential challenges | Tactical response |
|---|---|
| Reduced grain yield | Choose varieties and sowing times to spread the crop across different frost windows |
| | Cut hay from affected paddocks to recover income |
| | Graze affected paddocks to recover income |
| Grain marketing position exposed | Regularly evaluate crop yield potential to reduce risk of contract washouts, with thorough monitoring of crop damage |
| Reduced grain quality | Be conscious of quality specifications on grain contracts |
| | Blend or clean grain to meet required specifications |
| | Seek alternative markets, such as feedlots |
| Spray efficacy or crop safety compromised | Prioritise sensitive spray jobs during periods of optimal spraying weather |

## Extreme cold events, including frost

Periods of extreme low temperatures, in particular frosts, can have a severe impact on crops at different times of the year and cause significant yield loss. A complex combination of crop type and crop stage, moisture conditions, position in the landscape and low temperature influences the impact of frost in any given situation. The financial impacts on a grain business due to frost can be severe, as frost damage often occurs at a point in the season when most of the inputs have already been applied (e.g. spring).

Grain yield potential and quality can be impacted following a frost at various stages during the growing season, for example, plant death during severe vegetative frosts early in the season, stem frost through the early reproductive stages, sterility from a frost during flowering, or a late frost impacting grain quality. Different crop species and varieties vary in their susceptibility to frost and environmental factors, such as stubble load or soil type, also play a role. The presence of extremely low temperatures remains the most important weather-related factor in damaging frosts.

Managing frost-prone landscapes often requires some strategic actions, such as changes to enterprise mix, or investment in hay equipment and infrastructure, however, knowing when an extreme cold period (with associated frost-risk) can be expected opens up some tactical opportunities that can be implemented to prepare and minimise risk. Examples of such actions include preparing to cut hay on affected paddocks, considering harvest arrangements to blend grain, considering grazing options, re-assessing grain marketing options and reconsidering late-season inputs, such as nitrogen or fungicides.

Extreme cold conditions, including frosts can also have operational impacts, for example, some herbicides are sensitive to frost conditions from either a crop safety or efficacy perspective. Knowing when a period of extreme cold is likely can help you prioritise jobs in the spray program.

The *chance of extremes* maps for unusually cool minimum temperatures can provide insight as to whether there is an increased risk of frost events occurring. For more accurate prediction of frosts, the FWFA *chance of extremes* map can be used in conjunction with the 7-day weather forecasts. The *chance of extremes* map for cool temperatures presents the chance for both minimum and maximum temperatures. Using them in conjunction with each other can provide some insights as to whether a frost might be expected with a longer outlook than a weather forecast. An example of the *chance of extremes* map for unusually cool maximum temperatures is shown in Figure 4.

Grain producers identified a range of challenges regarding the impact of frost, as summarised in Table 3, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

### Key messages

- Frosts can have severe impacts on grain yield and quality, and profitability, for a grain business.
- Being prepared to graze or cut hay from frost affected paddocks is a sound way to recover some income.
- Closely monitoring grain marketing position and estimated yields during frosty conditions is critical to reduce risk of contract washouts.

## Extended wet

Periods of extended wet weather can derail logistics in the supply chain or on the farm and affect the ability to complete paddock operations in a timely manner.

Flooding is a common occurrence during an extended wet period. Flooding can be at farm-level with multiple paddocks waterlogged for an extended period, or access points cut off for machinery. As such, the range of issues associated with extended wet periods can vary, depending on scale and impact. Subsequently, the variety of responses to these issues may need to vary, too.

At a farm-level, one of the primary issues of waterlogged paddocks is the potential for denitrification and loss of crop vigour. Flow-on effects from this can be increased weed competition, nitrogen-deficient crops, and potential disease issues. Another flow-on effect could be the need for increased weed control post-flooding.

Examples of potential responses to these issues include selecting waterlogging-tolerant crops for vulnerable paddocks, altering the timing of nitrogen applications, and potentially sowing longer season varieties early to increase early root growth and grow a larger root system. To maintain timeliness of paddock operations during periods of waterlogging aerial spreading or spraying may be considered if a ground rig is not practical.

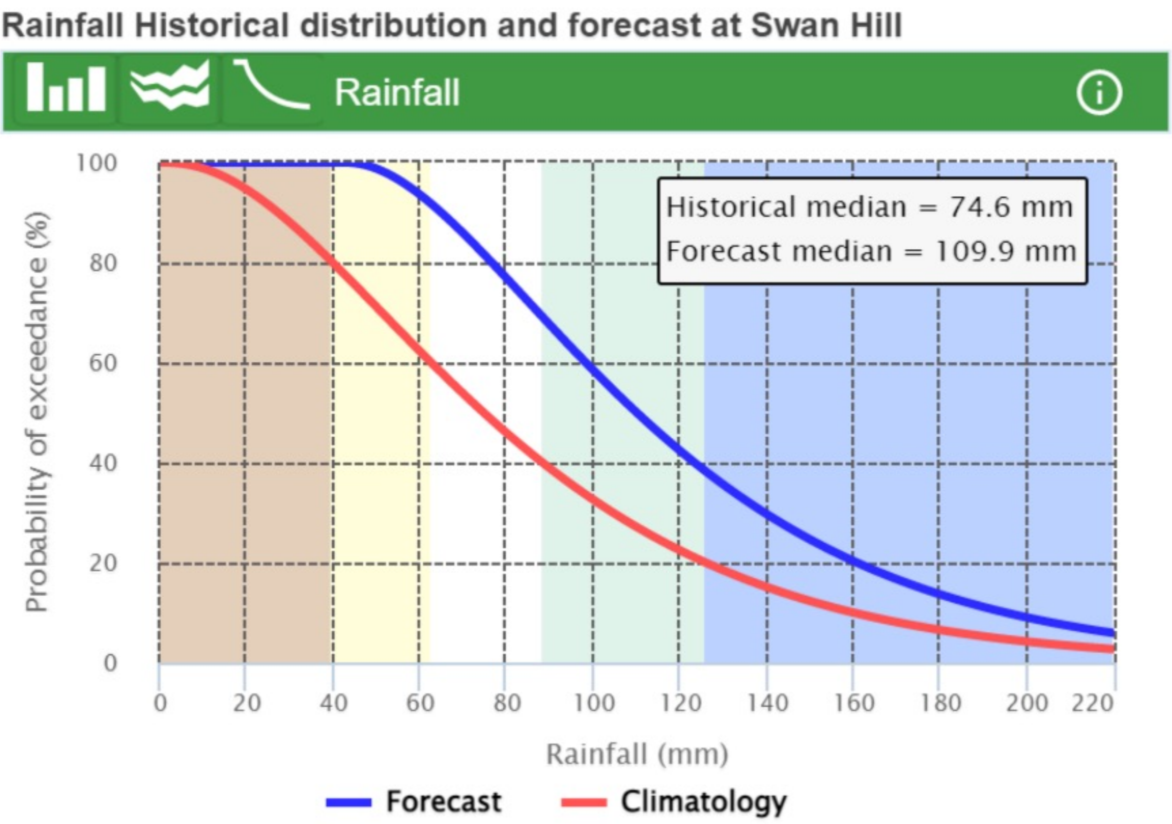



**Figure 5.** Example of the *probability of exceedance* tool, showing an extreme wet outlook for Swan Hill. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

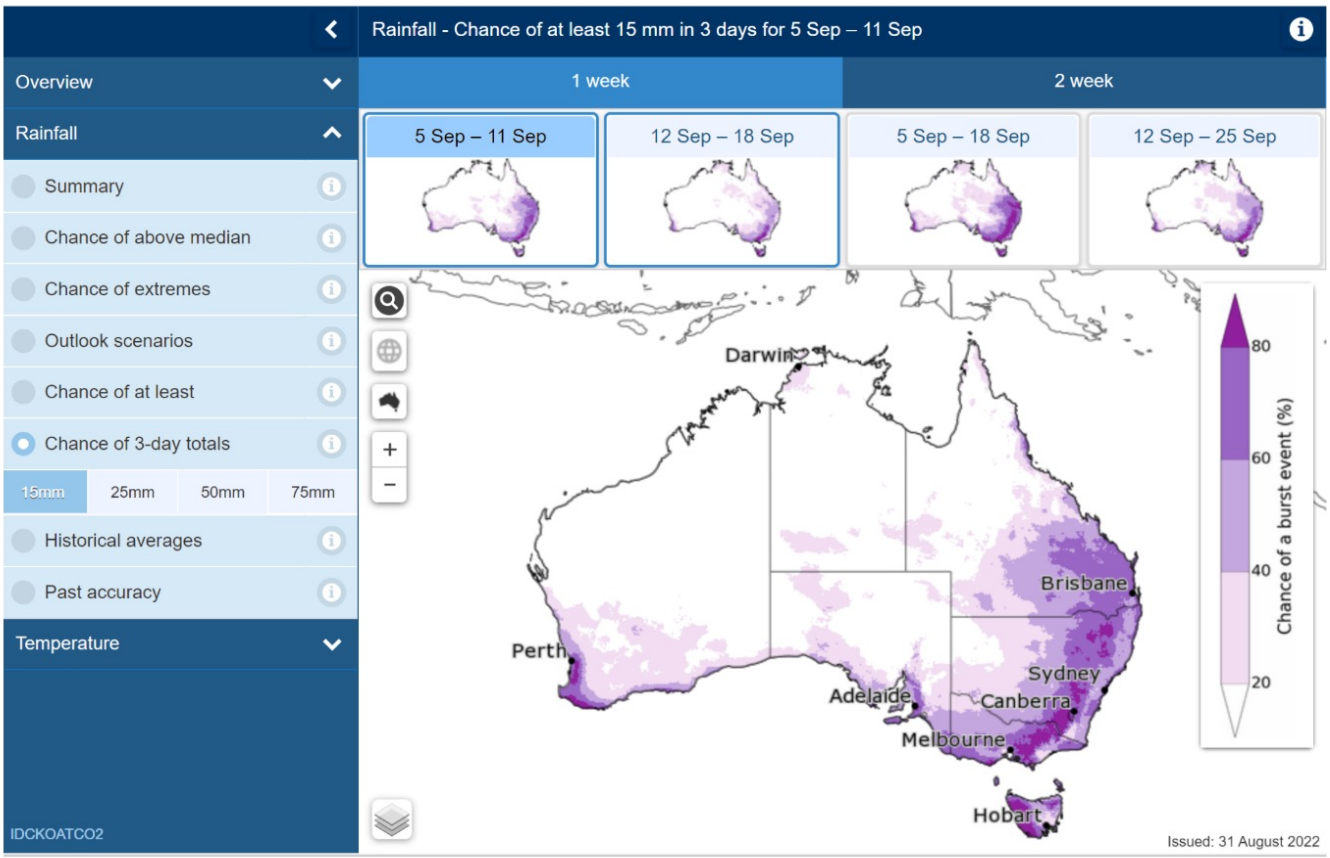



**Figure 6.** Example of the *chance of 3-day totals* tool, showing the chance of a burst event of at least 15mm in three days between 5 Sep and 11 Sep 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

Extreme wet weather can also have impacts on the crop with increased disease pressure. Tactics to manage this risk can include growing resistant varieties, and the use of protective fungicide programs.

The Bureau's timeline graph in combination with the *chance of 3-day totals* tool could indicate the probability of exceeding median rainfall and highlight the chance of the three-day total rainfall exceeding, for example, 50 mm. Being a step ahead of a potential extreme weather event provides the opportunity to complete any upcoming operations on waterlogging-prone paddocks, make any preparations for vulnerable grain, hay or machinery in flood prone storage locations, or move livestock while the farm is still trafficable. Figure 5 and Figure 6 provide an example of what an extreme wet event looks like using the *probability of exceedance* tool (Figure 5) and the *chance of 3-day totals* tool (Figure 6).

Southern grain growers have identified a range of challenges posed by extended wet weather, which are summarised in Table 4, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

### Key messages

- Extended wet weather can present issues for grain farms through operational challenges as well as plant responses such as increased disease.
- Different tactical responses can be implemented at different times of the season if the soil profile is close to full and the likelihood of extreme wet weather is high.

**Table 4.** Summary of challenges and responses associated with extended wet weather relevant to Australia's southern grains industry.

| Potential challenges | Tactical response |
|---|---|
| Waterlogging | Sow water-logging tolerant crops |
| | Timing of nitrogen applications to reduce denitrification |
| | Row orientation to improve drainage |
| | Earlier time of sowing to increase root growth |
| | Aerial spraying or spreading to maintain timely operations |
| Foliar disease problems | Protectant fungicide use |
| | Disease-resistant varieties |
| Minimal spraying days available to complete program | Use of contractors if available, prioritise spraying jobs |
| Tracks and paddock access impacted | Well maintained multiple access points for paddocks |
| Delayed harvest | Grain contract delivery times may need to be adjusted |
| Lack of harvest or sowing resources to hit operational windows | Use of contractors if available |
| | Earlier start date (sowing) or increased labour or shift length to cover more country |
| Grain, hay and machinery storage damaged or stranded | Move grain, hay or machinery to safe ground |
| | Prepare infrastructure (diversions, reinforcements etc) |

# 3.3 Tactical decision making in the southern Australian red meat industry

## Decision making

Decisions are made daily in a farming business. Some decisions relate to the day-to-day operation of the livestock business, such as when to drench ewes, or sell weaners. This is operational decision making. Decisions made for the longer term of the business are strategic decisions and examples include deciding whether to invest in capital items, setting targets (such as return on investment and gross margin targets), and optimising labour use efficiency. Tactical decisions and plans are designed to achieve the longer term strategy, usually with a medium-term view (1 – 12 months). Examples of tactical decisions for a livestock business might include when to shear, lamb or calve, when and what type of supplementary feed to purchase, and how to manage a feed deficit or surplus.

A tactical climate sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the weather. Examples include decisions about stocking rates, feed rations and nitrogen rates on crops and pastures.

Information from FWFA is most relevant to tactical or operational decisions, however, long-term or strategic decision making can be the most cost-effective way to manage extreme events. Examples include planting wind breaks and constructing shade structures for heat events, and fencing off flood-prone areas. Determining the costs and benefits of these decisions requires historical climate data and climate change projections on the frequency and severity of rare events. Historical climate data can be accessed via the Bureau's website: http://www.bom.gov.au/. Under *Our services, Climate and past weather*, the rainfall and temperature records are available under *Rainfall history* and *Temperature history*.

Farmers deal with weather variability daily, influencing their operational decision making. This type of decision making is something we are more familiar (and comfortable) with, than those decisions around less frequent, but more impactful, extreme events. As a part of the FWFA project, the Bureau developed five tools to support short-term and medium-term decision making regarding extreme climate risks. As these tools focus on a seasonal timeframe, they are most suited to supporting on-farm operational and tactical decision making.

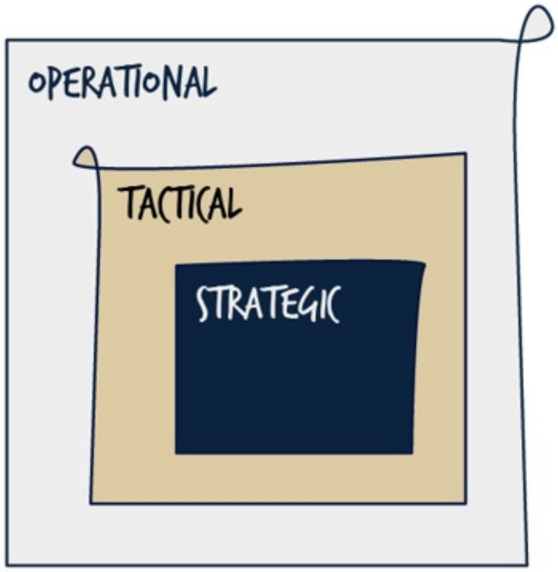



**Figure 1.** The three types of decisions (from Dairy Australia – Our Farm Our Plan)

Before you can use these tools effectively in your livestock business you need to fully understand the operations and assets of your business that can be affected by an extreme event. While we often focus on the risks of these events, it's important to realise they may also create opportunities. Following are some examples of tactical decisions that can potentially mitigate these risks or capitalise on the opportunities. These are not designed to operate in isolation from a whole enterprise risk assessment and management plan, but rather to complement them.

### Key messages

- A tactical climate-sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the climate.
- FWFA tools are best used to support tactical decision-making for managing extreme weather events.

## Key risks

A livestock business' calendar of operations usually considers the seasonality of activities relevant to the location of the farm. Extreme weather events are highly likely to disrupt these operations.

The three extreme events of most concern to southern red meat producers are extended wet periods, extended dry periods (drought), and extreme high temperatures (heatwaves). These can affect pasture and the feedbase, livestock health, infrastructure and operations, cashflow and social wellbeing. Each of these impact areas will be affected to different degrees by extreme events (e.g. extreme wet events are of particular concern during hay season), and may require different tactical responses. Some tactical responses are more relevant in cases when the duration of the extreme event is prolonged.

Extreme events can disrupt business cashflow, irrespective of the industry in which the business operates. Additionally, extreme weather events can have a flow-on effect on commodity prices, with a range of possibilities that may create risks for some businesses and opportunities for other businesses (e.g. if production in one region is impacted by drought, this may drive up prices, meaning regions unaffected by the drought will benefit).

Tools such as farm management deposits or budget contingencies for unforeseen costs can aid a business' financial security. Planning for these allowances can be part of a business' strategic and tactical decision making. Ensuring ways of staying up to date with the availability of industry and government funding for extreme events is another way to manage some of the financial risks. These opportunities may involve funding for improving infrastructure, mitigating impacts of future extreme weather events, or recovery after an extreme event. These funding sources often lag an event or are not immediately accessible and can take time to move through regulatory processes. Such funding should not be relied on, and sound financial management with contingencies should be built into management of the business.

Social wellbeing is another area that can be impacted by extreme events. Mental fatigue from dealing with challenging circumstances, particularly when these events are extended, is not uncommon. Enduring losses or traumatic experiences related to an extreme event can impact mental health and affect relationships. Seeking support early, by being aware of your emotional wellbeing and the wellbeing of people around you, is invaluable.

Extreme events can also cause workplace health and safety issues by affecting conditions in the workplace, including new hazards following extreme conditions. For example, an extreme heat event can impact the livestock and the people who work in such conditions. Tactical responses such as early starts or finishes to the workday can circumvent the need to work during the hottest time of day, reducing the risk of heat stress for people and animals. Other safety issues could involve the location of livestock, and potential escape routes, in case of floods, or bushfire. Having emergency policies and procedures in place, communicated, and understood by all staff can help mitigate risks and keep people and livestock safe from adverse impacts during extreme event.

Understanding the extreme weather events your location and industry are susceptible to, is critical in planning and preparing responses for those extreme events. Establishing thresholds or triggers for your business can provide early warning to implement an extreme weather response ahead of its occurrence, and can potentially mitigate or reduce the impact.

### Key messages

- The extreme events of most concern to the southern red meat industry are extended wet periods, drought, or heatwaves.
- Sound financial management with contingencies should be built into the business.
- Be aware of impacts on mental well-being - seeking support early for yourself or encourage those around you to do likewise.
- Use emergency procedures, communicated to, and understood by, staff, to help keep people safe during an extreme event.
- Be aware of the extreme weather events your location and industry are vulnerable to, and establish triggers or thresholds for response.

## Extended wet weather

Periods of extended wet weather can derail planned activities on the farm, affect livestock wellbeing and disrupt supply chain logistics.

Flooding and soil waterlogging commonly result from an extended wet period. Flooding or waterlogging may occur at farm-level across multiple paddocks for an extended period of time, and/or on a larger scale across a wider region. As such, the range of issues associated with extended wet periods may vary, depending on scale and impact. Hence, the responses to these issues will also need to vary.

The Bureau's timeline graph in combination with the *chance of 3-day totals* tool can be used to get more insight in the probability of exceeding median rainfall and highlight the chance of three-day total rainfall exceeding, for example, a 50 mm rainfall. Being a step ahead of a potential extreme weather event provides the opportunity to move livestock while the farm is still trafficable, organise agistment, or source equipment to sustain the increased logistics to feed out in a sacrifice paddock or stand-off area. Figure 2 and Figure 3 provide an example of what an extreme wet event looks like using the *probability of exceedance* tool (Figure 2) and the *chance of 3-day totals* tool (Figure 3).

One of the primary issues from waterlogged paddocks is the potential for significant impact on pastures. The flow-on effects of waterlogged pastures include reduced feed availability resulting from damaged and reduced pasture growth. Another flow-on impact could be the need for pasture renovation following the extreme event. This may have significant budgetary implications, especially when combined with the costs associated with supplementary feed during the extreme wet event, and if pastures are out of production during renovation.

Examples of potential responses to mitigate these issues include early destocking, by either selling off stock or sourcing agistment in an unaffected area. Destocking would need to occur before larger scale impacts, such as transport logistics breakdown (e.g. if roads and laneways become too wet for trucks to access the property). Short-term lot-feeding in a sacrifice paddock on drier ground could ensure livestock are safe from flood waters, allow better stock monitoring and feed management, and reduce pugging and damage to waterlogged areas. This could have a positive impact on both the livestock and the pasture-base, though it places a greater onus on having reliable equipment and infrastructure to manage the lot-feeding operation.

Southern red meat producers have identified a range of challenges posed by extended wet weather, which are summarised in Table 1, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

### Key messages

- Similar to droughts, extreme wet events can damage the feedbase long-term as well as creating short-term feed gaps due to reduced pasture growth and quality.
- Extreme wet events can also create animal welfare challenges. Floods are one extreme, but ongoing wet weather and wet muddy paddocks can also create animal health issues, particularly for vulnerable animals (e.g. pregnant cows/ewes, sheep off-shear, lambing/calving).
- Knowing extreme wet conditions are ahead can enable early preparations, such as moving animals to drier ground, ensuring supplementary fodder supplies are available or destocking (agistment or sales).

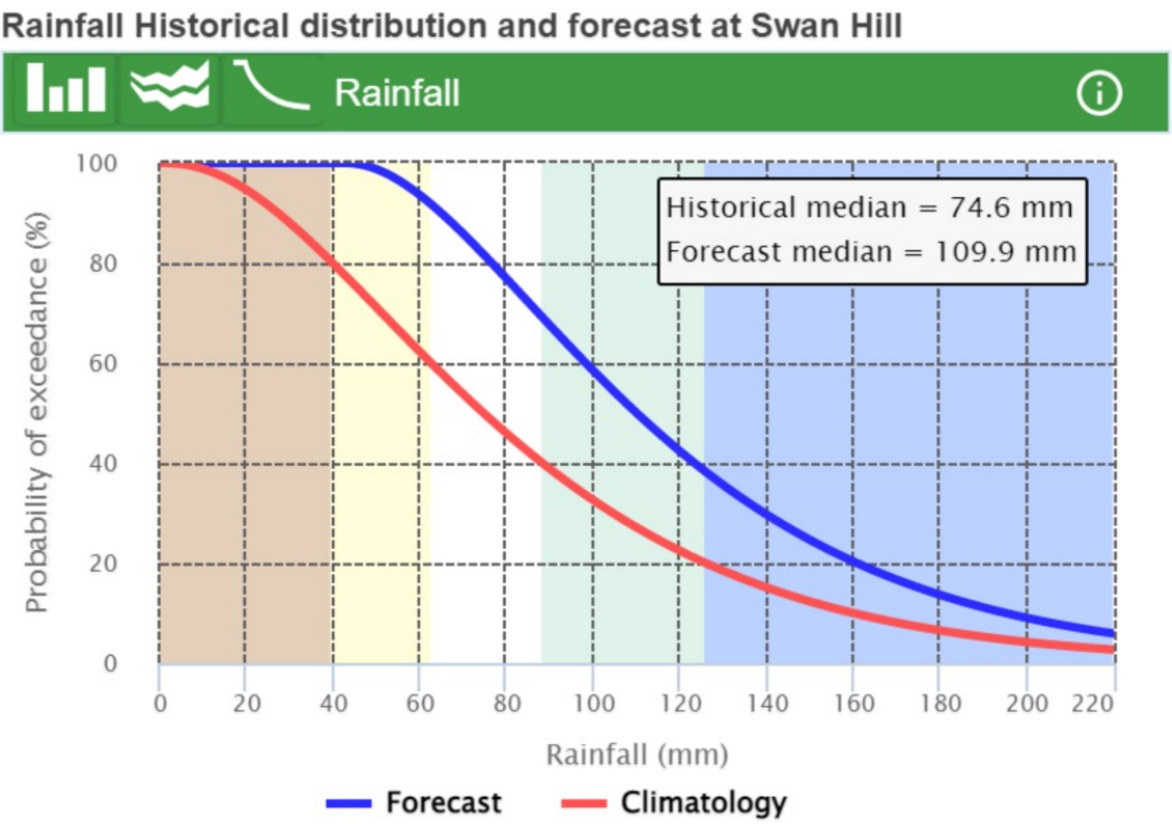



**Figure 2.** Example of the *probability of exceedance* tool, showing an extreme wet outlook for Swan Hill. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

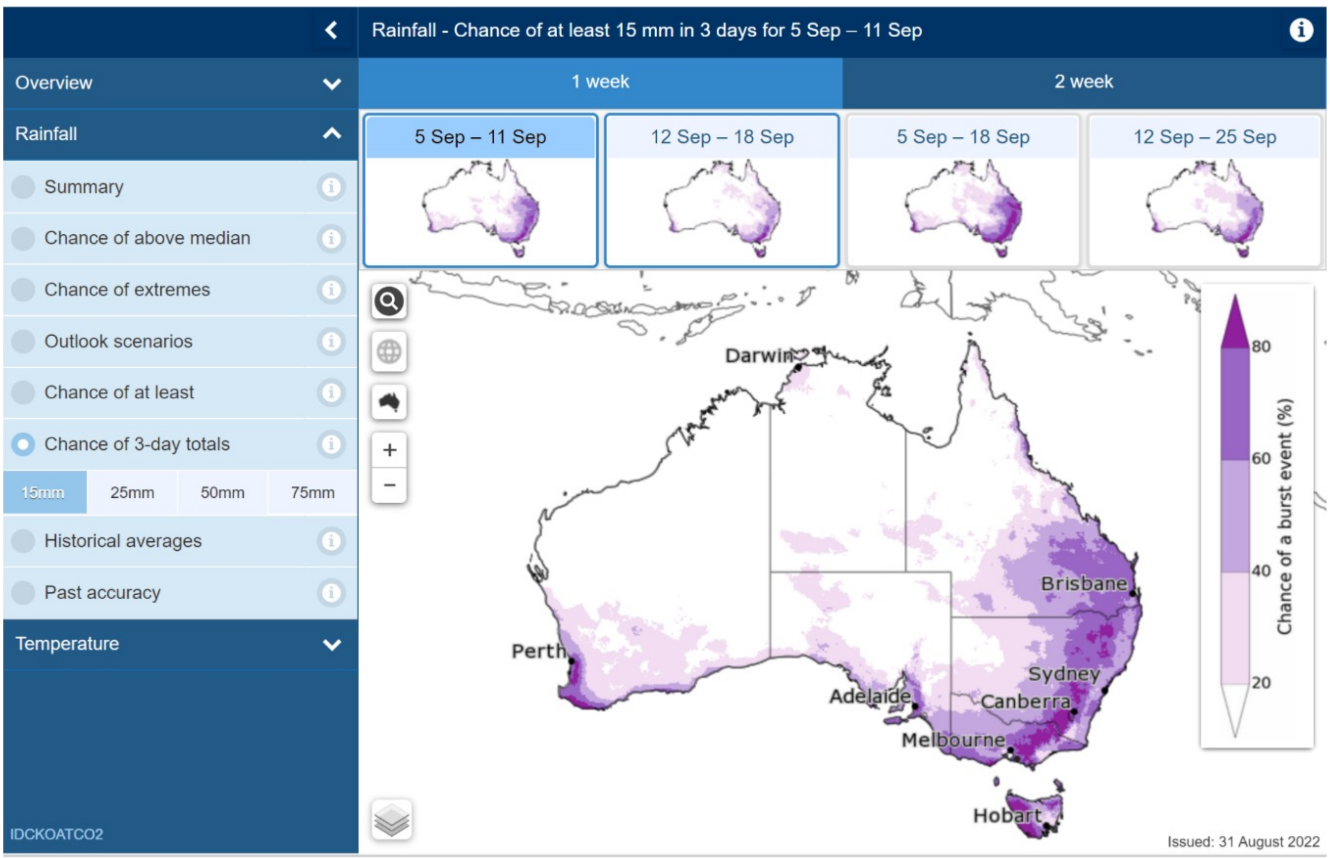



**Figure 3.** Example of the *chance of 3-day totals* tool, showing the chance of a burst event of at least 15mm in three days between 5 Sep and 11 Sep 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 1.** Summary of challenges and responses associated with the impact of periods of extended wet weather relevant to Australia's southern red meat industry.

| Potential challenges | Tactical response |
|---|---|
| Degraded pasture base due to wet conditions | Destocking early (e.g. agistment, sales) |
| | Sacrifice paddocks |
| | Stand-off areas for feeding |
| | Budget for increased pasture renovation costs |
| | Plan grazing rotation to rest paddocks most impacted by wet conditions |
| Feed or fodder deficit, due to reduced pasture growth and/or quality | Planning for supplementary feeding (review fodder on-hand, purchase options) |
| | Destocking early (e.g. agistment, sales) |
| Pugging | Feed around edges of paddocks to reduce walking and pugging |
| | Sacrifice paddocks |
| | Stand-off areas for feeding |
| | Plan grazing rotation to rest paddocks most impacted by wet conditions |
| Calving or lambing in wet conditions | Carefully move stock to sheltered and drier areas if possible |
| Hypothermia (winter) | Monitor animal condition score and health |
| | Ensure access to (natural) shelter |
| | Strategic shearing schedule |
| Increased logistical pressure | Reallocate labour and hire additional casual labour if required |
| Bogged machinery | Stand-off areas for feeding |
| | Stock run on better drained areas |
| Pests and diseases | Monitor animal condition score and health |
| Reduced accessibility | Review grazing rotation and target more accessible areas |
| Stock loss/mortalities | Ensure feed supply meets feed demand (supplementary feed stores sufficient and animals fed to meet their requirements) |
| | Monitor animal condition score and health |
| | Move animals out of flood prone or heavily waterlogged areas early |

## Drought

Periods of extended dry weather, more commonly referred to as droughts, impact availability of resources such as water and feed. Growing seasons can be significantly reduced or absent altogether during periods of drought.

Historical records can help to form a picture of the likely annual and growing season rainfall for a district. Utilise this knowledge to make strategic decisions about the types of enterprises to run or decisions about investing in major infrastructure (e.g. water storage or irrigation, or silos or barns). Considerations such as the frequency with which droughts have occurred in the past, and their duration, can aid strategic decision making and ensure the business' continued viability.

On a different scale, less frequent or shorter droughts can cause considerable challenges for a business. Disruption to water supplies and reduced likelihood of rain is likely to require tactical responses to manage limited water supply. Actions such as finding alternative water sources and managing existing water sources will lessen the risk of fully depleting water supplies, and optimises catchment capacity to make the most of stock water in the event of rain. For example, keeping livestock out of dam water maintains the quality of the water and structure of the containment, prevents animal distress and mortality from bogging in low water mud and protects refill quality.

An unusually dry period has varying impacts depending on the previous seasonal conditions and time of year, therefore risk mitigation responses need to vary accordingly. The *Chance of extremes – unusually dry* tool could indicate the chance of rainfall being in the lowest 20% of the historical range for a specified time (ranging from a week to three months). A dry outlook for spring might prompt a manager to secure supplementary feed early, in anticipation of increased demand during summer. A dry outlook during winter could trigger reassessment of the feed budget and consider agistment in an area with higher expected rainfall, or selling off specific classes of stock. An example of such a dry outlook for late autumn is shown in Figure 4.

Southern red meat producers have identified a range of challenges posed by drought, which are summarised in Table 2, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

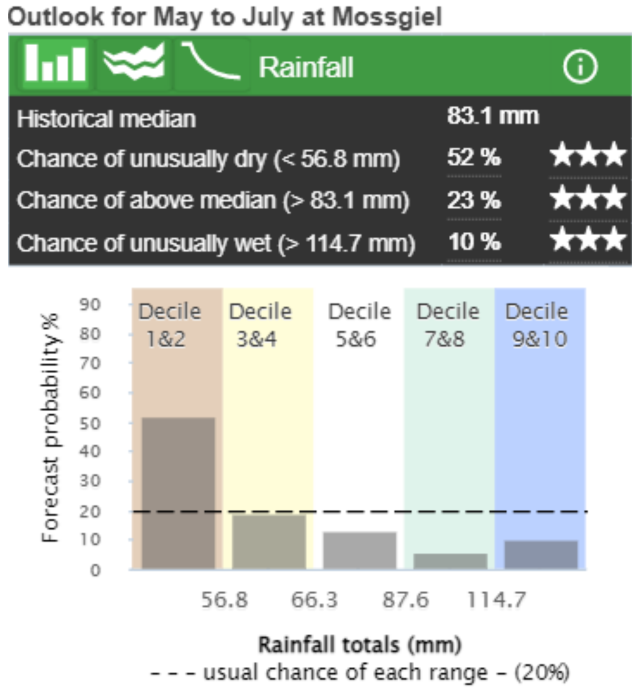



**Figure 4.** Example of the decile bar chart tool, showing the probability of an extreme dry (decile 1&2) event in Mossgiel, NSW. Source: www.bom.gov.au 4/4/2023.

### Key messages

- Droughts can affect the pasture and feed base in different ways depending on the season in which a (prolonged) extreme dry event occurs.
- Droughts can damage the feedbase long-term as well as creating short-term feed gaps due to reduced pasture growth and therefore generally require readdressing of feed budgets.
- Droughts can create animal welfare challenges, particularly for vulnerable animals (e.g. young stock, pregnant cows/ewes, lambing/calving animals), mainly due to inability to meet nutritional requirements.
- Knowing extreme dry conditions are ahead can enable early preparations, such as ensuring supplementary fodder supplies are available or destocking (agistment or sales).

**Table 2.** Summary of challenges, responses and weather forecasting timeframes associated with the impact of drought relevant to Australia's southern red meat industry.

| Potential challenges | Tactical response |
|---|---|
| Degraded pasture base (lack of soil moisture, exacerbated by over-grazing) | Destocking early (e.g. agistment, sales) |
| | Sacrifice paddocks |
| | Containment areas (feed/drought lots) |
| | Budget for increased pasture renovation costs |
| | Plan grazing rotation to optimise paddock rest |
| Feed or fodder deficit | Feed budgeting to estimate feed supply and feed demand |
| | Planning for supplementary feeding (feed stores available and feeding logistics) |
| | Manage competition from feral and native animals |
| | Post drought recovery plan for pastures |
| | Destocking early (e.g. agistment, sales) |
| Reduced water supply | Alternate water source |
| | Monitor and manage water provision proactively |
| Reproductive wastage | Retain (best) breeders |
| | Pregnancy scanning and management of multiples through appropriate feed allocation |
| | Monitor animal condition score and health |
| Stock loss (mortalities) | Destocking early (e.g. agistment, sales) |
| | Monitor animal condition and health |
| | Ensure feed supply meets feed demand (supplementary feed stores sufficient and animals fed to meet their requirements) |

## Heatwaves

Periods of extreme high temperatures, otherwise known as heatwaves, can stress the farm system and underpinning biological systems. In areas of high fuel load, a combination of a prolonged dry event and a heatwave can result in bushfires.

The Bureau's *chance of extremes* maps indicate the chance of temperatures being in the highest 20% of the historical range for a specified time, ranging from a week to three months ahead. Such notice could allow you to prioritise tasks related to water infrastructure to secure water availability, or to muster and relocate stock to areas with more shelter available.

Figure 5 shows an example of what a high chance of an extreme maximum temperature could look like using the *chance of extremes* map for maximum temperature. This example uses a three-month outlook for May to July. A heatwave is defined by the Bureau as an event of three or more days in a row when both daytime and night-time temperatures are unusually high in relation to the local median.

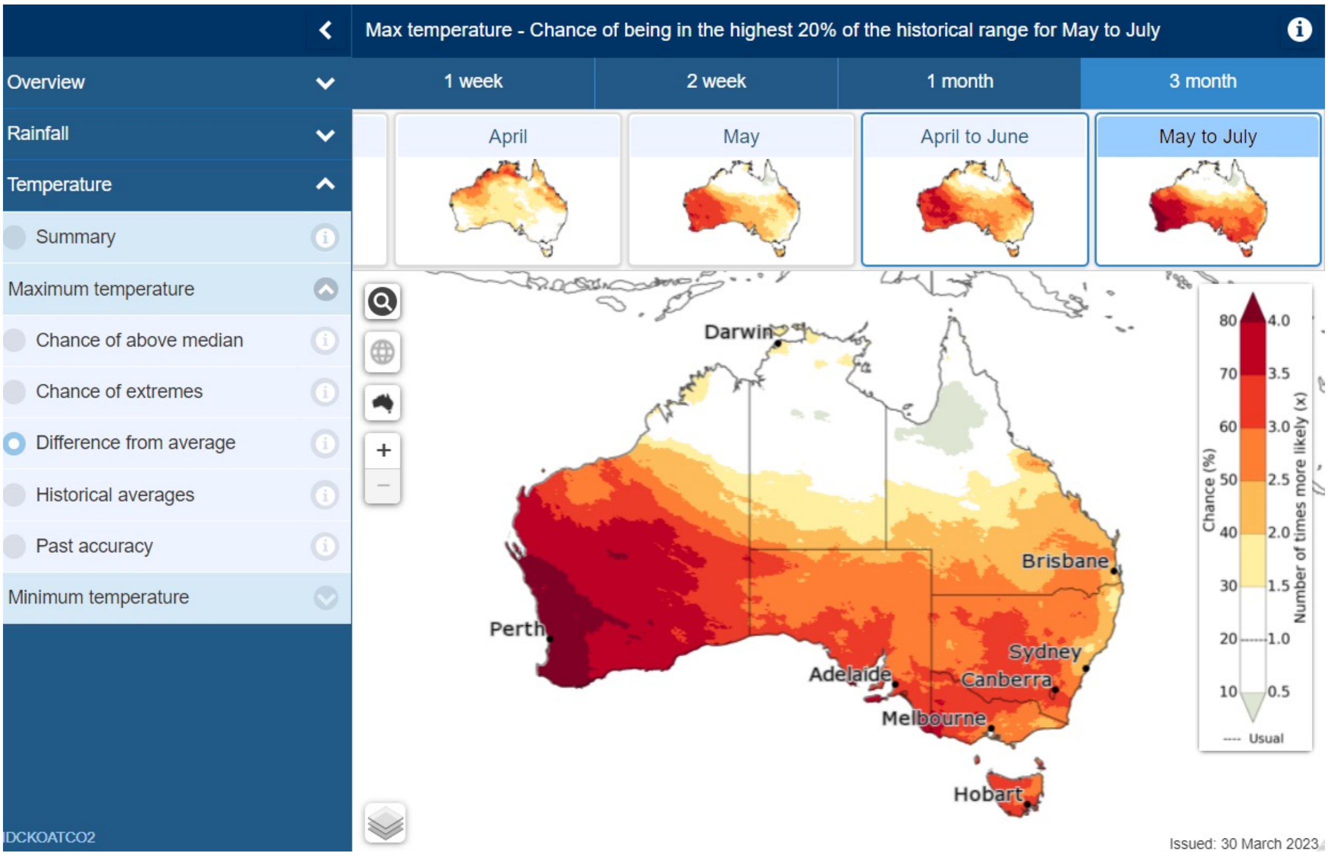



**Figure 5.** Example of the *chance of extremes* map for maximum temperatures in the period between May and July 2023 for Australia. Source: www.bom.gov.au 4/4/2023.

As such, there is no single temperature threshold defined for a heatwave in Australia. Using tools, such as the decile bar charts or timeline graphs, for a location of interest can provide insight into what maximum temperature can be expected and how it compares to the median. The same can be done for minimum temperatures to see if they are also unusually high for the same period of time.

Pasture can be lost following a heatwave by direct radiative burning, dehydration, root burn and death due to hot soils, or from fire damage in the event of a bushfire. Knowing when a heatwave is forecast provides an opportunity to prepare and minimise risk. Livestock are impacted in heatwaves by increased heat stress. Examples of heat wave management for livestock include keeping livestock in areas where shade and water are readily accessible without too much walking required, and ensuring the water supply will keep up with increased demand on hot days.

To protect pasture from heatwave impacts, management could include keeping ample length on pasture to avoid direct heat on the soil and potential for root burn, or choosing pasture species more resilient to heat (i.e. deeper rooted varieties).

Bushfires pose a serious risk to livestock, less to the pasture-base, which is likely to regenerate when conditions improve. Having in place an over-arching bushfire plan, which can be reviewed when heatwaves are forecast, enables livestock locations and escape routes to be identified early. As an additional precautional valuable or vulnerable stock could be relocated early to areas at lower risk (e.g. with low biomass, or close to infrastructure that is likely to be defendable and protected). Establishing fire breaks is also an option with enough notice. Bushfires can promote pasture regeneration and enrich the soil, which both can promote growth of biomass. A reduction in pest pressure and new opportunities for land management can promote recovery. Establishing a post-fire recovery plan can help capture these opportunities.

The overall wellbeing of animals *and* people is at risk during heatwaves. Monitor animals and people exposed to extreme heat for signs of heat stress and act accordingly. For animals, this includes rescheduling planned handling or movement, if practicable. Providing adequate shelter and sufficient water are important, so leverage the Bureau's tools to prioritise repairs and maintenance of shade and water supply infrastructure in a lead-up to a heatwave.

Southern red meat producers have identified a range of challenges posed by heatwaves, which are summarised in Table 3.

**Table 3.** Summary of challenges and responses associated with the impact of heatwaves relevant to Australia's southern red meat industry.

| Potential challenges | Tactical response |
|---|---|
| Death of pasture plants | Plant deeper-rooted pasture species |
| | Standing residual feed in grazing rotation provides some shade for soil |
| | Budget for increased pasture renovation costs |
| | Rotational grazing to enable grazed pastures to recover post-grazing |
| Decline in conception rates | Avoid joining during summer |
| | Provide shade and water in joining paddocks |
| Water supply | Alternative water source |
| | Monitor and manage water provision proactively |
| Heat stress impacting animal health, with risk of stock mortality | Monitor livestock condition and health |
| | Monitor and manage water provision proactively |
| | Reschedule stock handling activities |
| | Ensure access to shade and shelter. |
| Risk of bushfire – stock mortality | Bushfire response plan prepared, updated and ready to go |
| | Move livestock to safer locations |
| | Establish fire breaks in key locations |

## Key messages

- Heatwaves can damage soils and pastures. One of the most effective ways of protecting soils and pasture roots systems is to have adequate ground cover to protect the soil from radiant heat.
- Heat stress can impact animal health and wellbeing. Ensure livestock have easy access to water and shade, and monitor animals.
- There is no single temperature threshold defined for a heatwave in Australia.
- Bushfire is also a risk during heatwave events. Knowing bushfire conditions are likely can enable early preparations, such as ensuring relocating livestock to safer areas or establishing fire breaks.
- Using the decile bar charts and timeline graphs, in addition to the *chance of extremes* map, for both maximum and minimum temperature provides insight into the temperature ranges to be expected. It can give an indication if a heatwave may be on the cards.

# 3.4 Tactical decision making in the dairy industry

## Decision making

Decisions are made daily in a farming business. Some decisions relate to the day-to-day operation of the dairy business, such as when to spread fertiliser or drench the herd. This is operational decision making. Decisions made for the longer term of the business are strategic decisions and examples include deciding whether to invest in capital items, setting targets (such as return on investment and gross margin targets), and optimising labour use efficiency. Tactical decisions and plans are designed to achieve the longer term strategy, usually with a medium-term view (1 – 12 months). Examples of tactical decisions for a dairy business might include how to manage a feed deficit or surplus, rates and timing of fertiliser applications, and selection of pasture species.

A tactical climate sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the weather. Examples include stocking rate, supplementary feeding, changing feed rations for dairy cows, and nitrogen application and rates on crops and pastures.

Information from FWFA is relevant to tactical or operational decisions, however, long-term or strategic decision making can be the most cost-effective way to manage extreme events. Examples include constructing feed pads for wet weather on dairy farms, planting wind breaks, and constructing shade structures for heat events. Determining the costs and benefits of these decisions requires historical climate data and climate change projections on the frequency and severity of rare events. Historical climate data can be accessed via the Bureau's website: http://www.bom.gov.au/. Under *Our services, Climate and past weather*, the rainfall and temperature records are available under *Rainfall history and Temperature history*.

Farmers deal with weather variability daily, influencing their operational decision making. This type of decision making is something we are more familiar (and comfortable) with, than those decisions around less frequent, but more impactful, extreme events. As a part of the FWFA project, the Bureau developed five tools to support short-term and medium-term decision making regarding extreme climate risks.

As these tools focus on a seasonal timeframe, they are most suited to supporting on-farm operational and tactical decision making.

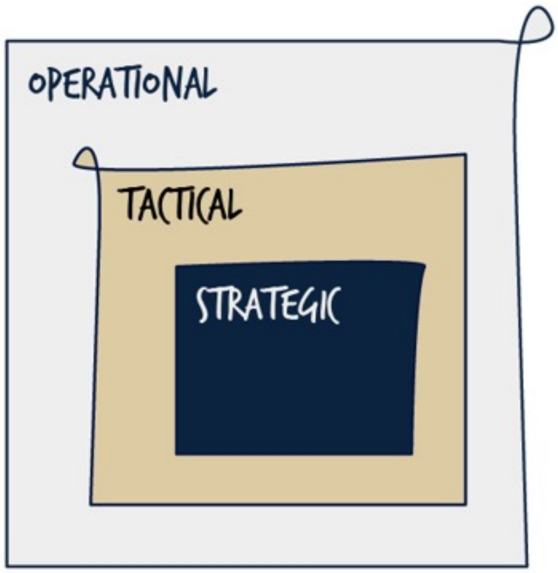



**Figure 1.** The three types of decisions (from Dairy Australia – Our Farm Our Plan)

Before you can use these tools effectively in your dairy business you need to fully understand the operations and assets of your business that can be affected by an extreme event. While we often focus on the risks of these events, it's important to realise they may also create opportunities. Following are some examples of tactical decisions that can potentially mitigate these risks or capitalise on the opportunities. These are not designed to operate in isolation from a whole enterprise risk assessment and management plan, but rather to complement them.

### Key messages

- A tactical climate-sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the climate.
- FWFA tools are best used to support tactical and operational decision-making for managing extreme weather events.

## Key risks

A dairy business' calendar of operations usually considers the seasonality of activities relevant to the location of the farm. Extreme weather events are highly likely to impact operations.

The three extreme events of most concern to dairy producers are extended wet periods, extended dry periods (drought), and extreme high temperatures (heatwaves). These can affect pasture and feedbase, livestock health, infrastructure and operations, cashflow and social wellbeing. Each of these impact areas will be affected to different degrees by extreme events (e.g. extreme wet events are of particular concern during silage season) and may require different tactical responses. Some tactical responses are more relevant in cases when the duration of the extreme event is prolonged.

Extreme events can disrupt business cashflow, irrespective of the industry in which the business operates. Additionally, extreme weather events can have a flow-on effect on commodity prices, with a range of possibilities that may create risks for some businesses and opportunities for other businesses (e.g. if production in one region is impacted by drought, this may drive up prices, meaning regions unaffected by the drought will benefit).

Tools such as farm management deposits or budget contingencies for unforeseen costs can aid a business' financial security. Planning for these allowances can be part of a business' strategic and tactical decision making. Ensuring ways of staying up to date with the availability of industry and government funding for extreme events is another way to manage some of the financial risks. These opportunities may involve funding for improving infrastructure, mitigating impacts of future extreme weather events, or recovery after an extreme event. These funding sources often lag an event or are not immediately accessible and can take time to move through regulatory processes. Such funding should not be relied on, and sound financial management with contingencies should be built into management of the business.

Social wellbeing is another area that can be impacted by extreme events. Mental fatigue from dealing with challenging circumstances, particularly when these events are extended, is not uncommon. Enduring losses or traumatic experiences related to an extreme event can impact mental health and affect relationships. Seeking support early, by being aware of your emotional wellbeing and the wellbeing of people around you, is invaluable.

Extreme events can also cause workplace health and safety issues by affecting conditions in the workplace, including new hazards following extreme conditions. For example, an extreme heat event can impact the livestock and the people who work in such conditions. Tactical responses such as early starts or finishes to the workday can circumvent the need to work during the hottest time of day, reducing the risk of heat stress for people and animals. Other safety issues can involve the accessibility of the dairy and equipment in case of floods, or prolonged wet saturating ground and causing laneway breakdown. Having emergency policies and procedures in place, communicated, and understood by all staff can help mitigate risks and keep people and livestock safe from adverse impacts during extreme event.

Understanding the extreme weather events your location and industry are susceptible to, is critical in planning and preparing responses for those extreme events. Establishing thresholds or triggers for your business can provide early warning to implement an extreme weather response ahead of its occurrence, and can potentially mitigate or reduce the impact.

### Key messages

- The extreme events of most concern to the dairy industry are extended wet periods, extended dry periods (drought) and extreme high temperatures (heatwaves).
- Sound financial management with contingencies should be built into the business.
- Be aware of impacts on mental well-being – seeking support early for yourself or encourage those around you to do likewise.
- Use emergency procedures, communicated to, and understood by, staff, to help keep people safe during an extreme event.
- Be aware of the extreme weather events your location and industry are vulnerable to, and establish triggers or thresholds for response.

## Extended wet

Periods of extended wet weather can derail planned activities on the farm, affect livestock wellbeing and disrupt supply chain logistics.

The Bureau's timeline graph in combination with the *chance of 3-day totals*, can be used to get insight in the probability of exceeding median rainfall and highlight the chance of three-day total rainfall exceeding, for example, a 50 mm rainfall event. Being a step ahead of a potential extreme weather event provides the opportunity to move livestock while the farm is still trafficable, organise agistment, or source suitable equipment to sustain the increased demand and logistics to feed in a sacrifice paddock or stand-off area (such as a feedpad). Figure 2 and Figure 3 provide an example of what an extreme wet event looks like using the *probability of exceedance* tool (Figure 2) and the *chance of 3-day totals* tool (Figure 3).

Flooding and soil waterlogging commonly results from an extended wet period. Flooding/waterlogging may occur at farm-level across multiple paddocks for an extended period of time, or/and on a larger scale across a wider region with major roads disrupted. As such, the range of issues associated with extended wet periods vary, depending on scale and impact. Subsequently, the treatments for/responses to, these issues will also vary.

One of the primary issues of waterlogged paddocks at farm-level is its potentially significant impact on pastures. The flow-on effects of waterlogged pastures include feed gaps resulting from damaged and reduced pasture growth and hence, reduced feed availability. Another flow-on impact could be the need for a significant pasture renovation budget following the extreme event, especially when considered in parallel with costs associated for additional feed due to subsequent reduced pasture availability in the grazing rotation when pastures are renovated.

Examples of potential responses to these issues include early offloading of young stock and dry cows from the milking platform and sacrificing a paddock to feed the milkers. Destocking would need to occur before larger scale impacts such as logistical breakdown when roads and laneways become too wet for trucks to access the property. A sacrifice paddock may be selected to provide safety from flood waters, allow better stock monitoring and feed management, and reduce pugging and damage to waterlogged areas. This could have a positive impact on both the livestock and the pasture-base, though places a greater onus on having reliable equipment and infrastructure.

Dairy producers have identified a range of challenges posed by extended wet weather, which are summarised in Table 1. Tactical responses are listed along with the areas of the business the response relates to. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple impact areas.

### Key messages

- Similar to droughts, extreme wet events can damage the feedbase long-term as well as creating short-term feed gaps due to reduced pasture growth and quality.
- Extreme wet events can also create animal welfare challenges. Floods are one extreme, but ongoing wet weather and wet muddy paddocks can also create animal health issues, particularly for vulnerable animals (e.g. pregnant cows, animals in the hospital mob and calves).
- Knowing extreme wet conditions are ahead can enable early preparations, such as moving animals to drier ground or areas with more shelter, ensuring supplementary fodder supplies are available or destocking (e.g. agisting young and dry stock).

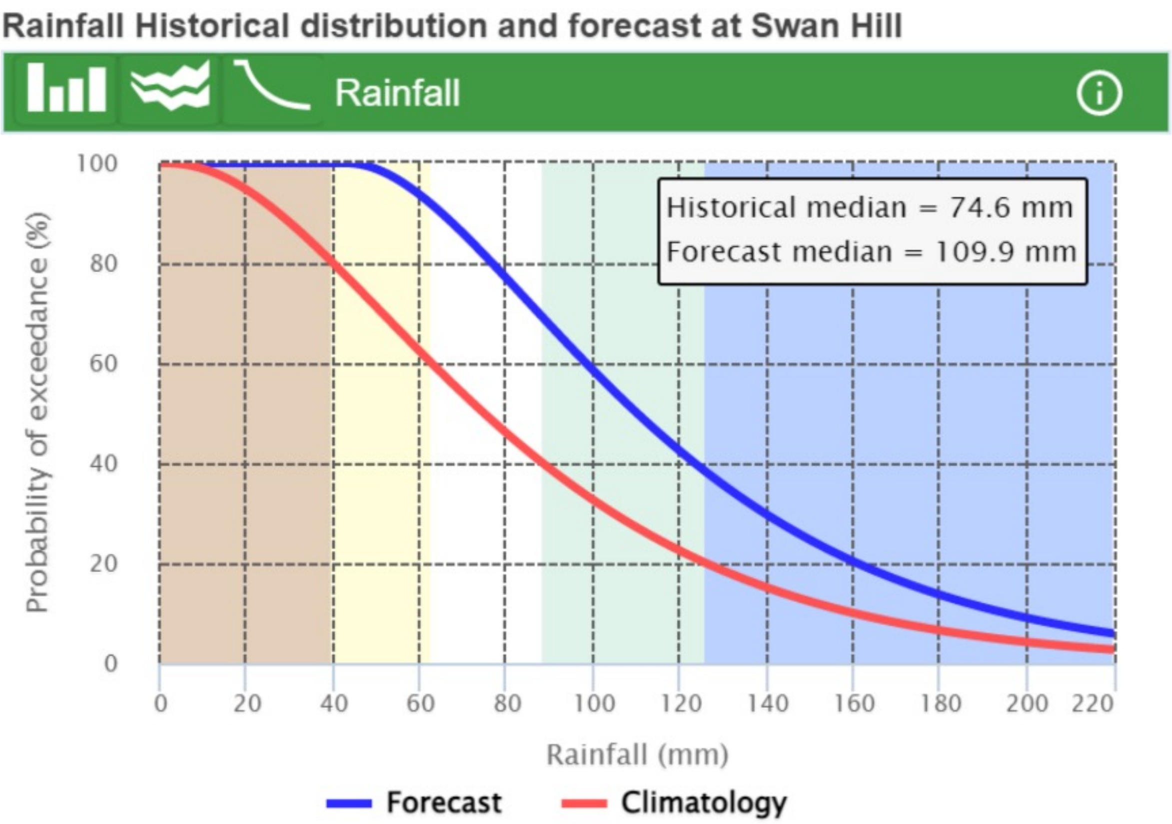



**Figure 2.** Example of the *probability of exceedance* tool, showing an extreme wet outlook for Swan Hill. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

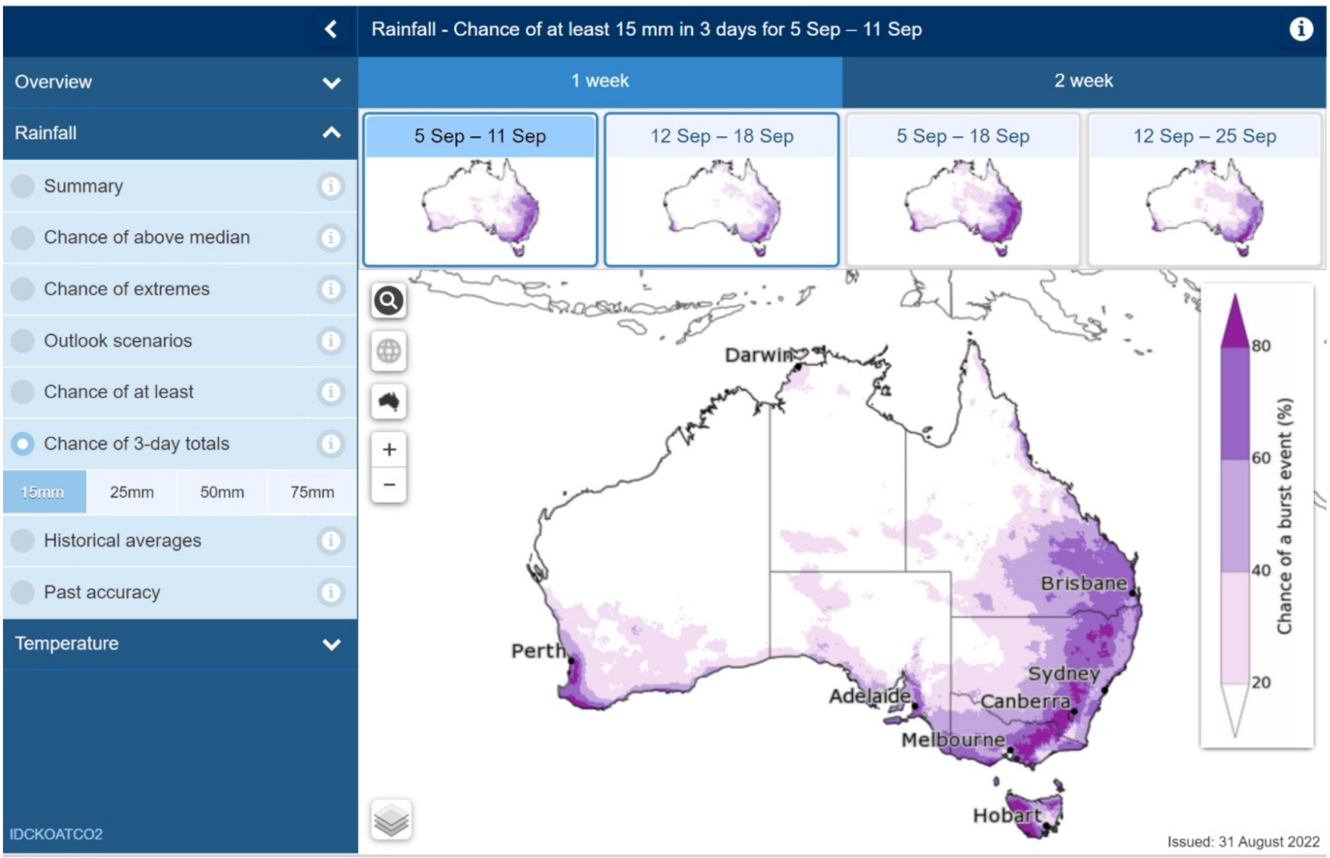



**Figure 3.** Example of the *chance of 3-day totals* tool, showing the chance of a burst event of at least 15 mm in three days between 5 Sep and 11 Sep 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 1.** Summary of challenges and responses associated with the impact of extended wet weather relevant to Australia's dairy industry.

| Potential challenges | Tactical response |
|---|---|
| Degraded pasture base due to wet conditions | Destocking early (e.g. agistment, sales) |
| | Sacrifice paddocks |
| | Stand-off areas for feeding |
| | Budget for increased pasture renovation costs |
| | Plan grazing rotation to rest paddocks most impacted by wet conditions |
| Feed or fodder deficit, due to reduced pasture growth and/or quality | Planning for supplementary feeding (review fodder on-hand, purchase options) |
| | Destocking early (e.g. agistment, sales) |
| Pugging | Feed around edges of paddocks to reduce walking and pugging |
| | Sacrifice paddocks |
| | Stand-off areas for feeding |
| | Plan grazing rotation to rest paddocks most impacted by wet conditions |
| Calving in wet conditions | Carefully move stock to sheltered and drier areas if possible |
| | Stand-off areas for calving |
| Hypothermia (winter) | Monitor animal condition and health |
| | Ensure access to shelter |
| Increased logistical pressure | Reallocate labour and hire additional casual labour if required |
| Bogged machinery | Stand-off areas for feeding |
| Pests and diseases | Monitor animal condition and health |
| Reduced accessibility | Review grazing rotation and target more accessible areas |
| | Stand-off areas for feeding |
| Stock loss/ mortalities | Ensure feed supply meets feed demand (supplementary feed stores sufficient and animals fed to meet their requirements) |
| | Monitor animal condition score and health |
| | Move animals out of flood prone or heavily waterlogged areas early |

## Drought

Periods of extended dry weather, more commonly referred to as droughts, impact availability of resources such as water and feed. Growing seasons can be significantly reduced or absent altogether during periods of drought.

Historical records can help to form a picture of the likely annual and growing season rainfall for a district. Utilise this knowledge to make strategic decisions about the types of enterprises to run or decisions about investing in major infrastructure (e.g. water storage or irrigation, or silos or barns). Considerations such as the frequency with which droughts have occurred in the past, and their duration, can aid strategic decision making and ensure the business' continued viability.

On a different scale, less frequent or shorter droughts can cause considerable challenges for a business. Disruption to water supplies and reduced likelihood of drought-breaking weather requires tactical responses to manage limited water supply on the farm. Actions such as finding alternative water sources and managing existing water sources will lessen the risk of fully depleting water supplies and optimises catchment capacity to make the most of water stock in the event a drought-breaking rain when it finally occurs. For example, keeping livestock out of dam water maintains the quality of the residual and structure of the containment, prevents animal distress and mortality from bogging in low water mud and protects refill quality.

An unusually dry period has varying impacts depending on the season and risk mitigation responses will vary accordingly. The *Chance of extremes – Unusually dry* tool could indicate the chance of rainfall being in the lowest 20% of the historical range for a specified time, ranging from a week to three months. So a dry outlook for spring might prompt a manager to secure supplementary feed early, in anticipation of increased demand over a dry spring and a potentially low-yielding harvest of silage and/or hay on farm. A dry outlook during autumn and winter might prompt reassessment of the feed budget and subsequent decisions on grazing rotations and plans to build a feed wedge over winter. An example of such a dry outlook for late autumn is shown in Figure 4 using the decile bar chart tool.

Dairy producers identified a range of challenges regarding the impact of drought, as summarised in Table 2.

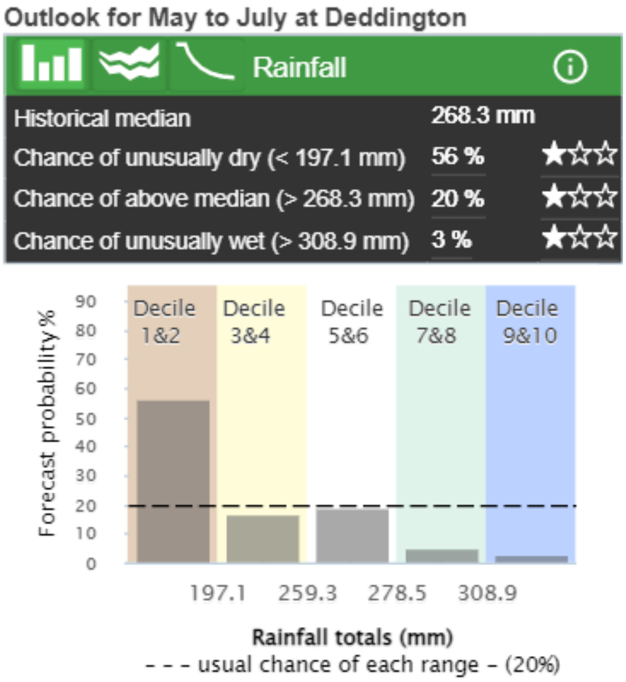



**Figure 4.** Example of the decile bar chart tool, showing the probability of an extreme dry (decile 1 & 2) event in Deddington, Tasmania. Source: www.bom.gov.au 4/4/2023.

### Key messages

- Droughts can affect the pasture and feed base in different ways depending on the season in which a (prolonged) extreme dry event occurs.
- Droughts can damage the feedbase long-term as well as creating short-term feed gaps due to reduced pasture growth and therefore generally require readdressing of feed budgets.
- Droughts can create animal welfare challenges, particularly for vulnerable animals (e.g. young stock, pregnant cows/ewes, lambing/calving animals), mainly due to inability to meet nutritional requirements.
- Knowing extreme dry conditions are ahead can enable early preparations, such as ensuring supplementary fodder supplies are available, drying off early or destocking (e.g. agistment of young and dry stock or sales).

**Table 2.** Summary of challenges and responses associated with the impact of drought relevant to Australia's dairy industry.

| Potential challenges | Tactical response |
| --- | --- |
| Degraded pasture base (lack of soil moisture, exacerbated by over-grazing) | Destocking early (e.g. agistment, sales) |
| | Sacrifice paddocks |
| | Stand-off areas for feeding |
| | Budget for increased pasture renovation costs |
| | Plan grazing rotation to optimise paddock rest |
| Feed or fodder deficit | Planning for supplementary feeding (feed stores available and feeding logistics) |
| | Manage competition from feral and native animals |
| | Post drought recovery plan for pastures |
| | Drying off early |
| Reduced water supply | Alternate water source |
| | Monitor and manage water provision proactively |
| Reproductive wastage | Retain (best) breeders |
| | Drying off early to manage energy demand for foetus, maintenance and growth (if first or second calver) instead of milk |
| Stock loss (mortalities) | Destocking early (e.g. agistment, sales) |
| | Monitor animal condition and health |

## Heatwaves

Periods of extreme high temperatures, otherwise known as heatwaves, can stress the farm management system and the underpinning biological systems. In areas of high fuel load, a combination of a prolonged dry event and a heatwave can lead to severe bushfires.

The Bureau's *chance of extremes* maps indicate the chance of temperatures being in the highest 20% of the historical range for a specified time, ranging from a week to three months ahead. Such notice could allow for prioritisation of tasks related to preparing the dairy yard, sheds or water infrastructure. Installing or repairing dairy yard sprinklers or prioritising maintenance works on the water infrastructure to allow for higher water flow and more secure water supply are examples of tasks that can be performed in anticipation of a forecasted heatwave.

Figure 5 shows an example of what a high chance of an extreme maximum temperature could look like using the *chance of extremes* map for maximum temperature. This example uses a three-month outlook for May to July. A heatwave is defined by the Bureau as an event of three or more days in a row when both daytime and night-time temperatures are unusually high in relation to the local median.

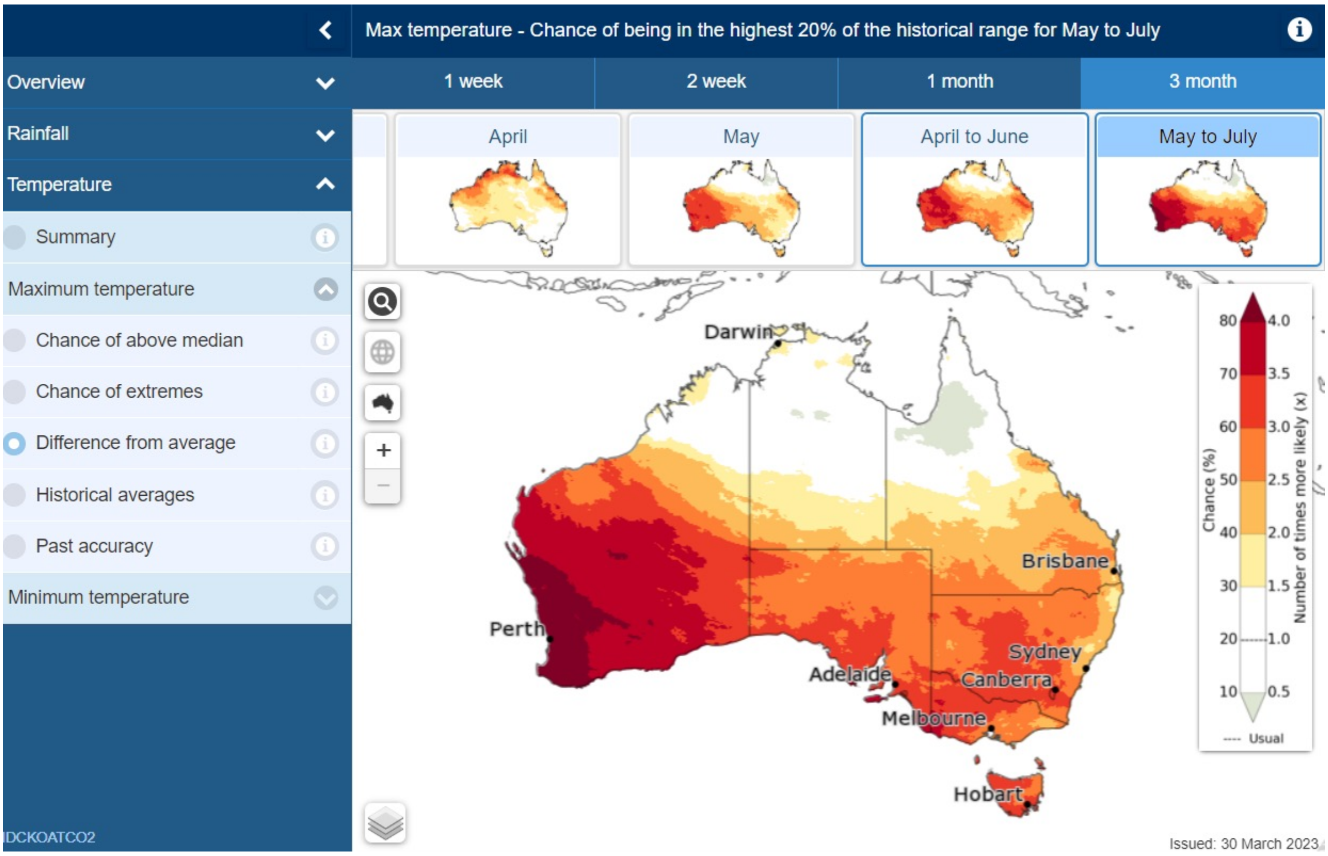



**Figure 5.** Example of the *chance of extremes* map for maximum temperatures in the period between May and July 2023 for Australia. Source: www.bom.gov.au 4/4/2023.

As such, there is no single temperature threshold defined for a heatwave in Australia. Using tools, such as the decile bar charts or timeline graphs, for a location of interest can provide insight into what maximum temperature can be expected and how it compares to the median. The same can be done for minimum temperatures to see if they are also unusually high for the same period of time.

Pasture can be lost following a heatwave by direct radiative burning, dehydration, root burn and death due to hot soils and/or from fire damage. Knowing when a heatwave is forecast provides an opportunity to prepare and minimise risk. Dairy livestock are doubly impacted in heatwaves by increased body heat and decreased milk production when they are unable to reduce their heat load (heat stress). Examples of heat wave treatments for livestock include keeping the milkers closer to the dairy, adjustment of milking times and moving the herd away from the hottest parts of the day, and keeping livestock in areas where shade and water are readily accessible without too much walking required. Pasture responses includes keeping ample length on pasture to avoid root burn and hot soil, choosing pasture species more resilient to heat (i.e. deeper rooted varieties) establishing fire breaks and planned cool burns.

Bushfires pose a serious risk to livestock, less to the pasture-base, which is likely to regenerate when conditions improve. Having in place an over-arching bushfire plan, which can be reviewed when heatwaves are forecast, enables livestock locations and escape routes to be identified early. As an additional precautional valuable or vulnerable stock could be relocated early to areas at lower risk (e.g. with low biomass, irrigated paddocks or close to infrastructure that is likely to be defendable and protected). Establishing fire breaks is also an option with enough notice. Bushfires can promote pasture regeneration and enrich the soil, which both can promote growth of biomass. A reduction in pest pressure and new opportunities for land management can promote recovery. Establishing a post-fire recovery plan can help capture these opportunities.

The overall wellbeing of animals and people is at risk during heat waves. Monitor animals and people exposed to extreme heat for signs of heat stress and act accordingly. For animals, this includes rescheduling planned handling or movement, if practicable. Providing adequate shelter and sufficient water are important, so leverage the Bureau's tools to prioritise repairs and maintenance of shade and water supply infrastructure in a lead-up to a heatwave.

Challenges associated with heatwaves, as identified by dairy producers, are summarised in Table 3.

**Table 3.** Summary of challenges and responses associated with the impact of heatwaves relevant to Australia's dairy industry.

| Potential challenges | Tactical response |
|---|---|
| Loss of pasture | Plant deeper rooted pasture species |
| | Sacrifice paddocks |
| | Stand-off areas for feeding |
| | Budget for increased pasture renovation costs |
| | Post-fire recovery plan for pastures |
| Heat stress | Shift stock handling times |
| | Ensure shade/shelter access |
| | Monitor livestock condition |
| Decline in conception rates | Avoid joining over summer |
| Water supply | Alternate water source |
| | Monitor and manage water provision proactively |
| Stock loss/mortalities | Monitor livestock condition |
| | Monitor and manage water provision proactively |

## Key messages

- Heatwaves can damage soils and pastures. One of the most effective ways of protecting soils and pasture roots systems is to have adequate ground cover to protect the soil from radiant heat.
- Heatwaves can create animal welfare challenges. Having insight in the probability of higher than usual temperatures can allow proactive prioritisation in ensuring animal welfare can be ensured should a heatwave occur.
- There is no single temperature threshold defined for a heatwave in Australia.
- Bushfire is also a risk during heatwave events. Knowing bushfire conditions are likely can enable early preparations, such as ensuring relocating livestock to safer areas or establishing fire breaks.
- Using the decile bar charts and timeline graphs in addition to the *chance of extremes* map for both maximum and minimum temperature provide insight in the temperature ranges to be expected. It can give an indication if a heatwave may be on the cards.

# 3.5 Tactical decision making in the wine industry

## Decision making

Decisions are made daily in a farming business. Some decisions relate to the day-to-day operation of the wine business, such as prioritising spraying jobs, or when to apply fertiliser. This is operational decision making. Decisions made for the longer term of the business are strategic decisions and examples include deciding whether to invest in capital items, setting targets (such as return on investment and gross margin targets), and optimising labour use efficiency. Tactical decisions and plans are designed to achieve the longer term strategy, usually with a medium-term view (1 – 12 months). Examples of tactical decisions for a wine business might include planning crop protection for the weeks ahead, whether to crop thin, minimising frost risk through vineyard practices or scheduling of harvest around grape maturity.

A tactical climate sensitive decision is one where the time frame is within the season and the ideal decision depends on the weather. Examples include timing a disease protection spray during flowering, irrigation and the timing of harvest to avoid a rain event.

Information from FWFA is most relevant to tactical or operational decisions, however, long-term or strategic decision making can be the most cost-effective way to manage extreme events. Examples include planting wind breaks, installing overhead irrigation for frost protection, changing interrow species for improving water infiltration and retention, switching to more heat tolerant wine grape varieties and/or changing row orientation. Determining the costs and benefits of these decisions requires historical climate data and climate change projections on the frequency and severity of rare events. Historical climate data can be accessed via the Bureau's website: http://www.bom.gov.au/. Under *Our services, Climate and past weather*, the rainfall and temperature records are available under *Rainfall history* and *Temperature history*.

Farmers deal with weather variability daily, influencing their operational decision making. This type of decision making is something we are more familiar (and comfortable) with, than those decisions around less frequent, but more impactful, extreme events. As a part of the FWFA project, the Bureau developed five tools to support short-term and medium-term decision making regarding extreme climate risks. As these tools focus on a seasonal timeframe, they are most suited to supporting on-farm operational and tactical decision making.

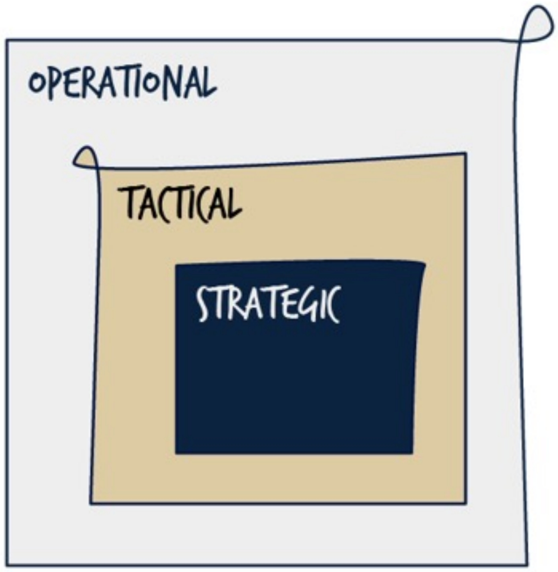



**Figure 1.** The three types of decisions (from Dairy Australia – Our Farm Our Plan)

Before you can use these tools effectively in your wine business you need to fully understand the operations and assets of your business that can be affected by an extreme event. While we often focus on the risks of these events, it's important to realise they may also create opportunities. Following are some examples of tactical decisions that can potentially mitigate these risks or capitalise on the opportunities. These are not designed to operate in isolation from a whole enterprise risk assessment and management plan, but rather to complement them.

### Key messages

- A tactical climate-sensitive decision is one where the time frame is within the season *and* the ideal decision depends on the climate.
- FWFA tools are best used to support tactical and operational decision-making for managing extreme weather events.

## Key risks

A wine business' calendar of operations usually considers the seasonality of activities relevant to the location of the farm. Extreme weather events are highly likely to disrupt these operations.

The four extreme events of most concern to wine producers are extended wet periods, extended dry periods (drought), extreme high temperatures (heatwaves) and extreme low temperatures (frost). These can affect grape yield and quality, soil condition, infrastructure and operations, cashflow and social wellbeing. Each of these impact areas can be impacted differently by extreme events (e.g. extreme wet events are of particular concern during flowering or harvest), and may require different tactical responses. Some tactical responses are more relevant in cases when the duration of the extreme event is prolonged.

Extreme events can disrupt business cashflow, irrespective of the industry in which the business operates. Additionally, extreme weather events can have a flow-on effect on commodity prices, with a range of possibilities that may create risks for some businesses and opportunities for other businesses (e.g. if production in one region is impacted by drought, this may drive up prices, meaning regions unaffected by the drought will benefit).

Tools such as farm management deposits or budget contingencies for unforeseen costs can aid a business' financial security. Planning for these allowances can be part of a business' strategic and tactical decision making. Ensuring ways of staying up to date with the availability of industry and government funding for extreme events is another way to manage some of the financial risks. These opportunities may involve funding for improving infrastructure, mitigating impacts of future extreme weather events, or recovery after an extreme event. These funding sources often lag an event or are not immediately accessible and can take time to move through regulatory processes. Such funding should not be relied on, and sound financial management with contingencies should be built into management of the business.

Social wellbeing is another area that can be impacted by extreme events. Mental fatigue from dealing with challenging circumstances, particularly when these events are extended, is not uncommon. Enduring losses or traumatic experiences related to an extreme event can impact mental health and affect relationships. Seeking support early, by being aware of your emotional wellbeing and the wellbeing of people around you, is invaluable.

Extreme events can also cause workplace health and safety issues by affecting conditions in the workplace, including new hazards following extreme conditions. For example, an extreme heat event can impact the people who work in such conditions. Tactical responses such as early starts or finishes to the workday can circumvent the need to work during the hottest time of day, reducing the risk of heat stress. On a vineyard, extreme weather relating to bushfire risk can also influence work practices with some tasks, such as the slashing of midrow grass in the summer, not able to safely continue under extremely hot conditions. Other safety issues can involve the accessibility of sheds, equipment and vineyards in case of floods following an extreme wet event. Having emergency policies and procedures in place, communicated, and understood by all staff can help mitigate risks and keep people safe from adverse impacts during extreme event.

Understanding the extreme weather events your location and industry are susceptible to, is critical in planning and preparing responses for those extreme events. Establishing thresholds or triggers for your business can provide early warning to implement an extreme weather response ahead of its occurrence, and can potentially mitigate or reduce the impact.

### Key messages

- The extreme events of most concern to the wine industry are extended wet periods, extended dry periods (drought), extreme high temperatures (heatwaves), extreme cold temperatures (frost).
- Sound financial management with contingencies should be built into the business.
- Be aware of impacts on mental well-being - seeking support early for yourself or encourage those around you to do likewise.
- Use emergency procedures, communicated to, and understood by, staff, to help keep people safe during an extreme event.
- Be aware of the extreme weather events your location and industry are vulnerable to, and establish triggers or thresholds for response.

## Extended wet

Periods of extended wet weather can derail intake scheduling between the vineyard and the winery and affect grape yield and quality. A common extreme event resulting from an extended wet period is a disease outbreak.

Multi-week rainfall forecasts will influence decision making including planning crop protection for the weeks ahead. Extended wet weather, when combined with warm weather, presents very challenging conditions for managing diseases in the vineyard as grape yield, berry and wine quality can all be severely affected.

Botrytis rot is a weather-driven disease that can cause significant loss of grape yield and quality, even after application of a full program of fungicides. Botrytis spores are almost always present in vineyards. Infection can be initiated from spores carried over from the previous season, in sources such as cane debris, bunch remnants, tendrils, leaf petioles and leaf blades. These spores spread in air currents, by rain splash and by insect carriers. Rain that causes berries to split often leads to direct infection of ripening berries. The key weather variables are temperature and the duration of surface wetness, provided by rain, fog, dew or mist. Free water is needed for the spore to germinate and high relative humidity may be sufficient to cause condensation of water inside tissues such as flowers. Temperature determines how fast infection occurs, with the optimum temperature in the range 18–21°C. Longer wetness periods are needed to achieve the same level of infection at sub-optimum temperatures.

Downy mildew is also driven by the weather. The disease can devastate individual vineyards and, in some seasons, affect production from entire regions. Downy mildew needs the combination of warmth and rainfall. Periods of high risk from downy can be determined by monitoring the vineyard microclimate for factors such as temperature, rainfall, relative humidity (RH) and leaf wetness.

Flooding can occur at the vineyard-level with multiple blocks getting waterlogged for an extended period. This is a different scale from when flooding occurs in the wider region with major roads being affected and major infrastructure disrupted. As such, the range of issues associated with extended wet periods can vary based on scale and impact. Subsequently, the variety of responses to these issues can vary by scale and impact, too.

At the vineyard-level, one of the primary issues of waterlogged blocks is the effect on vines. Flow-on effects from the affected vines is reduced yield and quality. Flooding may be caused by heavy localised rains, flood waters slowly flowing across the landscape or a combination of both. Whatever the cause, the duration and timing of flooding are important to consider. Flooding of well-drained soil types, where water disappears in one or two days, usually has little impact on vine growth. Where flood water is slow to recede, either due to soil type or the volume of water, some issues may arise. When soil becomes waterlogged, it becomes anaerobic as air is forced out from pores in the soil. Roots need air to function, and waterlogged roots will die over a period of time. Often there is a need to continue with crop protection sprays, and each tractor pass over the waterlogged area will compact the soil adjacent to the vines. Previous short-term flood events have shown that vines are resilient, and can return to production in the following season without significant side-effects. However prolonged flooding can result in vine decline and death.

The Bureau's timeline graph in combination with the *chance of 3-day totals* can be used to indicate the probability of exceeding median rainfall and highlight the chance of three-day total rainfall exceeding, for example, a 50 mm rainfall. Being a step ahead of a potential extreme weather event provides the opportunity to apply sprays to protect against disease, modify grape turgor through spray applications or irrigation, or to harvest early to avoid the rain. Figure 2 and Figure 3 provide an example of what an extreme wet event looks like using the *probability of exceedance* tool (Figure 2) and the *chance of 3-day totals* tool (Figure 3).

Wine producers have identified a range of challenges posed by extended wet weather, which are summarised in Table 1. Tactical responses are listed as suggestions and an overview of the range of impact of these responses is identified. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple impact areas.

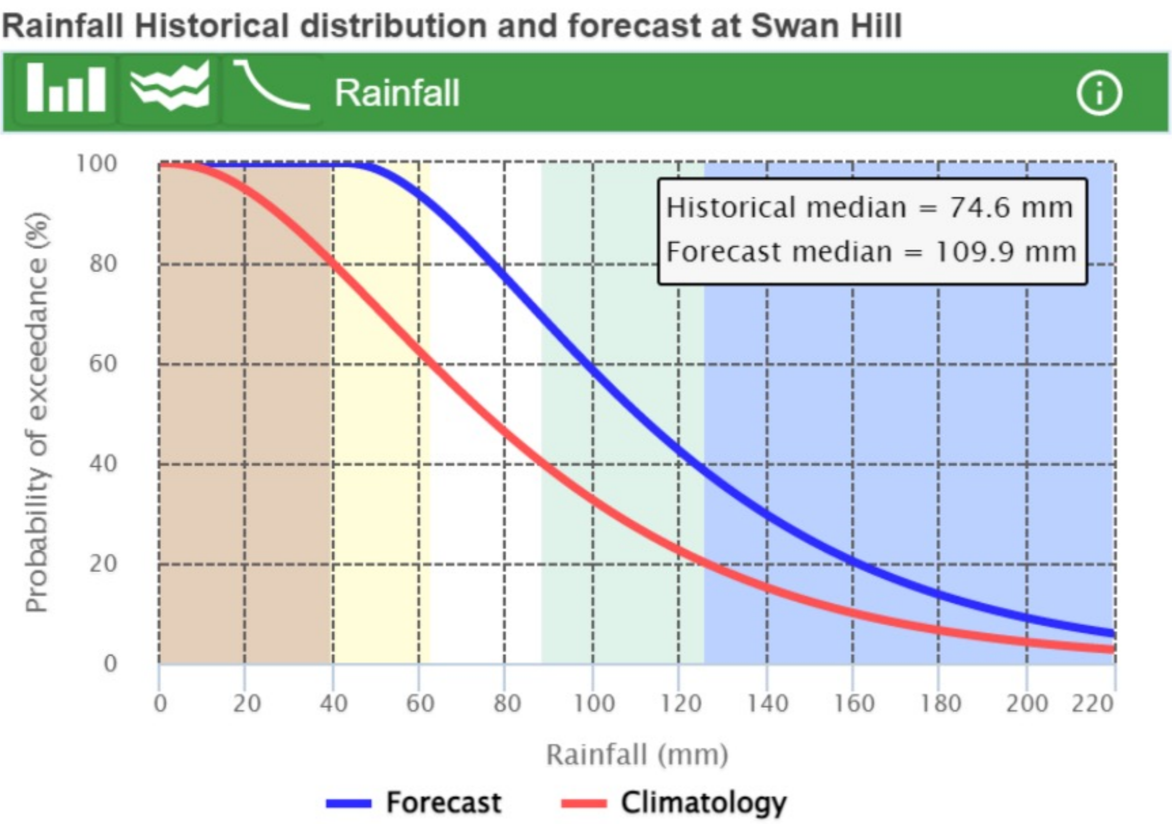



**Figure 2.** Example of the *probability of exceedance* tool, showing an extreme wet outlook. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

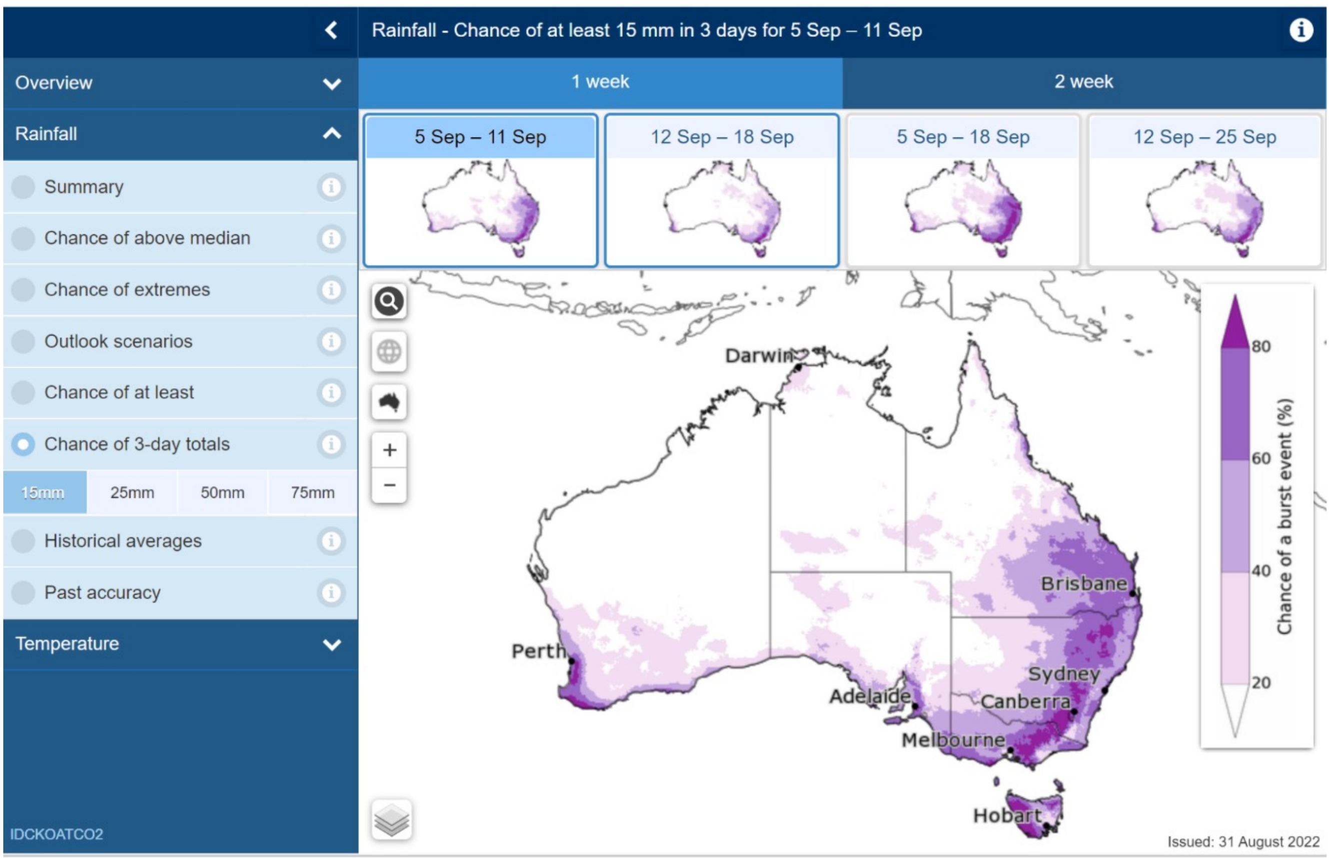



**Figure 3.** Example of the *chance of 3-day totals* tool, showing the chance of a burst event of at least 15mm in three days between 5 Sep and 11 Sep 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 1.** Summary of challenges and responses associated with the impact of periods of extended wet weather relevant to Australia's wine industry.

| Potential challenges | Tactical response |
|---|---|
| Increased disease pressure | Apply fungicide sprays |
| | Canopy management to improve airflow |
| Split berries | Apply preventative sprays and irrigate, harvest early |
| Wheel ruts from vehicles | Reduce vehicle access |
| Increased logistical pressure | Planning intake scheduling |
| Bogged machinery | Consider aerial spraying for crop protection |

## Key messages

- Extended wet weather can present issues for vineyards through operational challenges as well as vine responses such as increased disease.
- Different tactical responses can be implemented at different times of the season if the soil profile is close to full and the likelihood of extreme wet weather is high.
- When wet weather coincides with harvest, it might be possible to harvest early to prevent berry splitting.

## Extended dry weather

Periods of extended dry weather, more commonly referred to as droughts, often involves the limited availability of water resources. Generally, water availability is reduced, the cost of water increases and the vine growing season can be shortened due to drought.

The Bureau's decile bar chart tool can be used to indicate the probability of an unusual dry event and presents an opportunity for wine producers to create a water management plan and associated water budget to set them up for the season ahead. A successful water management plan provides information about current and projected water use and water security (availability, quality and costs). It also provides information about where water use efficiency improvements can be made to help growers prioritise and allocate funding to the activities. Being a step ahead of a potential event gives the opportunity to be prepared and make the most of a challenging situation. An example of what an unusually dry event can look like using the Bureau's decile bar chart tool is shown in Figure 4.

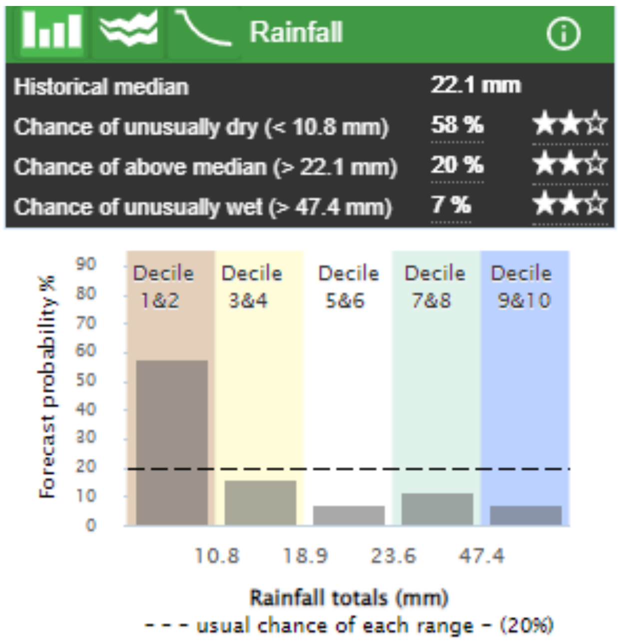



**Figure 4.** Example of the decile bar chart tool, showing the probability of an extreme dry (decile 1&2) event. Reproduced from www.bom.gov.au.

The severity of impacts that drought conditions have on grapevines depends on a number of factors that are specific to individual vineyards. Some of the factors that influence a grower's ability to manage severe water stress include:

- timing of water delivery
- amount of water available
- duration, intensity, and timing of hot spells
- soil texture
- soil depth
- method of irrigation

In newly planted vineyards, water management is critical for successful vine establishment.

For established vines, extreme water stress is most damaging when it occurs between flowering to pea-sized berries (late spring to early summer), when there is rapid shoot growth, ovule fertilisation, and rapid cell division in young berries. Water stress during this time will result in low yield due to poor berry set and small berries.

Properties that are reliant on localised catchment areas to supply on-farm dams are highly susceptible to dry conditions, where lack of rainfall not only requires more supplementary irrigation, it also impacts the replenishment of water storage (dam or aquifer), limiting the amount of water available to irrigate with.  Larger irrigation schemes are typically impacted by broad-scale drought, impacting irrigation availability "down-stream".

Effective storage dam design, installation, monitoring and maintenance has a significant influence on water availability. Monitoring for leaks and seepage should be conducted regularly to identify and manage problems early. Regular maintenance should be conducted to prevent problems and improve the operation and longevity of the storage.

Wine producers have identified a range of challenges posed by drought, which are summarised in Table 2. Tactical responses are listed as suggestions and an overview of the range of impact of these responses is identified. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple impact areas.

## Key messages

- Drought can be an issue for wine producers whether it's for an extended period, or for shorter periods at important times of the year, such as the spring growth period.
- Tactical responses to managing crop failure can include changing crop load and target wine style.
- Managing a drought and its impacts can occur over multiple seasons as challenges such as weak canes and poor bunch numbers can persist after the drought has broken.

**Table 2.** Summary of challenges and responses associated with the impact of extended dry periods relevant to Australia's wine industry.

| Potential challenges | Tactical response |
|---|---|
| Water supply | Alternate water source |
| | Monitor and manage water provision proactively |
| Restricted vegetative growth | Lightly fertilise, prune heavily and shoot thin to optimise shoot growth |
| | Irrigation scheduling |
| Restricted fruit development | As above plus shoot thinning and bunch thinning to optimise fruit growth |

## Heatwaves

Periods of extreme high temperatures, otherwise known as heatwaves, can cause shock to the farm management system and the underpinning biological systems. A combination of a prolonged dry event and a heat wave can lead to bush fires.

The effects of a heatwave on winegrapes will vary depending on the location of the vines. This is partly because vines acclimatise to certain conditions but also because viticulturists design irrigation systems and manage vineyards with a sense of what is normal or expected in their region.

The FWFA tools cannot indicate the occurrence of a heatwave as well as a weather forecast. However, the *chance of extremes* map for unusually warm temperatures for both maximum and minimum temperatures can provide an insight into periods when unusually warm conditions may be expected. An example of an unusually warm outlook is shown in Figure 2.

An insight into when unusually high temperatures could be expected over the warmer months presents an opportunity for wine producers to plan ahead for best practice water management to assist with managing the heat using water. Producers can also prepare to mitigate against fire and smoke damage. Being a step ahead of a potential event gives the opportunity to be prepared for a potentially challenging situation.

The effects of extreme heat on grapevines vary depending on the timing of the heat event relative to the developmental stage of the grapevine. Flowers are highly susceptible to heat stress. Exposure to extreme weather events may result in poor fruitset and in turn yield loss. Later in the season, grapes become more susceptible to heat damage as they soften, and stressed leaves reduce in photosynthetic activity, slowing the ripening period. Dark coloured grapes may get much hotter than the surrounding air temperature. Berries may shrivel or be sunburnt, leading to loss of yield and quality. Losses may also occur at the winery due to the increased requirement for cooling.

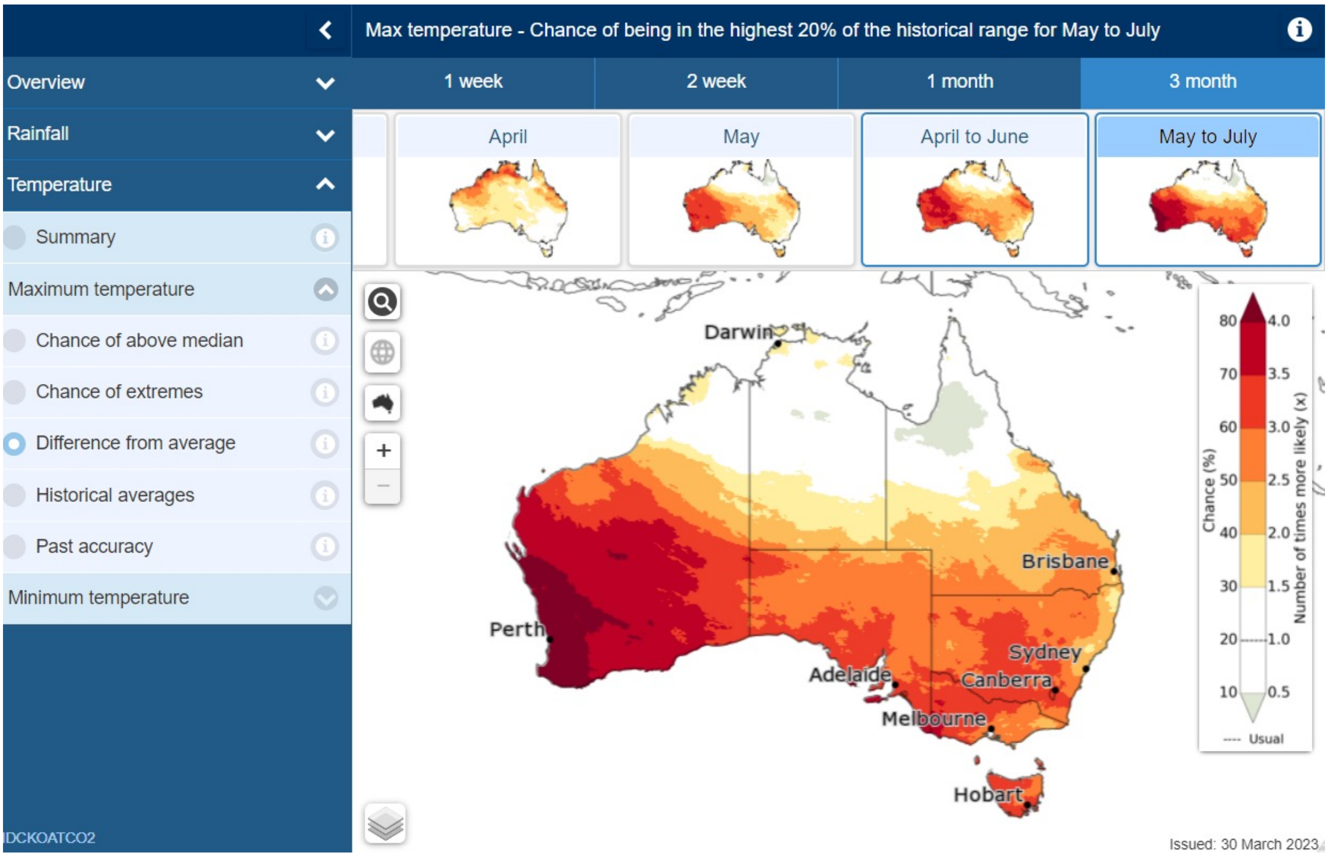



**Figure 5.** Example of the *chance of extremes* map for maximum temperatures in the period between May and July 2023 for Australia. Source: www.bom.gov.au 4/4/2023.

Bushfires are a possibility in any wine region around Australia. Fires present danger to vineyards, wineries, plant and equipment. Smoke from fires also brings with it a risk that fruit may be affected by the free volatile phenols that are produced when wood and vegetation is burnt.

Following a fire event, the impact within the vineyard can present itself in different ways. Some damage is obvious, such as dehydrated leaves and burnt bark, while some are more difficult to identify, such as that from radiant heat. Grapevines are capable of growing new shoots if trunk damage is not too severe. Depending on the extent of the fire damage, vines may be able to be rejuvenated or they may need to be replaced.

Smoke exposure can affect grapes any time during their development. Smoke taint risk depends on factors such as intensity and duration of the fire, proximity of the vineyard to the fire, prevailing weather conditions and grape variety.

Wine producers have identified a range of challenges posed by heatwaves, which are summarised in Table 3. Tactical responses are listed as suggestions and an overview of the range of impact of these responses is identified.

**Key messages**

- Heatwaves can impact both grape yield and quality, as well as winery operations.
- Fire danger from paddock operations is a key concern during heatwaves, which can affect operations.
- Smoke exposure can impact grape quality.

## Extreme cold events, including frost

Technically a frost occurs when the temperature at ground level falls below 0°C. Most temperate plant species, including vines, tolerate this temperature, even though surface ice may have formed. At about –2°C, water from within the cells in leaves, buds or flowers begins to move out into the ice layer that has been forming on the surface, resulting in desiccation and death of all or part of the exposed tissue. The lower the temperature and longer the duration, the more severe this desiccation and consequent damage becomes. To plant cells, frost damage is much like a sudden and severe drought.

Frosts damage buds, shoots and inflorescences, which are often actively growing when spring frosts occur. Damage to these parts of the grapevine result in loss of yield. In the case of a very severe late spring frost, there might even be carryover effects into the subsequent season if vine shoots are severely damaged.

Extreme cold conditions, including frosts, can also have operational impacts. For example, some herbicides will have reduced efficacy on weeds that have experienced stress from frost prior to spraying. Knowing when a period of extreme cold is likely can help you prioritise jobs in the spray program.

Although the FWFA tools do not predict frost events, the *chance of extremes* maps for unusually cool temperatures can provide insight as to whether there is an increased risk of frost events occurring, with a longer outlook than a 7-day weather forecast. An example of the *chance of extremes* map for unusually cool temperatures is shown in Figure 4.

**Table 3.** Summary of challenges and responses associated with the impact of heatwaves relevant to Australia's wine industry.

| Potential challenges | Tactical response |
|---|---|
| Heat stress | Maximise transpirational cooling with sprinklers |
| | Reduce bunch exposure using canopy shading or artificial shading |
| | Apply irrigation and refill root zone prior to heat wave |
| | Consider applying a sunscreen spray |
| | Reconsider any planned leaf removal or canopy manipulation (e.g. foliage wires) strategy that may lead to increased bunch/berry exposure |
| Water supply | Alternate water source |
| | Monitor and manage water provision proactively |
| Fire damage | Bushfire prevention and action plan |

A range of issues identified with frost are summarised in Table 4. Tactical responses are listed as suggestions.

## Key messages

- Frosts can have severe impacts on grape yield and quality, and profitability, for a wine business.
- Being prepared to protect vines during frost events and maintain best practice vineyard floor management is important.

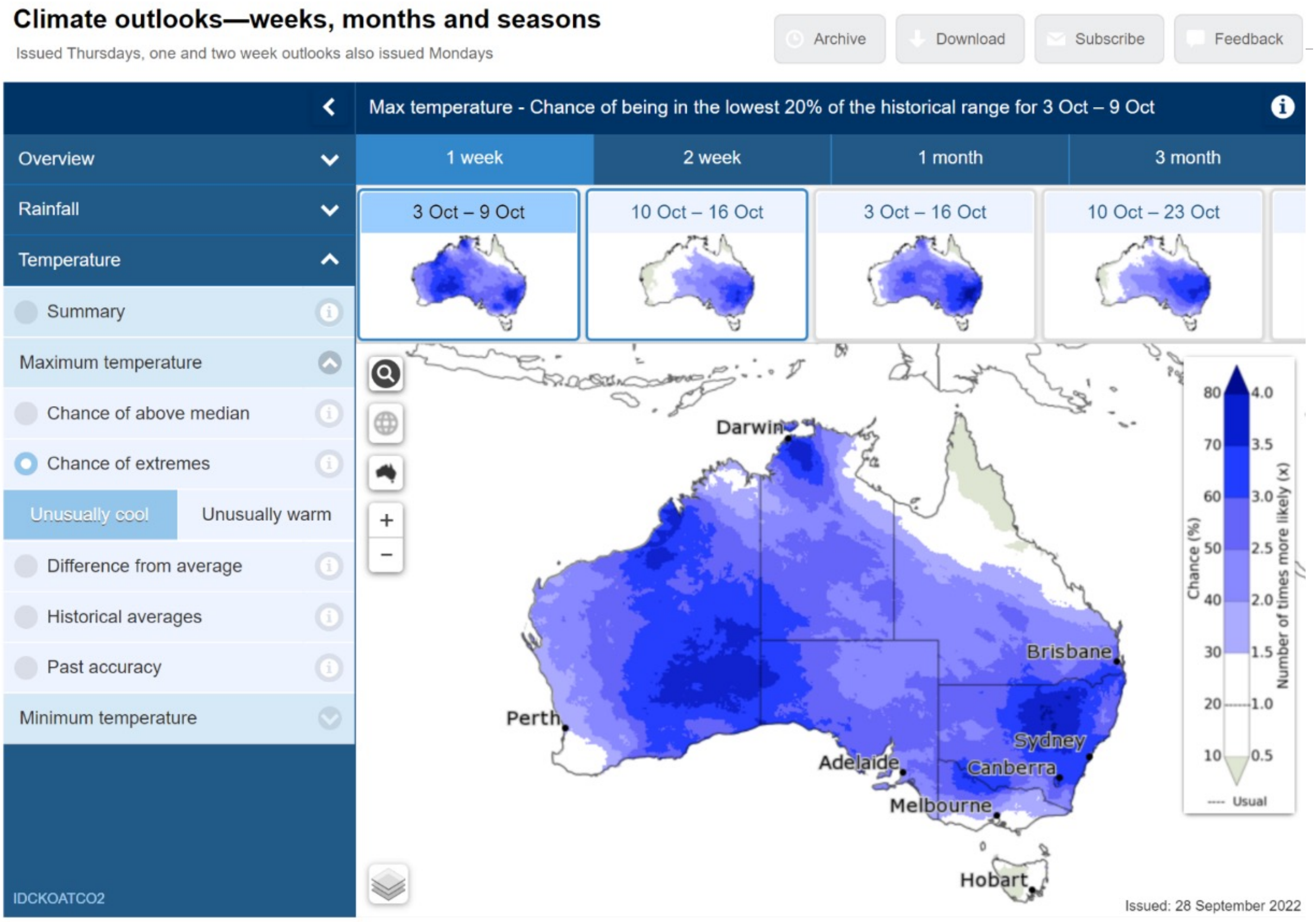



**Figure 6.** Example of the *chance of extremes* map for unusually cool maximum temperatures between 3 oct and 9 Oct 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 4.** Summary of challenges and responses associated with the impact of frosts relevant to Australia's wine industry.

| Potential challenges | Tactical response |
|---|---|
| Damage to vine tissue | Maintain clear moist soil or short grass in the interrow |
| | Employ fan or helicopter protection |
| | Employ irrigation protection |
| | Consider introducing heat through strategically placed heating |
| | Consider protectant sprays |

# 3.6 Tactical decision making in the sugar industry

## Decision making

Decisions are made daily in a farming business. Some decisions relate to the day-to-day operation of the canegrowing, such as land preparation, planting, weed and pest control, and harvesting. This is operational decision making. Decisions made for the longer term of the business are strategic decisions and examples include deciding whether to invest in capital items, setting targets (such as return on investment and gross margin targets), and labour use efficiency. Tactical decisions and plans are designed to achieve the longer-term strategy, usually with a medium-term view (1 – 12 months). Examples of tactical decisions for canegrowing might include management of sediment and drainage, the use of supplementary irrigation, soil amelioration and nutrient management, planting strategy (including area to fallow, if replanting is required to support improved block layout, time of planting and type of planting system), and fallow management (including rotational cash or cover crops, planting time and cropping system configuration).

A tactical climate-sensitive decision is one where the time frame is within the season and the optimal decision depends on the climate. Examples include adjusting harvesting schedule, deciding how to maintain surface cover after harvesting the final ratoon crop (e.g., plant a cover crop), and giving consideration to fertiliser product and timing.

Information from FWFA is only relevant to tactical or operational decisions. However, long term or strategic decisions are some of the most cost-effective ways to manage extreme events. Examples include upgrading or constructing infrastructure such as dams, drains, irrigation, roads and tracks. Determining the costs and benefits of these decisions requires historical climate data and climate change projections on the frequency and severity of rare events.  Historical climate data can be accessed via the Bureau's website: http://www.bom.gov.au/. Under *Our services, Climate and past weather*, the rainfall and temperature records are available under *Rainfall history* and *Temperature history*.

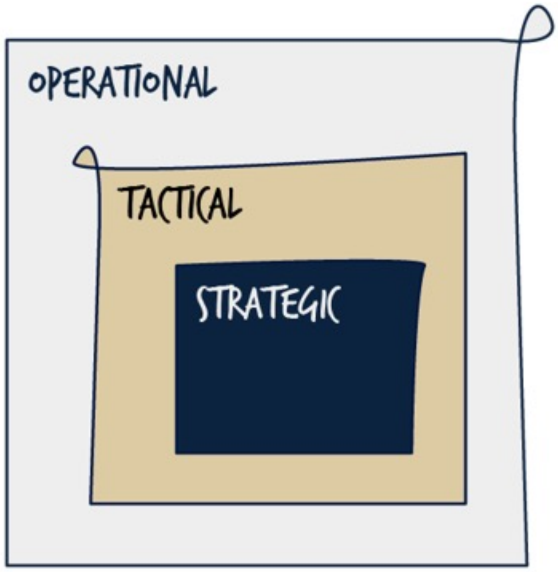



**Figure 1.** The three types of decisions (from Dairy Australia – Our Farm Our Plan)

Farmers deal with weather variability daily, influencing their operational decision making. This type of decision making is something we are more familiar (and comfortable) with, than those decisions around less frequent, but more impactful, extreme events. The Bureau has developed five tools to support short-term and medium-term decision making regarding extreme climate risks. As these tools focus on a seasonal timeframe, they are most suited to support on-farm operational and tactical decision making.

Before you can use these products effectively in your canegrowing business you need to fully understand the operations and assets of your business that can be affected by an extreme event. While we often focus on the risks of these events, it's important to realise they may also create opportunities. Following are some examples of tactical decisions that can potentially mitigate these risks or capitalise on the opportunities. These are not designed to operate in isolation from a whole enterprise risk assessment and management plan, but rather to complement them.

3.6

## Key risks

A canegrowing business' calendar of operations usually considers the seasonality of activities relevant to the location of the farm. Extreme weather events might disrupt these operations. The three extreme events of most concern for canegrowers are extreme wet and extreme dry periods, with extreme cold (<1°C) predominantly impacting southern canegrowing businesses. These can affect yield, sugar content (CCS) and harvest, soil health, infrastructure and operations, cashflow and social wellbeing. Each of these impact areas will be affected to different degrees by extreme events (e.g. extreme wet events are of particular concern during planting and harvesting), and may require different tactical responses. Some tactical responses are more relevant in cases when the duration of the extreme event is prolonged. There can also be both positive and negative impacts of extreme events. For example, extreme dry conditions during spring/summer may depress yield, but may be ideal for completing in-field machinery operations such as applying fertiliser.

Tools such as farm management deposits or budget contingencies for unforeseen costs can aid in a business' financial security. Planning for these allowances can be part of a business' strategic and tactical decision making. Ensuring ways of staying up to date with the availability of industry and government funding for extreme events is another way to manage some of the financial risks. These opportunities may involve funding for improving infrastructure, managing potential future extreme weather events, or recovery after an extreme event. These funding sources often lag an event or are not immediately accessible and can take time to move through regulatory processes. Such funding should not be relied on, and sound financial management with contingencies should be built into management of the business.

Social wellbeing is another area that can be impacted by weather extremes. Mental fatigue from dealing with challenging circumstances, particularly when these events are extended, is not uncommon. Enduring losses or traumatic experiences related to an extreme event can impact mental health and affect relationships. Seeking support early, by being aware of your emotional wellbeing, and the wellbeing of people around you, is invaluable.

Extreme events can also cause workplace health and safety issues by affecting conditions in the workplace, including new hazards following extreme conditions. For example, a heatwave can impact those having to work outside in the heat. Tactical responses such as early starts or finishes to the workday can circumvent the need to work during the hottest time of day, reducing the risk of heat stress. Ensure machinery is serviced so air conditioning is working. Leveraging the Bureau's extreme event tools to allow prioritising repairs and maintenance in the lead-up to a heatwave can make a difference. Other safety issues might involve the accessibility of the property, sheds, crops and equipment in case of floods following an extreme wet event. Having emergency policies and procedures in place, communicated, and understood by all staff can help mitigate risks and keep people safe during an extreme weather event.

Understanding the extreme weather events your location and industry are susceptible to is important to assist in planning extreme weather event responses. Establishing thresholds or triggers for your business can provide early warning to implement an extreme weather response ahead of its occurrence, and can potentially mitigate or reduce the impact.

### Key messages

- The extreme events of most concern to the canegrowing industry are extreme dry (drought), extreme cold (including frost) and extended wet periods.
- Sound financial management with contingencies should be built into the business.
- Be aware of impacts on mental well-being – seek support early for yourself and/or encourage those around you to do likewise.
- Use emergency procedures, communicated to, and understood by, staff, to help keep people safe during an extreme event.
- Be aware of the extreme weather events your location and industry are vulnerable to, and establish triggers or thresholds for response.

## Extended wet

Periods of extended wet weather can derail harvesting operations, affect sugarcane yield and sugar content, and increase the off-site movement of nutrients and chemicals.

Multi-week rainfall forecasts can provide advance knowledge regarding the risk of extreme rainfall events, and can be used to plan operations. Awareness of risk exposure for crops based on propensity to waterlog, water inundation due to flooding, and site access based on block location will help inform tactical responses. The range of issues associated with extended wet periods can vary in spatial scale and intensity and responses to these issues will need to vary, too.

Examples of diseases that can be prevalent in extreme wet periods include yellow spot, pineapple sett rot and chlorotic streak. Climate forecasts may assist with the timing of planting operations, so avoiding extended wet soil conditions that favour pineapple sett rot. Chlorotic streak occurs where poor drainage and extended wet weather prevail; forecasting will have a limited benefit here related to the timing of harvest (chlorotic streak may be favoured by harvesting under wet conditions). Yellow spot is managed through resistant varieties.

The choice of herbicide product, timing and rate is sensitive to both wet and dry conditions. For example, if the forecast suggests wet conditions, it may be wise to increase reliance on residual herbicides because machinery access may be limited. Conversely, if the forecast is for relatively dry conditions, there may not be sufficient rainfall to effectively incorporate residual herbicides. In the latter scenario, knockdown herbicides may be more effective.

The Bureau's timeline graph in combination with the *chance of 3-day totals* tool could indicate the probability of exceeding median rainfall and highlight the chance of the three-day total rainfall exceeding, for example, 50 mm. Being a step ahead of a potential extreme weather event provides the opportunity to complete any upcoming operations on waterlogging-prone paddocks, maximise yield within the expected conditions, and avoid logistical delays. Figure 2 to 4 provide an example of what an extreme wet event looks like using the *probability of exceedance* tool (Figures 2 and 3) and the *chance of 3-day totals* tool (Figure 4).

Canegrowers have identified a range of challenges posed by extended wet weather, which are summarised in Table 1, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but provide a solution for multiple challenges.

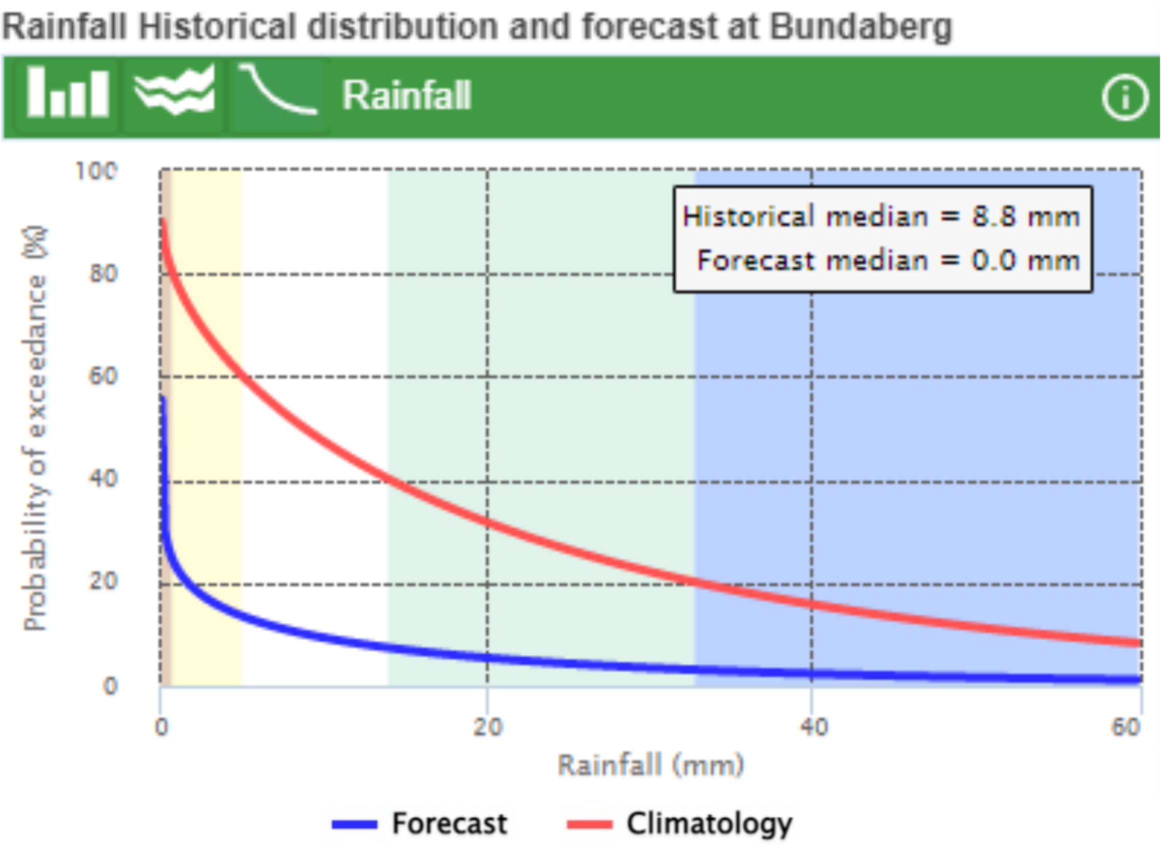



**Figure 2.** Example of the *probability of exceedance* tool, showing an extreme wet outlook for Bundaberg. Note: this is not showing a high probability of exceedance for rainfall as this was not the outlook at the time of workbook development.

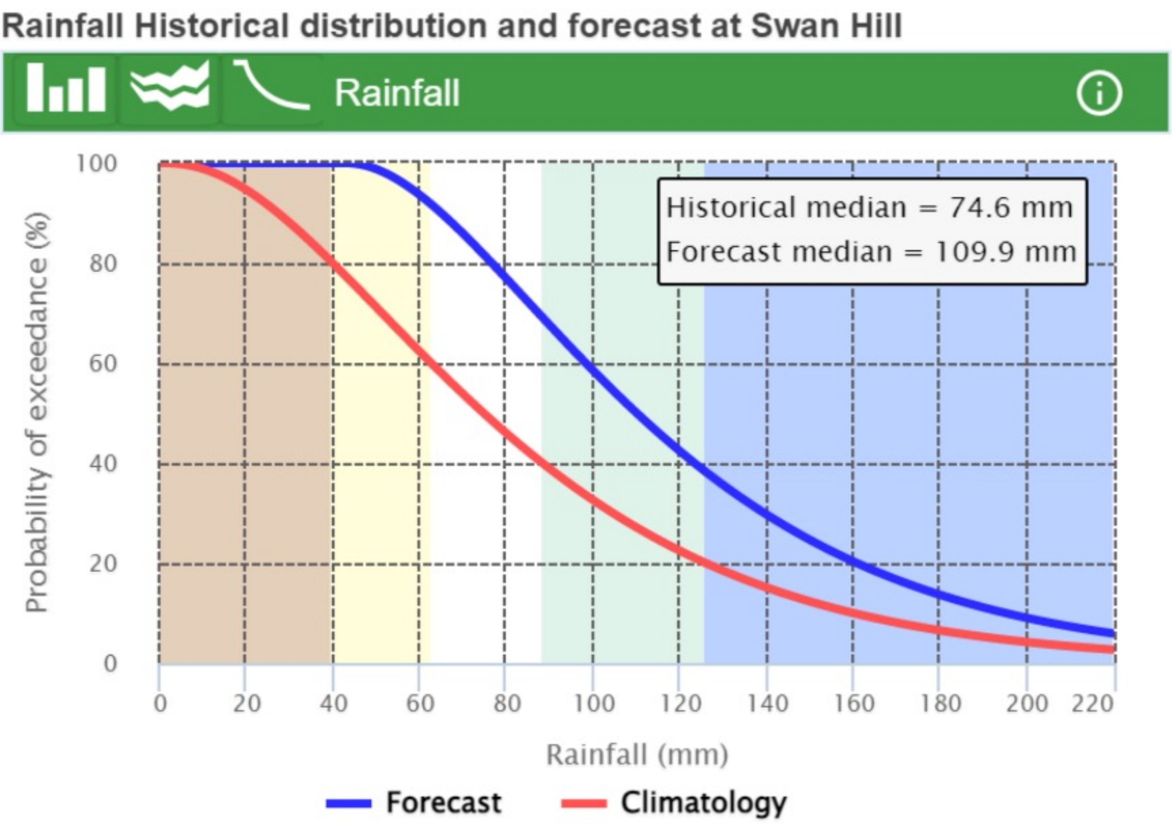



**Figure 3.** Example of the *probability of exceedance* tool, showing an extreme wet outlook for Swan Hill. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

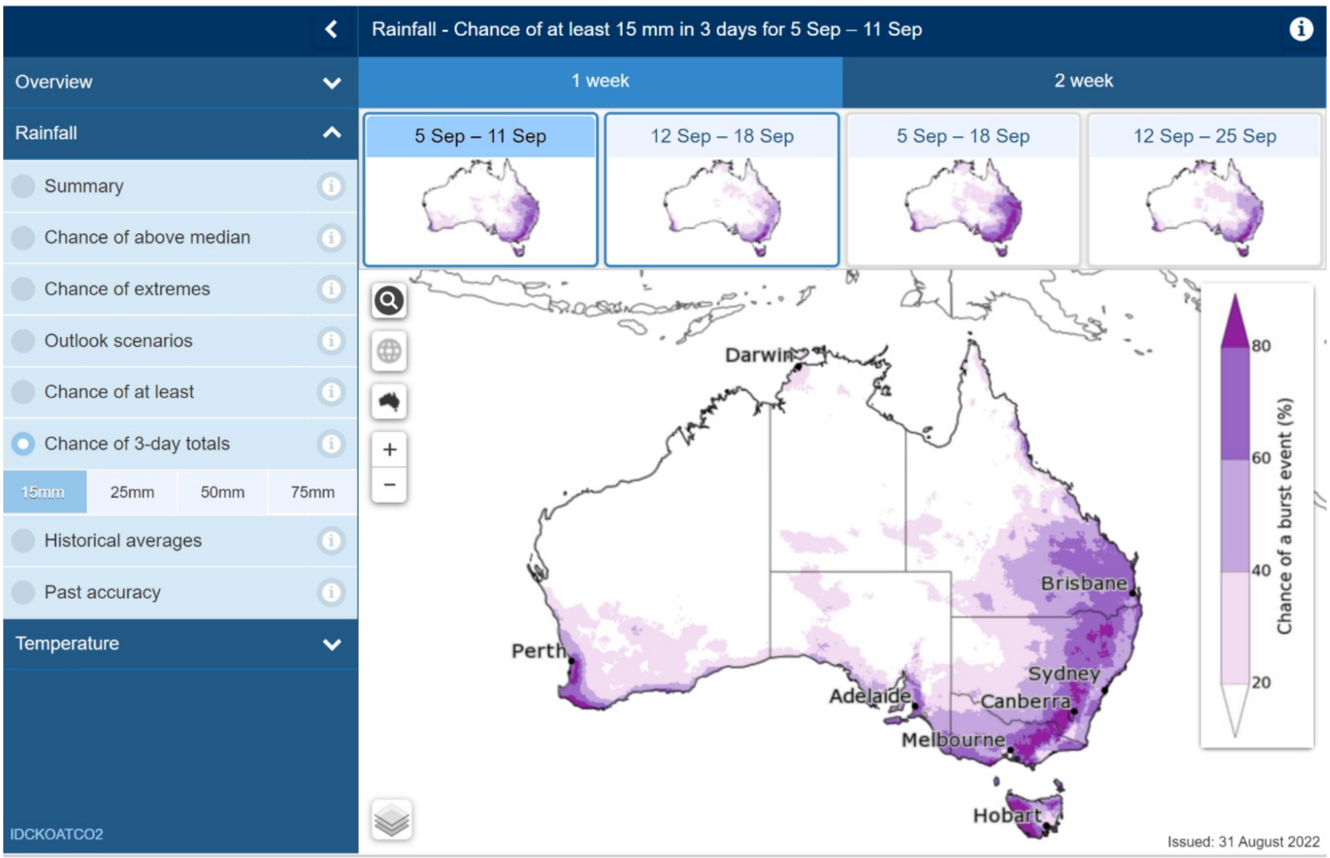



**Figure 4.** Example of the *chance of 3-day totals* tool, showing the chance of a burst event of at least 15 mm in three days between 5 Sep and 11 Sep 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 1.** Summary of challenges and tactical responses associated with extended wet periods in the context of Australian canegrowing.

| Potential challenges | Tactical response |
|---|---|
| Disrupted harvest due to heavy rainfall | Prioritise harvest of at-risk blocks. |
| | Schedule maintenance activities to coincide with rainfall event shutting down harvest and mill operations. |
| Increased disease pressure | Apply fungicide as required (e.g. to control pineapple sett rot). |
| | Manage for optimal soil drainage. |
| Lower sugar content (CCS) | Use forecasting products and on-farm measurements to decide on the use of crop ripeners. |
| Weed pressure | Review herbicide regime (e.g. expect more weed germination and vigorous growth, anticipate increased reliance on residual herbicides because machinery access may be limited, and identify products that have reduced efficacy if applied before heavy rainfall). |
| Reef Protection Regulations compliance | Inform whether erosion and sediment control measures are adequate. |
| | Inform the choice of surface cover after harvest (e.g. green cane trash blanketing, cover crop). |
| | Review nutrient management practices (e.g. rate, timing, product, placement). |
| Soil compaction | Consider soil impacts when scheduling operations. |
| | Identify ways to reduce the compressive stress on soils. |
| Bogged machinery | Schedule machinery operations ahead of heavy rainfall or after soils have dried. |
| | Headland/haul road improvements (if possible at short-notice). |

## Key messages

- Extended wet weather can present issues for sugarcane farms through operational challenges as well as plant responses such as increased disease or altered herbicide efficacy.
- Tactics such as crop ripeners and adjusting the harvest schedule can help with the continuity of harvest operations.
- Soil health and erosion issues can be a key challenge during extreme wet conditions for sugarcane farms. Effective tactics include post-harvest ground cover regimes or managing machinery to reduce erosion and compaction.

## Extended dry (drought)

In sugarcane, decreased water availability can lead to reductions in yield, and a shorter growing season if accompanied by high temperatures. Sugarcane is a water loving plant and is susceptible to water stress. Approximately 60% of sugarcane crops in Australia rely on full or supplementary irrigation, and this reliance varies greatly between regions. For example, in the Mareeba and Burdekin growing regions, irrigation (approximately 900 mm) is essential for canegrowing because effective rainfall is far lower than crop water use, whereas in Mackay-Proserpine and Bundaberg-Maryborough only supplementary irrigation (approximately 500 – 600 mm) is required for economic production. Irrigation is not needed in the Wet Tropics or New South Wales because effective rainfall is closely matched to crop water use.

In times of low water availability, tactical decision making around irrigation scheduling is crucial to a successful crop. For example, when irrigation scheduling is optimised, 100mm of soil water can produce up to twice the yield using the same amount of water. Balancing potential yield with water availability and the cost of irrigation is a crucial element of tactical decision making.

Other measures such as green cane trash blanketing can be undertaken to reduce evapotranspiration and suppress weeds when moisture retention is important. Conversely, in wet seasons green cane trash blanketing may increase the likelihood of waterlogging, and a trash blanket may interfere with water movement along an irrigated furrow.

The Bureau's decile bar chart tool can be used to indicate the probability of an unusually dry event. An example of what an unusually dry event can look like using the Bureau's decile bar chart tool is shown in Figure 5. Being a step ahead of a potential event gives the opportunity to be prepared and make the most of a challenging situation.

Sugarcane growers identified a range of challenges regarding the impact of drought, as summarised in Table 2, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

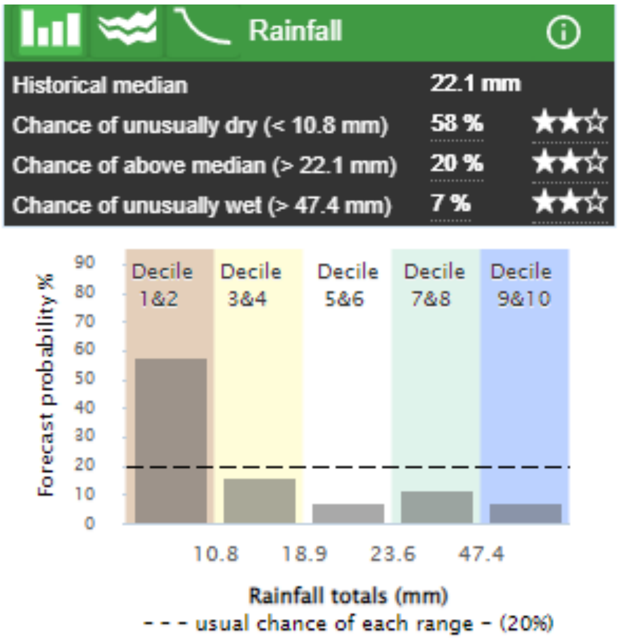



**Figure 5.** Example of the decile bar chart tool, showing the probability of an extreme dry (decile 1&2) event. Reproduced from www.bom.gov.au.

### Key messages

- Drought is an issue for sugarcane farms where it impacts irrigation water availability and soil moisture. Early review and optimisation of irrigation scheduling and water supply in times of drought and water stress are critical tactical responses.
- Re-consider fallow crop use if dry seasonal conditions are forecast (either don't plant or be prepared to spray out early).
- Herbicide efficacy can be impacted by soil moisture, review herbicide usage to ensure optimum efficacy.

**Table 2.** Summary of challenges and responses associated with extended dry periods in the context of Australian canegrowing.

| Potential challenges | Tactical response |
|---|---|
| Reduced growth (and yield) or crop failure | In NSW, decide whether to harvest a one- or two-year old crop. |
| Reduced water supply | Optimise irrigation schedule. |
| | Access an alternate water source (if possible). |
| | Install recycle pits and (increasingly) access water from them. |
| | Monitor and manage water provision proactively. |
| Increased disease pressure | Use tolerant varieties (e.g. to avoid smut or basal stem rot) and clean planting material (e.g., to avoid leaf scald). |
| | Monitor disease pressure to inform crop cycle duration (e.g. fallow varieties with intermediate smut tolerance). |
| Fallow crop management | Choose not to plant a fallow crop if the outlook suggests soil moisture will be low for plant cane. |
| | Spray out a fallow crop to conserve soil moisture for plant cane. |
| | Inform choice of rotational cash crop. |
| Changed herbicide efficacy | In the absence of irrigation, reconsider herbicides whose application requires wet soil, follow-up rains, or should not occur on hot, dry soil (e.g., atrazine, metribuzin). |

## Extreme cold events, including frost

Periods of extreme cold or temperatures <1°C can have severe impacts on sugarcane crops. Mild frosts (i.e. headland temperatures of -2 to 0°C, recorded at a height of 1 m) may result in leaf burn. Moderate frosts (< -2°C) may result in the death of growing points, especially if the crop has not been hardened by previous mild frosts, canopy development is poor, or if the event is prolonged. Severe frosts (< 3.5°C) may result in extensive leaf burn and the death of growing points in all crops. Frost events can cause mortality in cane plants, as well as decreases in yield. Southern cane growing areas are more likely to be impacted by frost than northern areas. Impact is also influenced by landscape characteristics (e.g. creek flats and hollows are more prone).

There are four main stages of frost damage ranging from least to most severe: foliage, growing point, eyes and internal stalk. Cane that has been severely impacted by frost can stop growing, at which point the amount of sugar in the cane decreases, and a decision on whether to harvest must be taken. For example, some areas in northern NSW and southern Queensland were impacted by severe frost in June 2018, resulting in the harvesting of 5% more one-year cane than in the previous year.

Strategies for managing extreme cold range from operational through to strategic. Frost damage, or imminent frost damage, may require plans for immediate harvest prioritised by the severity of the damage. Canopy management is important for the tactical response to extreme cold events. Achieving a closed canopy by winter by selecting varieties with an erect habit, and by applying sufficient fertiliser and irrigation (if available) to support early crop growth and canopy development can help keep relatively warm, unstirred air within the canopy during extreme cold and subsequent frost events. Grading the land to remove depressions where cool air will settle is an example of a long-term strategy for managing extreme cold weather events.

The *chance of extremes* maps for unusually cool minimum temperatures can provide insight as to whether there is an increased risk of frost events occurring. For more accurate prediction of frosts, the FWFA *chance of extremes* map can be used in conjunction with the 7-day weather forecasts. The *chance of extremes* map for cool temperatures presents the chance for both minimum and maximum temperatures. Using them in conjunction with each other can provide some insights as to whether a frost might be expected with a longer outlook than a weather forecast. An example of the *chance of extremes* map for unusually cool maximum temperatures is shown in Figure 6.

Sugarcane growers identified a range of challenges regarding the impact of frost, as summarised in Table 3, with suggestions for tactical responses listed. Some responses might be targeted at a specific issue, but in turn provide a solution for multiple challenges.

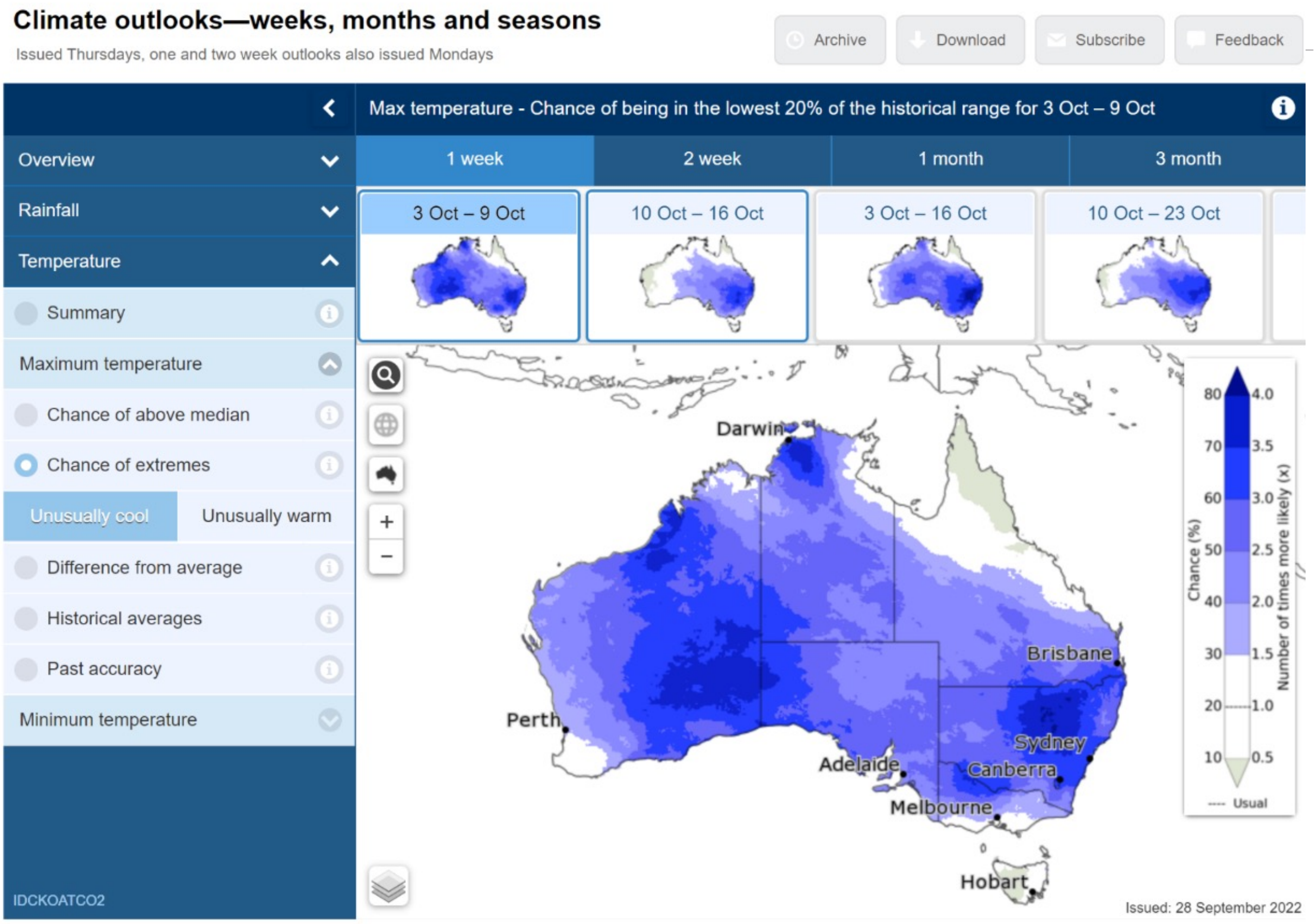



**Figure 6.** Example of the *chance of extremes* map for unusually cool maximum temperatures between 3 oct and 9 Oct 2022 for Australia. Reproduced from Agriculture Victoria's eLearning course 'Using seasonal climate prediction tools'.

**Table 3.** Summary of challenges and responses associated with the frost events in the context of Australian canegrowing.

| Potential challenges | Tactical response |
|---|---|
| Frost during growing season | Optimise planting strategy (timing, location). |
| | Check regularly for frost damage to inform operational decision making. |
| | Don't use frost damaged cane for planting material. |
| Growth point damage | Establish harvest priority for damaged blocks. |
| | Identify damaged blocks that should not be grown a second year. |
| Eye frost damage | Harvest as soon as possible post-frost event to minimise yield and quality impacts. |
| Low CCS | For high-risk locations, plant high CCS varieties that can be harvested at one year. |

## Key messages

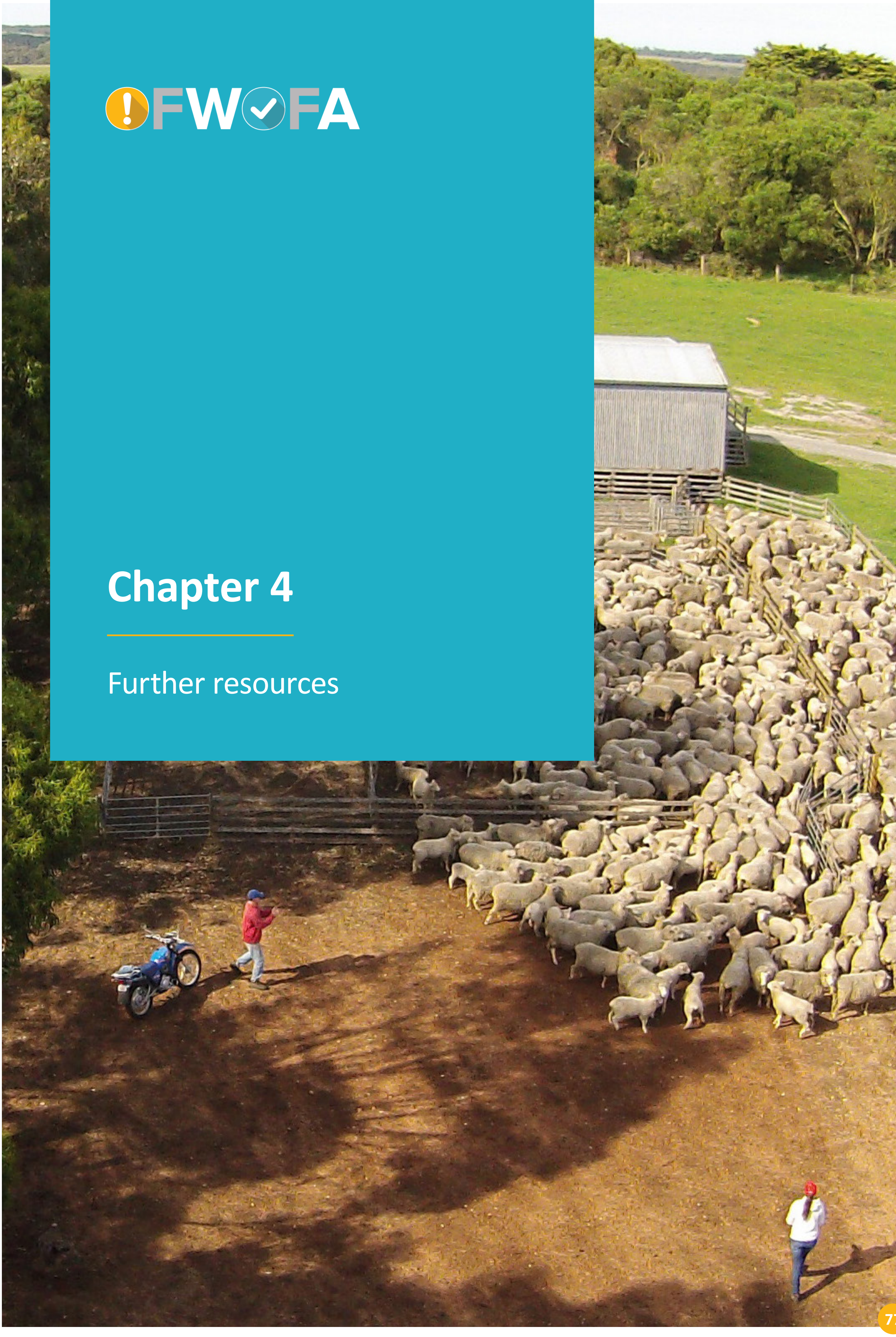
- Frosts can have severe impacts on sugarcane yield and quality, and profitability, for a canegrowing business.
- Being prepared to harvest affected paddocks as soon as possible following a frost event will help to minimise yield and quality impacts.
- Plan ahead for at-risk areas (e.g. plant high CCS varieties that can be harvested at one year and implement protective canopy management).

## Notes

## Notes

# Chapter 4

## Further resources



# 4 Further resources

**An overview of the Forewarned is forearmed project is available on the Climate kelpie website.**

For any technical support in using the tools, contact agriculture@bom.gov.au

SCAN ME

## Online courses

Agriculture Victoria has produced some excellent online courses, including Climate Outlook tools from the Bureau of Meteorology, which can be accessed for free at https://agriculture.vic.gov.au/support-and-resources/elearning/climate-and-weather-courses

SCAN ME

The Northern Australia Climate Program has developed the *Climate Training Course – Forecasting for Decision Making*, which can be accessed for free at https://nacp.org.au/outreach/training/videos

SCAN ME

## Climate drivers

The following transcripts of the Climatedogs videos (http://www.climatekelpie.com.au/index.php/climatedogs/) provide extra information about the climate drivers.

SCAN ME

### The roundup – introducing the Climatedogs

Meet the Climatedogs. They represent the climate processes that drive the rainfall variability across Australia. These working dogs love rounding up our rainfall.

From a farmer's perspective, when they're behaving, they bring moisture from the oceans and allow it to fall as rain – hopefully delivering the right amount at the right time. But they don't always work how we'd like them to, and can sometimes scatter the mob, effectively chasing rainfall away from Australia. These dogs often work as a team, helping one another to bring about our wetter and drier seasons.

Over recent decades, some of these dogs have started to change their behaviour, contributing to the variability and changing weather patterns that many farmers have noticed. While we can't control what these climate dogs are up to, there are tools that can assist farmers to keep an eye on the pack, helping to improve our understanding of seasonal forecasts and manage climate risks.

### Introducing ENSO – The El Niño Southern Oscillation

The El Niño Southern Oscillation, or Enso, has a big influence on Australia's climate and seasonal variability.

In a normal, or neutral, year, the Pacific Ocean trade winds blow from east to west, pushing moist air towards Australia. This moist tropical air is a big source of rain across many parts of Australia. But Enso's behaviour can vary from year to year.

During La Niña, Enso chases greater amounts of moist tropical air across Australia. Many La Niña years have seen higher winter and spring rainfall across large parts of Australia. And in northern Australia, the first rains of the wet season tend to be earlier during La Niña years, along with an increased chance of floods and tropical cyclones.

During El Niño, Enso changes its mind and drives warm moist air away from Australia and towards South America instead. El Niño years have often resulted in a drier winter and spring for eastern Australia, as well as an increased chance of frost and heatwave events. Up north, El Niño can bring a later start to the wet season rains, with typically fewer tropical cyclones and floods.

Enso often teams up with the other Climatedogs to affect our seasonal rainfall. Climatologists closely follow Enso's behaviour, looking at ocean temperatures, the SOI, and cloud and wind patterns to work out where it might chase that moisture next. So Enso is definitely an important dog to keep your eye on.

### Introducing INDY – The Indian Ocean Dipole

This is the Indian Ocean Dipole, also known as Indy, who influences south-east and central Australia's rainfall, mainly in spring. Indy likes to herd moisture from the warm north-east Indian Ocean across to south-eastern Australia. When this moist air meets up with southern weather systems, it can deliver significant rainfall. Some years, the north-eastern Indian Ocean is cooler than normal, meaning less evaporation and Indy can't deliver as much moisture, usually meaning a drier spring in the centre and south-east.

Historically Indy often likes to team up with Climatedog Enso, with both being a significant source of rainmaking moisture. In recent years, scientists have noticed that much of the Indian Ocean has been getting warmer, and that's why they are investigating Indy's behaviour, so we can better understand this Climatedog and improve our rainfall forecasts in the future.

### Introducing Ridgy – The Sub-tropical Ridge

This is Ridgy or, as scientists like to call him, the Sub-tropical Ridge. Ridgy is one of the major drivers that shapes southern Australia's weather. So let's look at how he does it.

As warm air rises in the tropics, moves south, then cools and falls, large areas of high pressure are created. This band of high pressure – in this case, Ridgy – is great at blocking rain-bearing fronts. From November through until April, Ridgy chases away cold fronts around southern Australia for days or even weeks at a time. When winter sets in, Ridgy heads north and cold fronts find it much easier to reach southern Australia and deliver their rain, until Ridgy returns again next November.

Ridgy travels north and south every year, but in recent decades he's been getting more effective at chasing away cold fronts from parts of southern Australia, meaning more dry weather and later autumn breaks. The Bureau of Meteorology has observed that Ridgy's increasing strength is related to the rising global average temperature. but the scientists are continuing to investigate how this climate dog might change his behaviour in the future.

### Introducing Sam – The Southern Annular Mode

Meet Sam. Sam herds cold fronts up from the Southern Ocean, a significant source of rain for much of southern Australia. If we take a look at the Southern Ocean, we can see westerly winds roaring around Antarctica, throwing out cold fronts of stormy wet weather. The strength and position of these winds is known as the Southern Annular Mode, or Sam.

Sam is an unreliable climate dog, often changing behaviour over a matter of weeks. This can affect southern Australia's rainfall in winter, and even parts of eastern and northern Australia's rainfall in summer. When Sam is tied up, strong winds are pulled south towards Antarctica and there is a reduction in the number and strength of cold fronts that reach southern Australia, reducing winter rainfall.

When Sam is let off the leash, this can drive westerly winds further north, increasing the chance of cold fronts and rainfall across the southern states. But in summer, Sam acts a bit differently. If Sam is sitting further south, it can actually coax more moisture and summer rain over parts of eastern & northern Australia.

Sam's behaviour is complicated, and is linked to what the other Climatedogs are up to. However, over recent decades Sam has been tied up more often, resulting in fewer cold fronts and less cool-season rainfall for parts of southern Australia. Scientists are watching this climate dog closely, hoping to tease out how it may impact our weather and seasonal climate variability down the track.

### Introducing Eastie – East Coast Low-Pressure Systems

This is Eastie, better known as the East Coast Low. Eastie represents the deep low-pressure systems that are an important climate feature along the south-east coast of Australia. These deep low-pressure systems can be caused by upper-atmosphere disturbances, decaying cyclones, existing low-pressure conditions or in the wake of passing fronts.

Scientists have found that Eastie tends to have a mind of his own and can be quite hard to predict. This energetic little dog can be triggered into action overnight causing strong winds, big surf, heavy rains and lots of rough weather. Eastie can appear all year round but typically prefers the seasons of autumn and winter. Even one-off events can dominate a region's annual rainfall tally, explaining a lot of the seasonal variability east of the Great Dividing Range.

Eastie usually cares little about what the larger climate dogs are up to; however, scientists have noticed that Eastie can be a bit timid when Ridgy, with his high pressure, is around. Scientists continue to look into Eastie's behaviour.

### Introducing MOJO
### – The Madden-Julian Oscillation

This is the Madden-Julian Oscillation or, as we like to call him, MOJO. He can have a big influence on Australia's weather and climate, especially during the warmest months of the year.

Mojo runs eastward moving a pulse of cloud and rainfall close to the equator and travels around the earth every thirty to sixty days. Mojo sends a wave of weather across the Indian Ocean which can create cyclones and bring widespread rain events through parts of Australia. Scientists track these rain making waves providing updates on the intensity and timing of the next wave.

Mojo mainly affects northern Australia, but can influence rain events further south, especially if one of Mojo's moisture waves feeds into a timely weather event down south. Mojo's behaviour is often unpredictable, with periods of moderate to strong activity followed by periods of little or no activity, but this dog is well worth keeping an eye on.

## La Niña and El Niño

La Niña and El Niño are two phases of the El Niño-Southern Oscillation (ENSO) cycle, which is a natural climate pattern that occurs in the Pacific Ocean. Both La Niña and El Niño can have significant impacts on weather patterns in Australia.

La Niña is characterized by cooler than normal sea surface temperatures in the central and eastern Pacific Ocean, which can lead to increased rainfall and flooding in Australia. During La Niña, the Pacific Ocean trade winds strengthen, pushing warm water to the western Pacific and bringing cool water to the eastern Pacific. This can lead to a strengthening of the Australian monsoon, which results in increased rainfall and cooler temperatures in northern and eastern Australia, particularly during the summer months. La Niña can also lead to an increased risk of tropical cyclones and flooding events in Australia.

On the other hand, El Niño is characterised by warmer than normal sea surface temperatures in the central and eastern Pacific Ocean, which can lead to reduced rainfall and drought conditions in Australia. During El Niño, the trade winds weaken, allowing warm water to move towards the eastern Pacific. This can lead to a weakening of the Australian monsoon, resulting in reduced rainfall and warmer temperatures in northern and eastern Australia, particularly during the summer months. El Niño can also lead to an increased risk of bushfires and heatwaves in Australia.

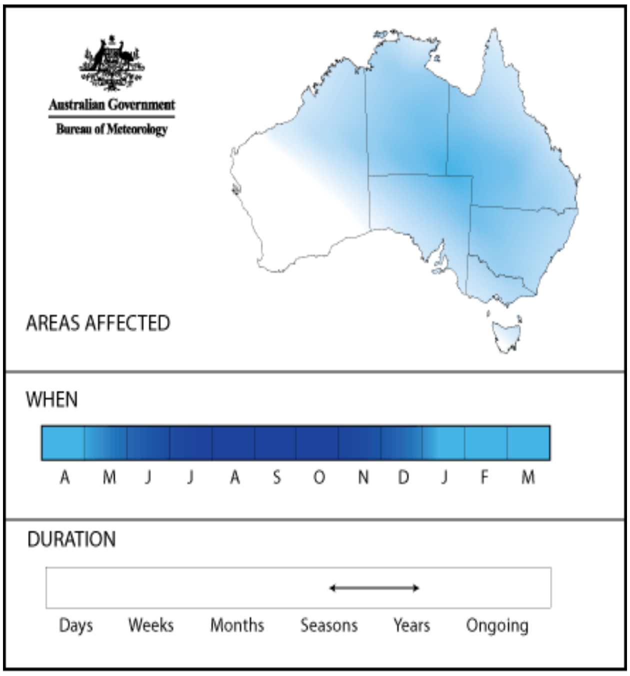



**Figure 1.** The area affected by La Niña, when it occurs and how long it may last.

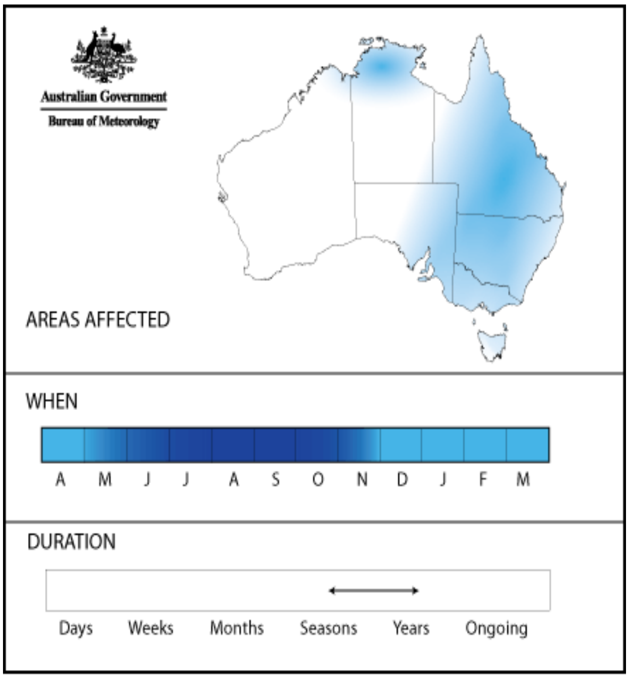
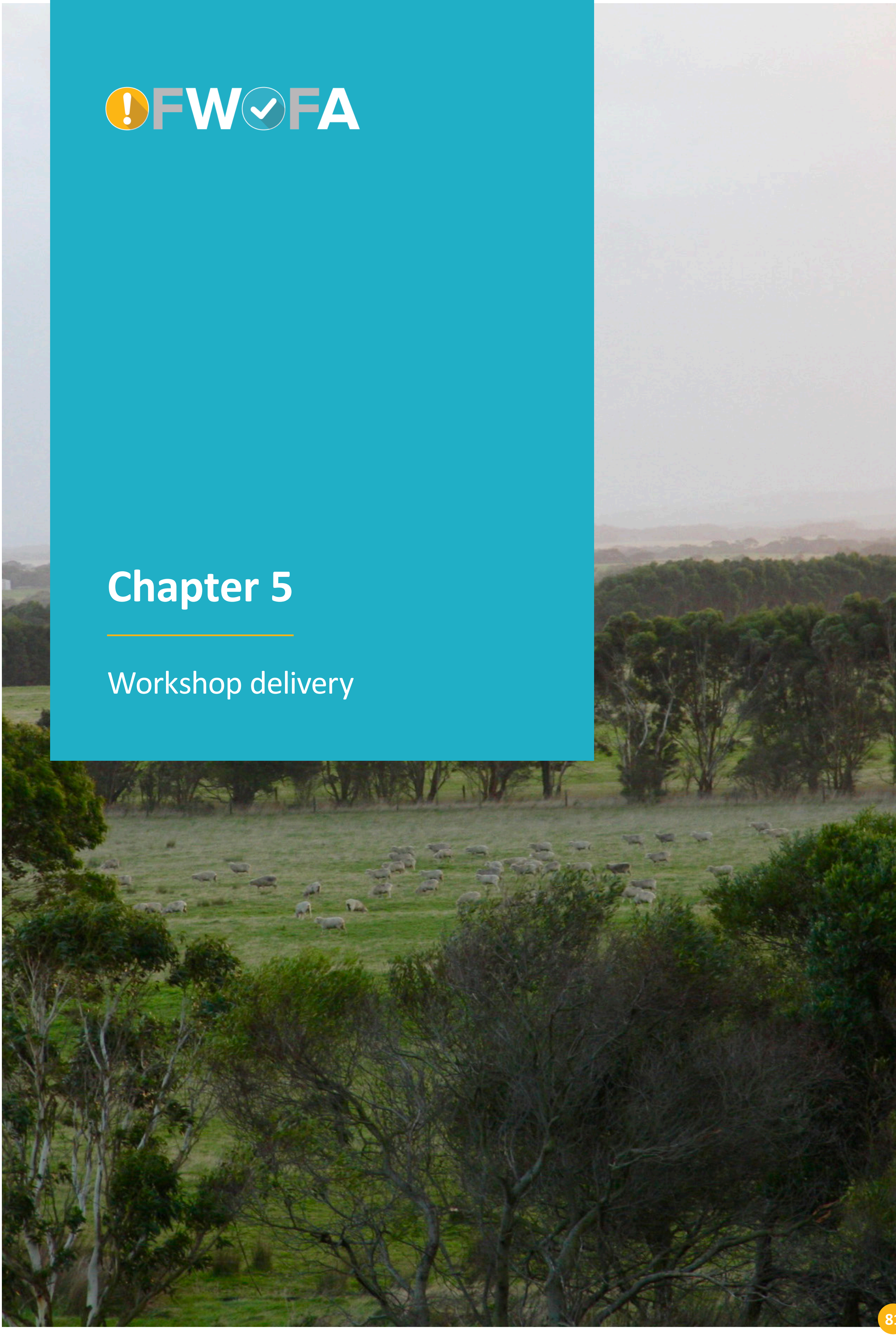



**Figure 2.** The area affected by El Niño, when it occurs and how long it may last.

The impacts of La Niña and El Niño on weather patterns in Australia can vary from year to year, and their effects are often not uniform across the country. Other climate drivers, such as the Indian Ocean Dipole (IOD) and the Southern Annular Mode (SAM), can also interact with ENSO to influence weather patterns in Australia.

# Chapter 5

## Workshop delivery



# 5 Workshop delivery

**This chapter contains information for workshop deliverers to support successful delivery of a workshop about the Bureau's climate outlook and forecasting tools.**

## The Forewarned is Forearmed project

The FWFA tools were developed during the national five-year *Forewarned is Forearmed* project (2017-2022). The objective of the project was to deliver direct value to farmers by improving the forecast of extreme weather events (such as extreme high or low rainfall, heat or cold) thereby equipping farmers with the information and tools to proactively prepare and make decisions with respect to the events of most consequence to their business. The aim of the project was to reduce the impacts of extreme weather events on farm, and on business profit.

The project was supported by funding from the Australian Government Department of Agriculture and Water Resources (now Department of Agriculture, Fisheries and Forestry) as part of its Rural R&D for Profit program in partnership with rural research and development corporations, commercial companies, state departments and research institutions. Meat & Livestock Australia managed the project. Throughout the project, farmers and farm advisors were consulted to ensure the relevance and value of the tools.

## Workshop outline

The purpose of the extension phase of the project is to raise awareness of the tools and how farmers can use them. The basic information can be delivered either in-person or online via a short 90-minute workshop. This flexible design means the *Forewarned is Forearmed* workshop can be tailored to meet different needs of deliverers or participants. For example, it could be delivered as a bolt-on to another extension activity, it could be fleshed out or it could be delivered as-is. The workshop specifically targets the southern red meat, wine, grains, sugar and dairy industries, but can be adapted for other industries, such as cotton, rice and pork.

### Learning outcomes

By the completion of the workshop, it is anticipated that participants will:

- Be familiar with the Bureau's five FWFA climate outlook and forecasting tools.
- Have a better understanding of the processes involved in weather and climate forecasting, including the key climate drivers and the skill (or forecasting ability) of forecast model runs.
- Understand how to correctly interpret a weather forecast.
- Be better able to apply forecast information in decision making for their industry and location.

## Workshop processes

### Workshop registration

As participants register for the workshop, they could be asked to identify their main industry and the main extreme weather event they would like to discuss during the workshop. This gives the deliverer an opportunity to tailor the workshop to the learner cohort and include relevant practical examples to help embed learning. Following are some examples of information to gather in your workshop registration process.

**Example information to gather**

*Preferred name:*

*Last name:*

*Phone:*

*Email:*

*City/town:*

*Dietary or other requirements:*

*Main industry (e.g., sheep, cattle, grains, etc):*

*The main extreme weather event you'd like to discuss during the workshop (e.g., unusually wet/ dry, or warm/ cool conditions):*

## Flipped learning

The workshop design involves a 'flipped learning 'approach, where prior to the workshop, participants are encouraged to read information or watch some short videos. Ideally these are sent 7–10 days before the workshop, with a compelling message to encourage them to complete this task in preparation for the workshop. This allows participants to familiarise themselves with the topic of the workshop so you can focus on practical use of the tools and address topics where there are specific questions or interest. This means the workshop is less a lecture and more a hands-on tutorial where participants apply what they have already learnt, allowing you to focus on answering queries. Below is some example content you might use.

You are encouraged to personalise the message and provide your contact details in a signature block. You can write a case study that's relevant for the area and the time of year you will be holding the workshop from the examples below.

### Example content to send to participants

*I'm delighted you have chosen to attend the forthcoming Forewarned is Forearmed (FWFA) workshop at XXX. Please arrive 15 minutes early at XX:XX, so we can start on time. This is going to be an engaging, interactive workshop. To make this interactive workshop as relevant as possible I need you to do some pre-workshop task — they should take less than 30 minutes and will allow us to start the workshop on the front foot.*

1. *Please watch this short video which gives an excellent overview of the FWFA project and the five tools we'll be discussing at the workshop:* ***Forewarned is Forearmed – Project and forecasting tools overview*** *(3:59) (https://www.youtube.com/watch?v=2vSbKAMF4HI)*
2. *Then watch this video:* ***Climate Outlooks: Stacking the odds in your favour*** *(2:38) (https://www.youtube.com/watch?v=8Y5poxiwEQM)*
3. *Work through the attached case study, which will prompt you to try using the tools. We will dive into this at the workshop together.*
4. *If you're curious to learn more, you can also read* ***About the long-range forecasts*** *(and click the tabs across the top of the page to see more). (http://www.bom.gov.au/climate/ahead/about/#tabs=Summary)*

*That's all… but we won't be taking the time during the workshop to re-watch the videos, so please do it now in preparation.*

*I look forward to seeing you at XXX soon.*

## Case studies

Industry-specific and location-specific case studies can be used to prompt workshop participants to trial the tools at home, before the workshop. This way they would already have be familiar with the tools' functionality and know where to find them. Any questions or uncertainties can then be shared at the workshop. This also provides a peer-to-peer learning opportunity at the workshop. You could also use case studies during the workshop to keep the learning practical.

Case studies examples for the red meat, dairy, grains, wine and sugar industries are provided in Appendix 1. These are intended as examples only. Tailor them to suit your group of participants for the industry/s, location and time of year the workshop is held. Ensure at least some of your case studies encourage participants to trial each of the five tools.

### Overview of the five FWFA tools

SCAN ME

You may like to watch this short 15 minute video where Peter Hayman from SARDI talks about using the five FWFA tools: https://youtu.be/Weo4miHgtEE

## Runsheet

The suggested runsheet for a 90-minute FWFA workshop is as follows:

| Time | Activity |
|---|---|
| 0:00 | **Welcome** (5 mins)<br>• **Introductions**<br>• **Logistics (location of toilets etc)**<br>• **Agenda overview, distribute workshop booklets** |
| 0:05 | **Overview of forecasting*** (20 mins)<br>• The difference between weather, multiweek and seasonal climate forecasts.<br>• The process of weather forecasting and the key climate drivers (ENSO, IOD, SAM and MJO)<br>• La Nina/ El Nino<br>• Q&A (3 mins) |
| 0:25 | **The Bureau's five tools* (20 mins)**<br>**An overview of the tools. Explain terminology during the discussion** (medians, deciles, box and whisker plots, hindcast vs forecast, percent chance of exceeding the median).<br>• **Chance of extremes**<br>• **Decile bar charts (previously only above/below median)**<br>• **Time-series graphs**<br>• **Probability of exceedance**<br>• **Chance of 3-day totals** |
| 0:45 | **Using the Bureau's five tools**** (35 mins)<br>**Starting with the homework one, use case studies to demonstrate how the tools can be used to manage the four key risks/opportunities with relevant local industry examples.**<br>• Heat extremes<br>• Cold extremes<br>• Rainfall wet extremes<br>• Rainfall dry extremes<br>• Q&A |
| 1:20 | **Further resources and evaluation** (10 mins) |
| 1:30 | **Close** |

** Using flipped learning approach | ** Using information gathered from the participant survey pre-workshop*

### Tip: start with the problem, then look for the solution

**Build the discussion to talk about the extreme event first and then its management, and only then discuss the FWFA tools. Don't start with a solution looking for a problem!**

Support the group to formulate management strategies (e.g. do you go into the season with an average budget or an extreme event budget?). Use discussion to demonstrate the potential for informed decision making to impact their business. Start talking about the important decisions they need to make and then link it back to tools.

**Tip: focus on the extreme event/s of most relevance to your audience**

**After the tools have been introduced (i.e. not too early in the workshop) and you're starting to talk about the case studies, you might like to incorporate this 3-step process:**

1. Ask a prompt question of the audience to gauge which extreme event is of most relevance to them. To help facilitate this, you could use the think, pair, share technique, where you ask them to think quietly and jot some some ideas, then discuss those ideas in pairs, and then share them with the larger group.
2. Then get them to discuss the key decisions required about that event (taking into account the probability of the event, and risk appetite).
3. Finally, ask them what information is needed to make decisions to mitigate or manage fall-out from the extreme event.

**Remember to keep the group focused on the tactical level, and not let them get bogged down in operational issues.**

**Tip:**

**Consider inviting the participants to bring their own PC or tablet to the workshop, so they can have some hands-on experience of using the tools.**

You could add this as a 30-minute session towards the end of the workshop. Invite participants to work in pairs, so they can work together and learn from each other while using the tools (you will need to allow at least an extra hour for workshop run time if going to do this).

*Tip: Ask them to keep their devices turned off while you are delivering the earlier session, otherwise there may be a lot of distracted participants!*

### Online delivery

If you are delivering an online version of the workshop, it will essentially follow the same runsheet. It is often best to start the online meeting 10 minutes early and greet people by name as they join, as that makes them feel welcome and tests their audio connection. At the start of the workshop, encourage participants to use the chat box to type in location and/or weather, so they are familiar with doing that later on. For the Q&A sessions, encourage participants to type their questions, as this is often much faster than unmuting people and letting them explain their question (in an often-long-winded manner). You could also encourage them to use some visual shorthand to indicate whether they understand the material just covered, for example by physically giving a thumbs-up, down or sideways (for unsure) to their webcam.

### Follow-up email

After the workshop (within two days), participants should receive follow-up resources and a short list of practical activities they might do to better understand the tools. There is example content you can use on the following page.

## Workshop evaluation

### Survey questions

As with all extension and adoption activities, it is strongly recommended to evaluate the delivery. This will enable you to continuously improve how you deliver, including adjusting the content or runsheet to better meet the needs of your audience. An evaluation template is provided in Appendix 3. Request participants  complete the evaluation at the end of the workshop, before departing.

**Example email content**

*Thanks for attending the FWFA workshop where we learnt more about the Bureau's five tools:*

1. *Chance of extreme maps for extreme rainfall and temperature*
2. *Chance of 3-day totals outlooks*
3. *Location specific decile bars for rainfall and temperature*
4. *Timeline graphs*
5. *Probability of exceedance (rainfall only).*

*If you are interested, here is where you can see more information:*

- *Decile bars, timeline graphs and probability of exceedance graphs explained: http://www.bom.gov.au/climate/ahead/about/#tabs=By-location*
- *Chance of extremes map explained: http://www.bom.gov.au/climate/ahead/about/#tabs=Extremes*
- *Chance of 3-day burst maps explained: http://www.bom.gov.au/climate/ahead/about/#tabs=Rainfall-scenarios*
- *The Climatedogs: http://www.climatekelpie.com.au/index.php/climatedogs/*

*To gain an even better understanding, you are welcome to work through the free online course 'Using seasonal climate prediction tools' created by Agriculture Victoria. It introduces the seasonal climate forecasting tools developed by the Bureau and steps you through the following topics:*

- *How are extreme temperatures or rainfall defined?*
- *Understanding the probability of experiencing extreme weather.*
- *Using climate outlook tools for predicting extreme weather conditions:*
    1. *The chance of extremes*
    2. *Three-day rainfall bursts*
    3. *Decile bar charts*
    4. *Timeline graphs*
    5. *Probability of exceedance*

*It takes about 30 to 60 minutes to complete and can be accessed here: https://rise.articulate.com/share/twWDSuOAj4Q03801gBK6nlFgv-rYTxYi#/*

# References


Agriculture Victoria has produced some excellent online courses, including *Climate Outlook tools from the Bureau of Meteorology*, which can be accessed for free at https://agriculture.vic.gov.au/support-and-resources/elearning/climate-and-weather-courses.

Hayman, P., Mudge, B., Stanley, M., Anderson, G., & Grey, D. (2019, August). Agronomic advice in a variable climate; chess, poker or the pokies. In *Proceedings of the 2019 Agronomy Australia Conference* (pp. 25-29).

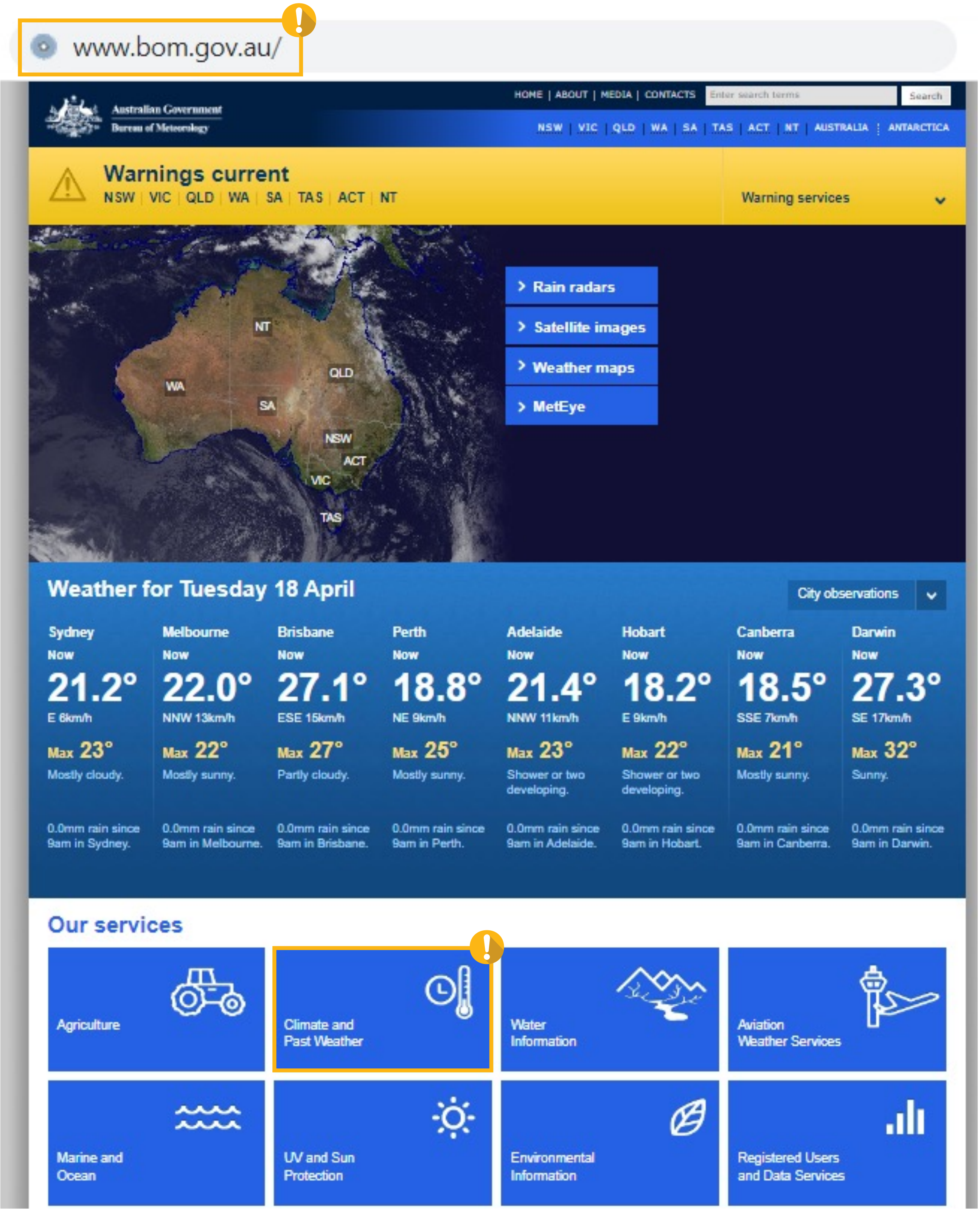
The Northern Australia Climate Program has developed the *Climate Training Course – Forecasting for Decision Making*, which can be accessed for free at https://nacp.org.au/outreach/training/videos.

# Appendices

How to access and navigate the FWFA tools, case studies and the event evaluation form.

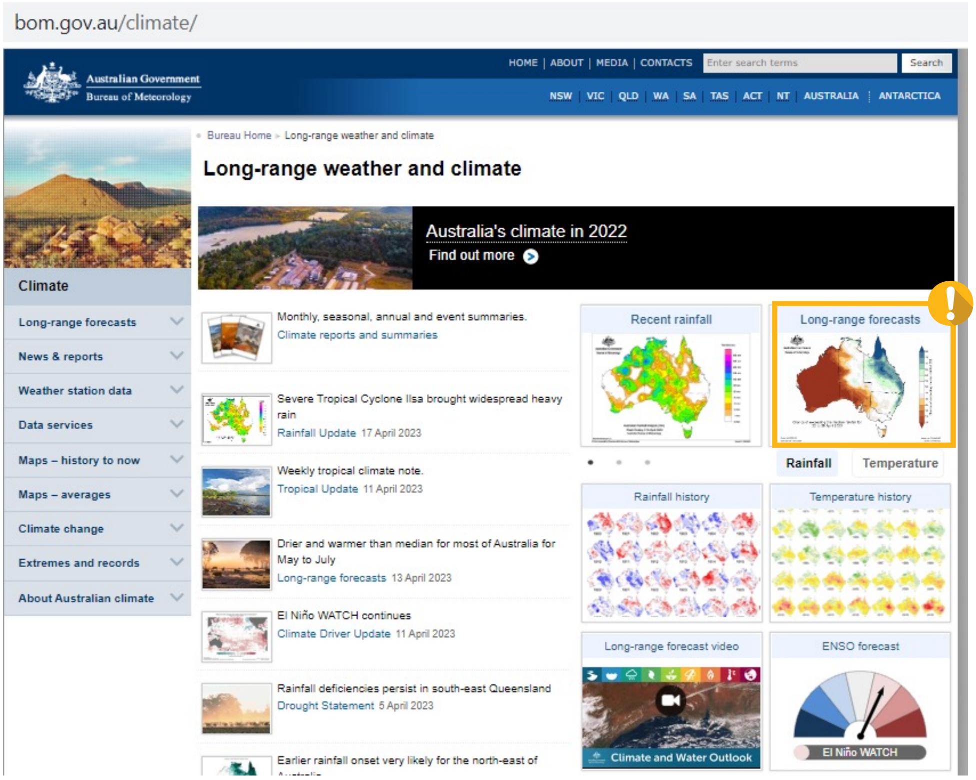
# A1 Appendix 1 – how to access the FWFA tools

**The Bureau of Meteorology has various tools and resources available on their website, accessible through www.bom.gov.au. The five climate forecast tools can be accessed through the homepage of the Bureau by clicking *Climate and Past Weather* under *Our Services*.**




*Please note: key website navigation items are indicated with a yellow box and FWFA exclamation (!) icon.*

From here, the *Long-range forecasts* can be found on the right side of the page.



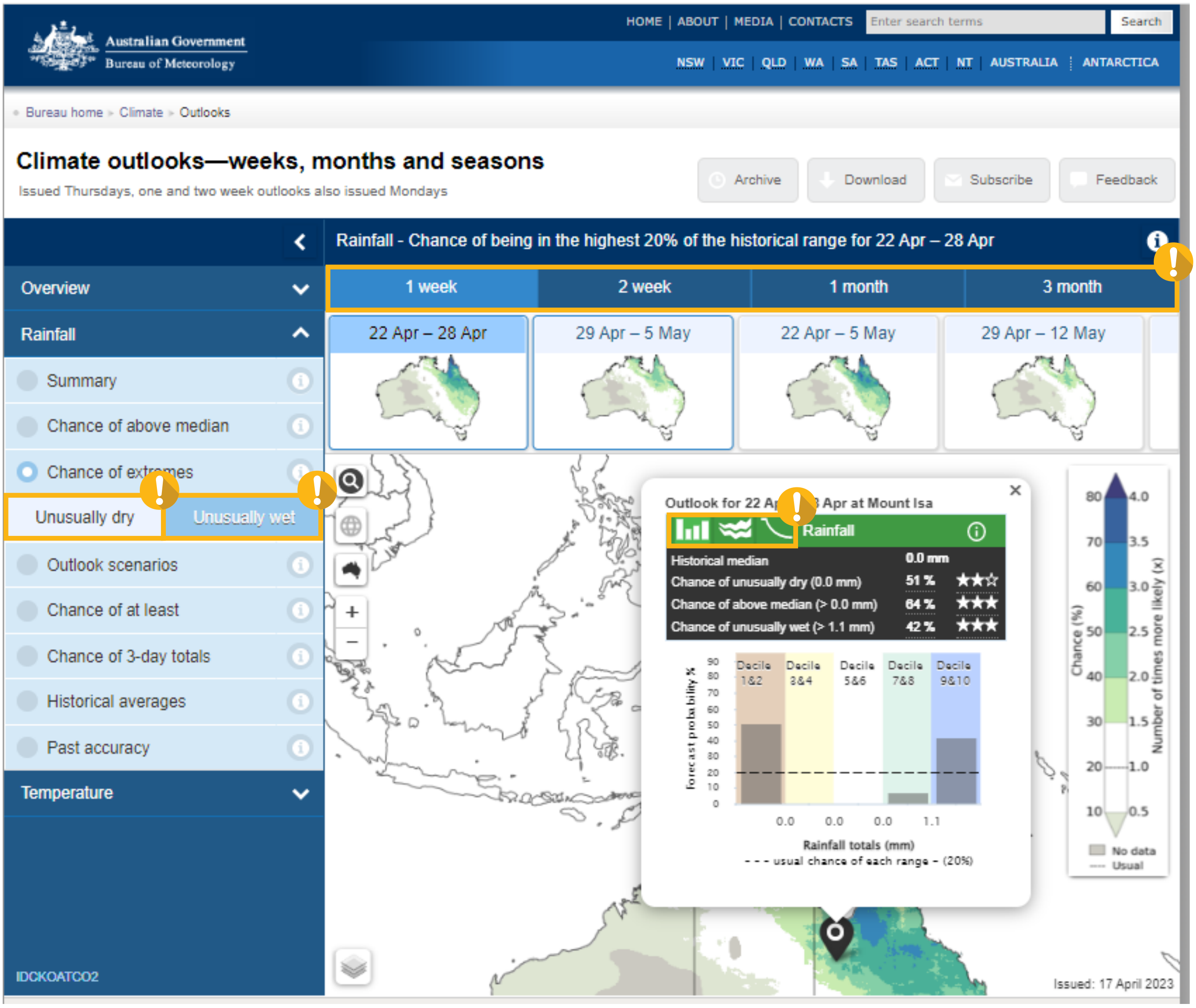

The next page presents an overview of the climate outlook tools, with options for *Overview, Rainfall and Temperature*.

Both under *Rainfall and Temperature*, we have access to several maps. Most of us will be familiar with the *Chance of above median*. Below this, we can select our *chance of extremes* map by clicking on *Chance of extremes*. For our *chance of 3-day totals* map, we can click on the *Chance of 3-day totals*.

A1

In the *Rainfall – Chance of extremes* setting, we can hit either *Unusually dry* or *Unusually wet* on the left side. It shows the map presenting the likelihood of that extreme. If we hit the magnifying glass on the map, we can search for any location in Australia by typing in the pop-up search box. Once the location is selected, a pin-drop will appear on the map and another pop-up will appear. This pop-up contains the other three tools, indicated with the icons on the top of the pop-up box. In order from left to right, they are the *decile bar chart*, the *timeline graph* and the *probability of exceedance*.

bom.gov.au/climate/outlooks/#/rainfall/extremes/p80/weekly/0



# Notes

# A2 Appendix 2 – navigating the FWFA tools

**The FWFA tools can be found by following the navigation instructions outlined in Appendix 1. This section refers to features of the FWFA tools to help explain how to use them.**

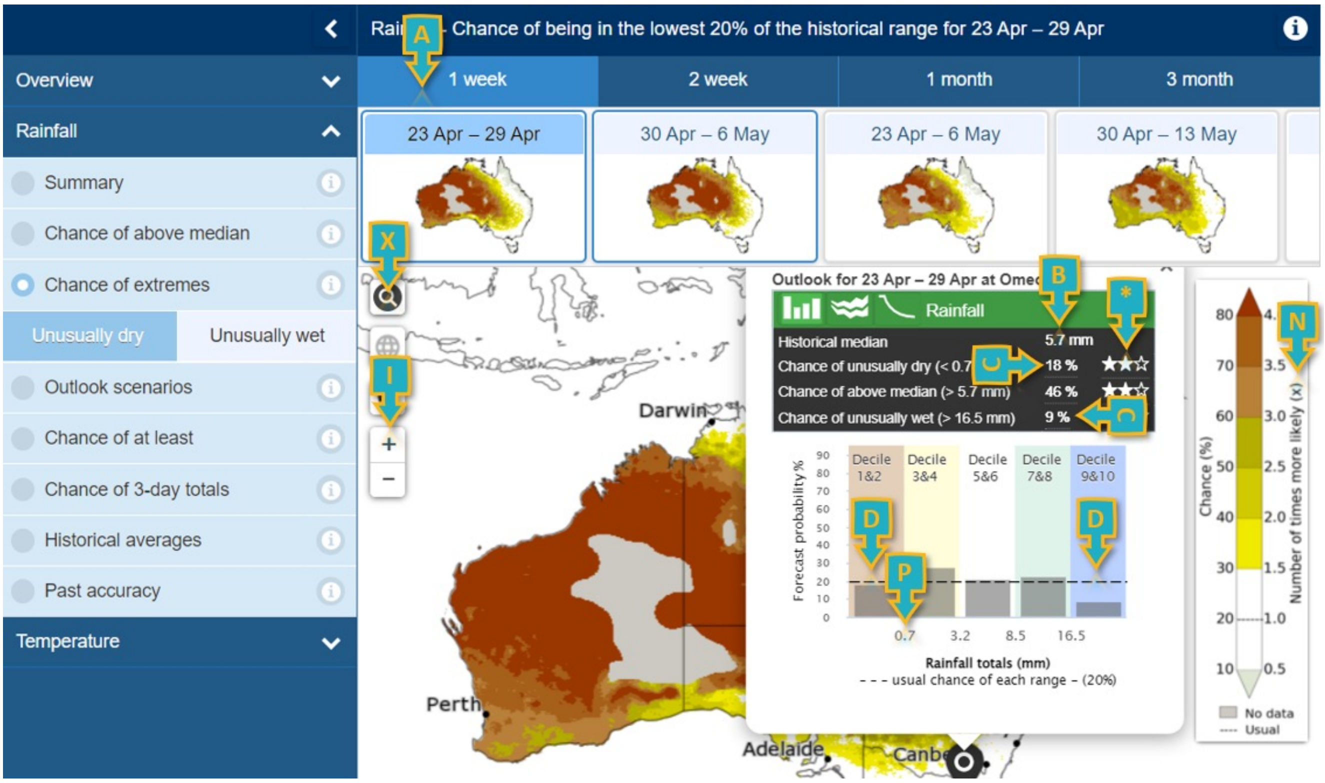



**Figure 1.** The *chance of extremes* map for unusually dry conditions displayed with the decile bar chart for Omeo (VIC), including markers to explain various features of the tools. http://www.bom.gov.au/ 18 April 2023.

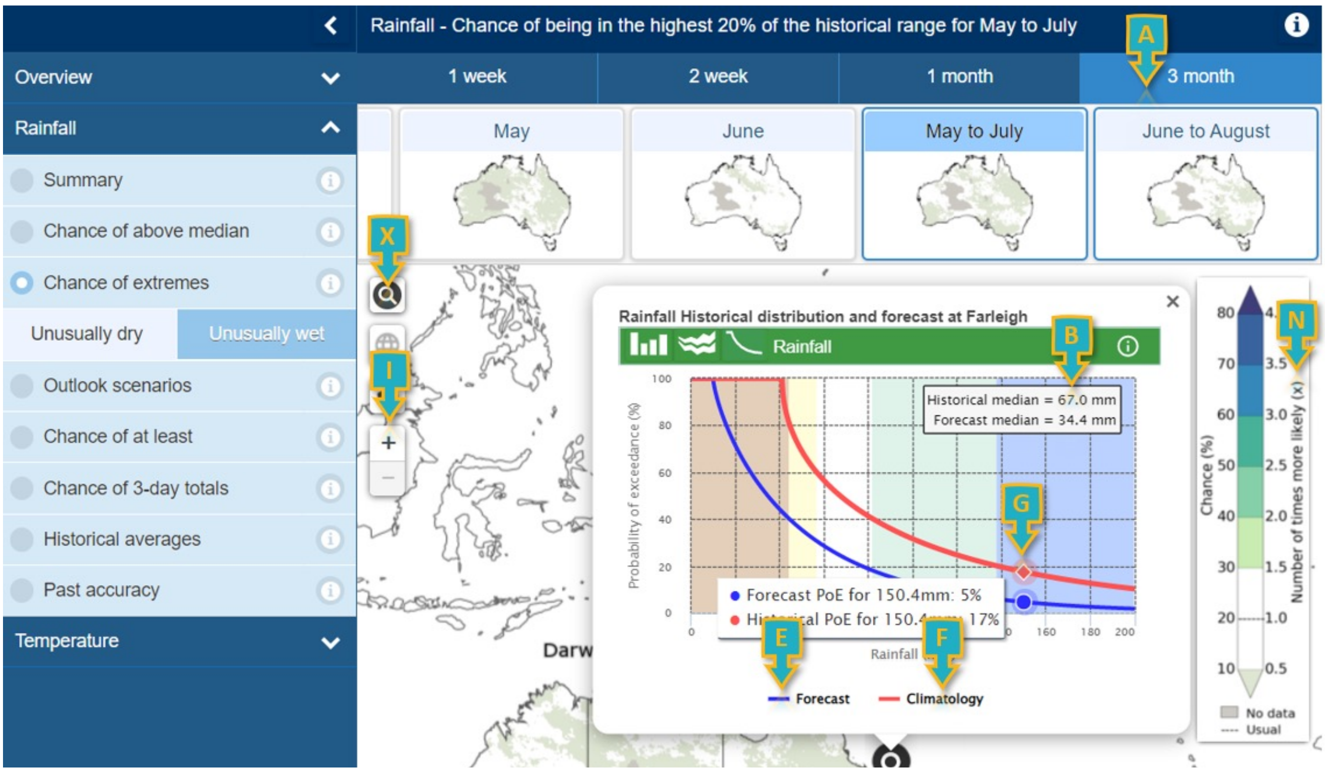



**Figure 2.** The *chance of extremes* map for unusually wet conditions displayed with the *probability of exceedance* graph for Farleigh (QLD), including markers to explain various features of the tools. http://www.bom.gov.au/ 18 April 2023.

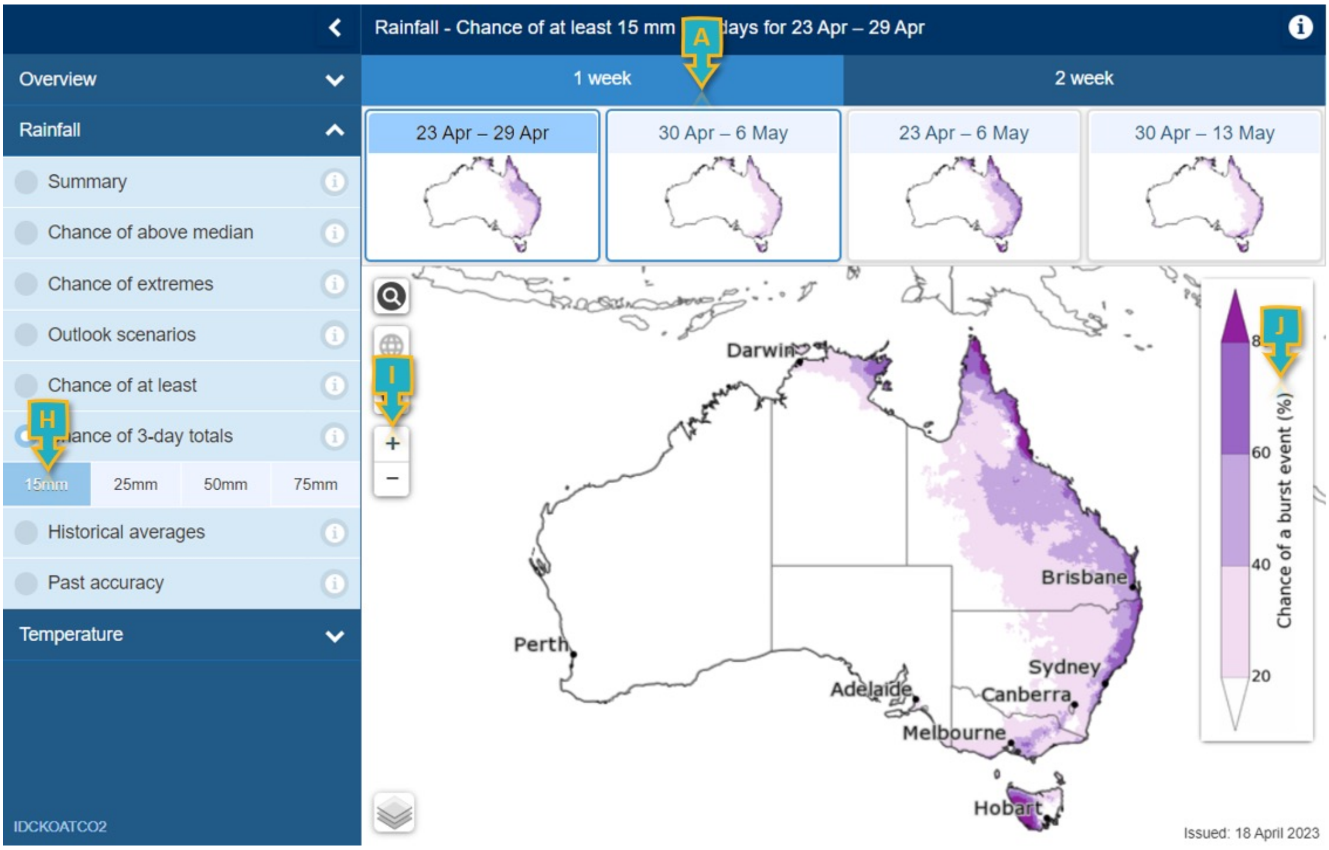



**Figure 3.** The *chance of 3-day totals* map for unusually dry conditions, including markers to explain various features of the tool. http://www.bom.gov.au/ 18 April 2023.

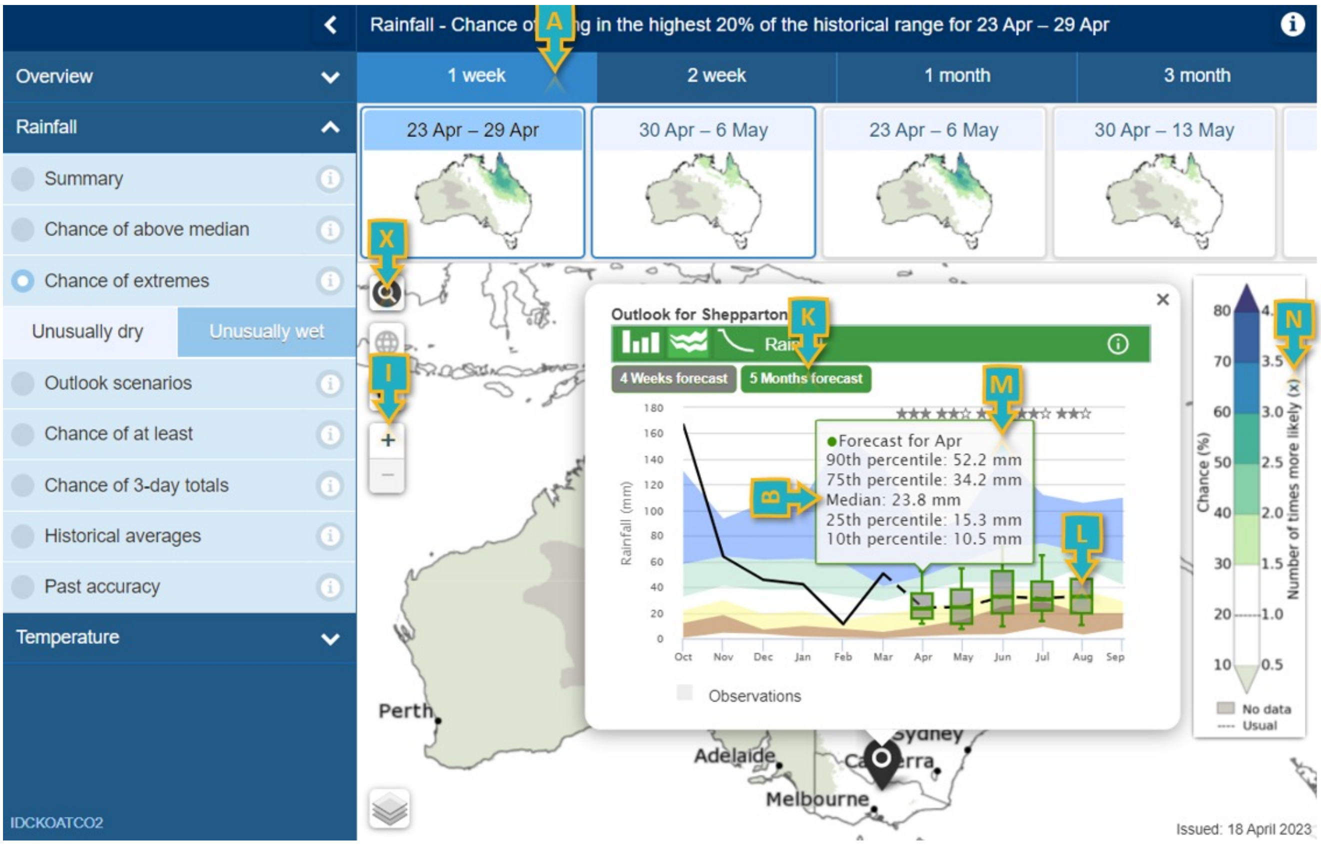



**Figure 4.** The *chance of extremes* map for unusually wet conditions displayed with the timeline graph for Shepparton (VIC), including markers to explain various features of the tools. http://www.bom.gov.au/ 18 April 2023.

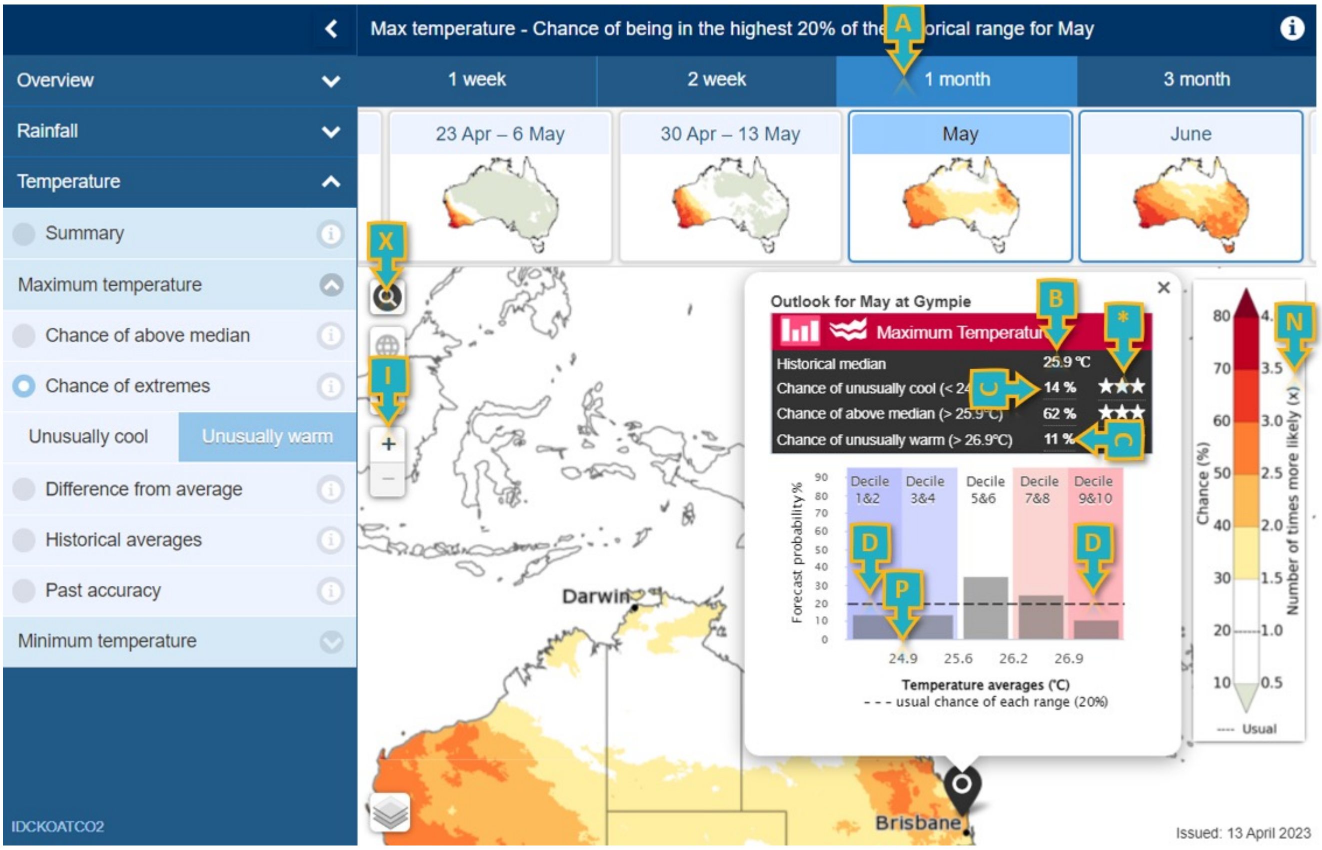



**Figure 5.** The *chance of extremes* map for unusually warm conditions displayed with the decile bar chart for Gympie (QLD), including markers to explain various features of the tools. http://www.bom.gov.au/ 18 April 2023.

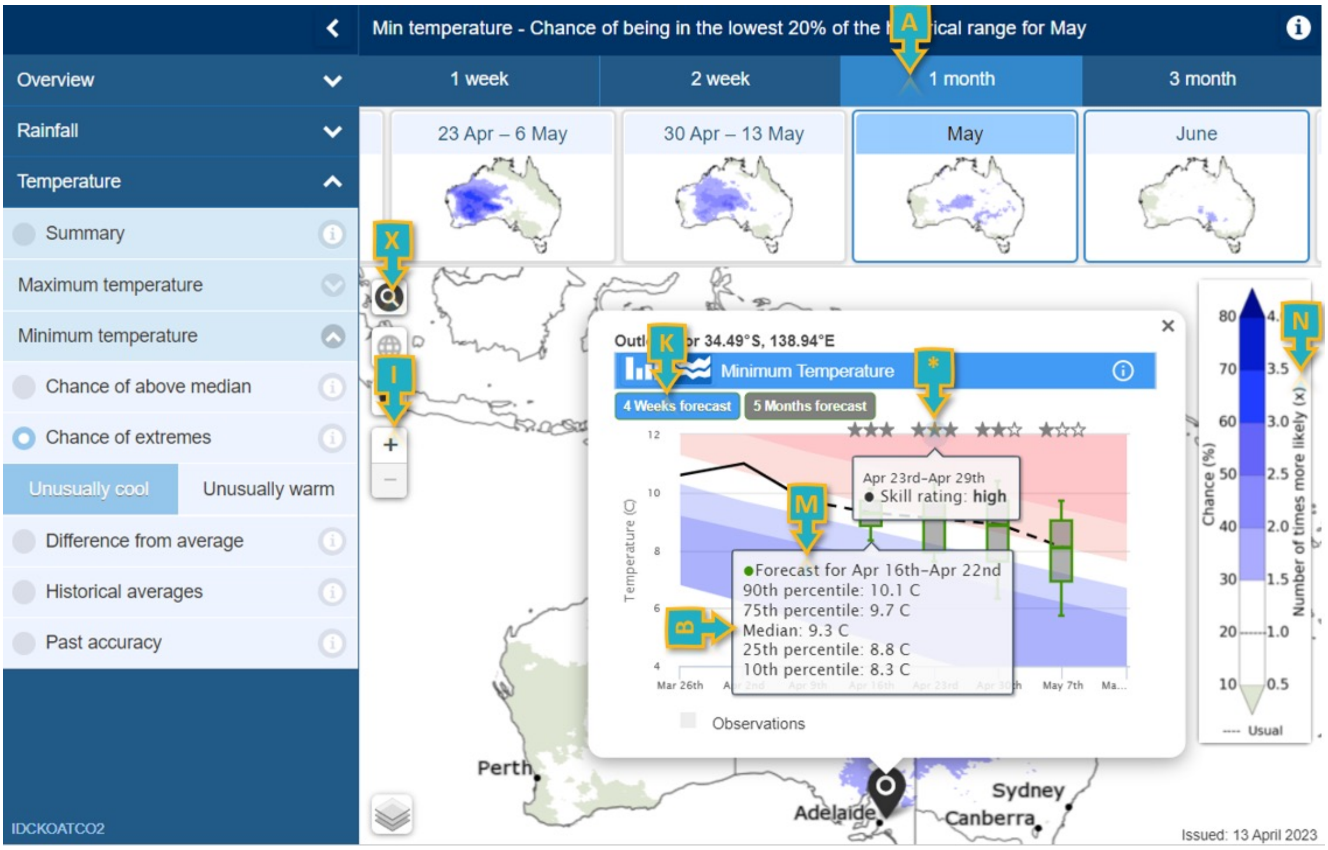



**Figure 6.** The *chance of extremes* map for unusually cool conditions displayed with timeline graph for a location in South Australia, including markers to explain various features of the tools. http://www.bom.gov.au/ 18 April 2023.

| Marker | Description |
| --- | --- |
| A | Selection of time scale from the ribbon: 1 week, 2 weeks, 1 month or 3 months |
| B | Median temperature or rainfall (historical or forecast) |
| C | Chance of an extreme (i.e. unusually cool/warm or dry/wet) |
| D | Decile bar |
| E | Forecast line in the *probability of exceedance* graph |
| F | Climatology line in the *probability of exceedance* graph |
| G | Selected rainfall on the X-axis with associated probability of exceedance |
| H | Selection of a rainfall total in a *chance of 3-day totals* event |
| I | Zoom function on the map |
| J | Probability scale for a burst event with corresponding colour coding |
| K | Selection of 4-week or 5-month forecast in the timeline graph tool |
| L | Box and whisker plot |
| M | Pop-up box with details for a box and whisker plot |
| N | Probability scale with corresponding colour coding |
| P | Upper limit of a decile in the *decile bar chart* tool |
| * | Accuracy estimate/scale |
| X | Location search function |

## Notes

A3

# Appendix 3 – case studies

**Case studies form an important part of the learning material for FWFA workshops. The case studies may be shared with workshop participants prior to the workshop (using the flipped learning approach) or they be used during the workshop, or a combination of both. The case studies are short scenarios offering context and a location to encourage participants to find and use the tools on the Bureau's website. They give participants a reason to play and learn more about the tools, and perhaps run into problems they might want to raise and clarify during a workshop.**

The case studies presented in this section can be used as they are. They can also be used as an example to help you design your own case study, based on the industry and the location relevant to the workshop you will be delivering.

When creating new case studies for your workshop, the case studies should:

- Prompt the workshop participant to:
  - *find* all five tools on the Bureau's website.
  - *use* all five tools.
  - *practice* interpreting the tools.
- Include a location to prompt the use of the search-function.
- Include all styles of farming (i.e. it should not raise discussion or disagreement on best management practice).
- Be simple (i.e. avoid being too detailed).
- Take gender-equity into account (i.e. consider the use of he/she/they sensibly).

When using the case studies during the workshops, start with questions about the case studies and the use of the tools first. Ensure all case studies are used to show how the tools are found, where the information within the tools is found, and how this could be used to answer a production question.

## Notes

# Case study – grain

## Grain 1: heatwaves and summer spraying efficacy in Bruce Rock (WA)

A grain producer in Bruce Rock (WA) has experienced a wet spring and harvest and there is now a significant summer spraying program to complete to preserve the soil moisture. Timely summer spraying is critical to keep costs down, preserve more moisture, and improve efficacy. Efficacy is impacted by heatwaves and the associated weed stress. The producer wants to know if this is likely to be an issue, so she can implement some actions to minimise the impacts on timely summer spraying (e.g. bring in contractors to get more done during periods of better weather).

Use the *chance of extremes map for maximum temperatures: chance of extremes – unusually warm*.

Select the *decile bars*.

- What is the historical median maximum temperature for Bruce Rock for the next month?

Select the *timeline graph*.

- What is the 75th percentile temperature on the 4-week forecast?
- What is the accuracy involved with the forecast 1 month from now?
- How does this accuracy differ with the forecast 5 months from now?

## Grain 2: rain outlook after sowing of canola in Jamestown (SA)

A grain producer in Jamestown (SA) is nervous about sowing canola into marginal soil moisture in late April in case there is a germination with no follow-up rain. The producer wants to know if there is likely to be a significant dry spell in late April and May that could compromise the canola survival and lead to establishment failure, so that she can implement some actions to minimise the impact (e.g. hold off sowing canola until suitable conditions).

Use the *probability of exceedance* graph for Jamestown (SA).

- Can this producer expect more or less rainfall than the typical rainfall for Jamestown for this time of year?
- What is the forecasted probability of exceedance for a total of 40 mm rainfall in the next month?

Use the *decile bar charts*.

- How likely is an extreme dry (decile 1 & 2) event? What is the associated probability?
- What is the accuracy of that forecast?

## Grain 3: temperature and rain outlook for a wheat producer in Pinnaroo (SA)

A grain producer at Pinnaroo (SA) has a wheat crop that has grown well but is now showing signs of severe moisture stress at flag leaf. She is concerned that with no further rain and warm weather the crop will yield poorly and have high screenings levels. She wants to know the likelihood of a significant rain in the next weeks, and the likelihood of high temperatures, so that she can implement some actions to minimise the impact (e.g. cut the crop for hay).

Use the *chance of 3-day totals* map.

- What is the chance of a bursts event of more than 15 mm rainfall within three days during the next two-week period?

Use the *chance of extremes map for maximum temperatures: chance of extremes – unusually warm*.

- What is the historical median maximum temperature for Pinnaroo for the next month?
- What is the chance of an unusually warm (decile 9&10) event? What is the accuracy involved? How does this differ from the chance and accuracy of decile 7&8?

# Case study results – grain

## Grain 1: heatwaves and summer spraying efficacy in Bruce Rock (WA)

Use the *chance of extremes* for maximum temperatures, unusually warm. Search for Bruce Rock (X) and select one month from the ribbon above the main map (A). Select the *decile bar chart* and read the historical median maximum temperature (B).

Use the *timeline graph*, select the 4-week forecast (K) and hover over the box and whisker plot to see the details associated with the plot (M). Read what the 75th percentile is. Hover over or click on the accuracy rating to see the skill rating associated with the point of interest, which is 1 month from now (the final box and whisker plot on the 4-week forecast). Change the timescale to the 5-month forecast (K) and look at the skill rating with the final box and whisker plot on the graph. Compare the two to see if the longer-term forecast has a lower accuracy than the shorter-term forecast.

The spread of the forecast outlooks can be assessed by looking at the length of the whiskers. Long whiskers and an elongated box indicate a bigger spread in forecast model outcomes, indicating more uncertainty about the forecast.

## Grain 2: rain outlook after sowing of canola in Jamestown (SA)

Search for Jamestown in the search function (X) and select the *probability of exceedance* graph. Have a look at the position of the forecast line (E) compared to the climatology line (F). If the forecast line is below the climatology line, the graph indicates that less than median rainfall can be expected. If the forecast line is above the climatology line, more than median rainfall can be expected. The probability of exceeding 40 mm rainfall in the next month requires selection of 1-month from the ribbon above the main map (A) and the cursor needs to be on the 40 mm (G) to be able to read the probability of 40 mm on the forecast line.

Use the *decile bar charts* for Jamestown (X) and look at the decile 1&2 bar (D). Find the associated probability by hovering over the bar (D) or reading the figure from the table above the bar chart for unusually cool (C). Check the accuracy of the forecast by hovering over the rating (*).

## Grain 3: temperature and rain outlook for a wheat producer in Pinnaroo (SA)

Use the *chance of 3-day totals* tool, select 2 weeks from the ribbon above the main map (A) and select 15 mm for the burst event (H). Select the search function to find Pinnaroo (X) and once found, exit the location-based pop-up by clicking the exit-cross on the top-right corner. Zoom in on Pinnaroo (I) to better see the colour shading the area around Pinnaroo and read the chance of a burst event using the colour scale beside the map (J). Highlighting the exact location of a place can be found and indicated with a pin with the search function gives the opportunity to explain that the location-specific tools do not provide more detail for a burst-event. The *chance of 3-day totals* tool is a map tool using colour coding (J) to indicate the chance of a burst event.

Use the *chance of extremes map* for maximum temperatures, unusually warm. Search for Pinnaroo (X) and select 1 month from the ribbon above the main map (A). The historical median maximum temperature can be found by using the *decile bar chart* or the *timeline graph*. When using the d*ecile bar chart*, the median maximum temperature can be read in the table above the bar chart (B). When using the *timeline graph*, hover over the boxplot to see the pop-up for a particular week (M). Demonstrating both approaches explains that with the timeline graph, you can view weekly medians on a longer timescale. Whereas with the *decile bar chart*, you can view the median for either 1 week, 2 weeks, 1 month or 3 months from the date of the last model iteration (date viewed on bottom right where it indicates "Issued:…").

To view the chance of an usually warm event, select the *bar chart* and read the probability from the table above the chart (C) or by hovering over the decile 9&10 bar (D).

# Case study – red meat

### Red meat 1: rainfall for sowing pasture on a beef farm in Omeo (VIC)

A beef producer in Omeo (VIC) is considering the timing of sowing a new pasture in autumn. The producer has set a threshold of 15 mm and a reasonable outlook for rainfall in the fortnight after, before wanting to consider sowing.

Use the *decile bar chart*.

- What is the historic median rainfall for Omeo in the period of the next two weeks?
- What is the probability of an extreme wet (decile 9&10) event?

Use the *probability of exceedance* graph.

- Can this producer expect more or less rainfall than the typical rainfall for Omeo for this time of year?
- What is the forecasted probability of exceedance for 40 mm rainfall in the next month?

Use the *chance of 3-day totals* tool.

- What is the chance of a bursts event of more than 15 mm rainfall within three days during the next two-week period?

### Red meat 2: lambing on a flood plain in Euabalong (NSW)

A fine wool merino producer in Euabalong (NSW) has been given the opportunity to agist lambing ewes near Shepparton (VIC). The producer is weighing up whether the extra cost will be worth it by assessing the risk of unusually wet conditions for the months to come.

Use the *chance of extremes map for rainfall: chance of extremes – unusually wet*.

Use the *decile bar charts*.

- What is the chance of an unusual wet event over the next three months for Euabalong?
- What is the chance of an unusual wet event over the next three months for Shepparton?

Use the *timeline graphs* for Euabalong and Shepparton for the five-month forecast.

- What are the monthly median rainfall figures for both Euabalong and Shepparton?
- Which location do you think is more likely to receive unusually wet weather?

## Notes

# Case study results – red meat

## Red meat 1: rainfall for sowing pasture on a beef farm in Omeo (VIC)

Use the *decile bar chart* for location Omeo (X), look at the historic median rainfall (B) for the next two weeks, selected from the ribbon above the main map (A). The probability of an extreme wet can be read in the table above the chart (C) or by hovering your mouse over the decile 9&10 bar (D).

Use the *probability of exceedance* graph and look at the position of the forecast line (E) compared to the climatology line (F). If the forecast line is below the climatology line, the graph indicates that less than median rainfall can be expected. If the forecast line is above the climatology line, more than median rainfall can be expected. The probability of exceeding 40 mm rainfall in the next month requires selection of 1 month from the ribbon above the main map (A) and your cursor will need to be on the 40 mm (G) to be able to read the probability of 40 mm on the forecast line.

Use the *chance of 3-day totals* tool, select 15 mm from the options (H) and select a timeframe of two weeks from the ribbon above the main map (A). Then zoom into the region around Omeo (I), and read the colour-code on the side (J).

## Red meat 2: lambing on a flood plain in Euabalong (NSW)

The use of the *chance of extremes* map is similar to case study 1, using the location search function (X). The same decile is looked at (D) in the *decile bar chart* tool. Select three months from the ribbon above the main map (A).

Use the *timeline graph* and select the five-month forecast (K). The median rainfall for the months is viewed by hovering the cursor over the box and whisker plots (L) and looking at the pop-up box (M) displaying (amongst other things) the median rainfall figure. You might want to write these figures down to be able to compare them between the two locations for the five months.

## Notes

# Case study – dairy

### Dairy 1: rainfall in a flood-prone area of Deloraine (TAS)

A dairy farm in Deloraine (TAS) is located in a flood-prone area and the farmers want to know if they can expect extreme wet weather in the next three months so they can be pro-active about decisions involving the potential need to destock.

Use the *probability of exceedance*.

- What is the outlook for the next three months like? Is it likely that forecasted rainfall will exceed historical rainfall for that time of year in Deloraine?

Use the *decile bar charts*.

- How likely is an extreme wet (decile 9&10) event? What is the associated probability?
- What is the accuracy of that forecast?

Use the *chance of 3-day totals* tool.

- What is the likelihood of Deloraine receiving more than 50 mm in three days over the next two weeks?
- What is the associated accuracy of that forecast?

### Dairy 2: heatwave preparation on a dairy farm in Gympie (QLD)

A dairy farmer in Gympie (QLD) is planning repair and maintenance work on the sprinkler system in the holding yard and wants to put up a new shade cloth. The farmer has to prioritise tasks but first wants to know how likely a heatwave will be in the next month.

Use the *chance of extremes map for maximum temperatures: chance of extremes – unusually warm*. Select the *decile bar chart*.

- What is the historical median maximum temperature for Gympie for the next month?
- How likely is it that the farmer can expect extreme hot weather in the next month?
- Is there a chance that temperatures will exceed 37 degrees?

Use the *timeline graph.*

- What is the 75th percentile temperature on the 4-week forecast?
- What is the accuracy involved with the forecast 1 month from now?
- How does this accuracy differ with the forecast 5 months from now?

## Notes

# Case study results – dairy

### Dairy 1: rainfall in a flood-prone area of Deloraine (TAS)

Use the *probability of exceedance* when selecting Deloraine as location (X) and 3 months from the ribbon above the main map (A). Compare the forecast (E) and climatology (F) lines. If the forecast is above the climatology line, a wetter outlook is expected. If the reverse, a drier outlook is expected.

Use the *decile bar charts* for Deloraine (X) and look at the decile 9&10 bar (D). Find the associated probability by either hovering over the bar (D) or reading the figure from the table above the bar chart (C). Check the accuracy of the forecast by hovering over the rating (*).

Use the *chance of 3-day totals* tool and select 50 mm (H). Zoom in on Deloraine (I) to better see the colour covering the area around Deloraine, and read the chance of a burst event using the colour scale beside the map (J).

### Dairy 2: heatwave preparation on a dairy farm in Gympie (QLD)

Use the *chance of extremes map* and select 1 month from the ribbon above the main map (A). Look at the historical median temperature (B). If needed, zoom into the area around Gympie (I) to look at the colour scale next to the map (N) indicating the chance of extreme maximum temperatures. This can also be assessed by looking at decile 9&10 (D). Remember that the tools only operate relative to the median, so what is classed as “hot weather” can be discussed with workshop participants. The purpose of this case study is for participants to see the historical median maximum temperature as an absolute figure, and compare it with what is agreed as a heatwave (in this example a threshold of 37 degrees).

Use the *timeline graph*, select the 4-week forecast (K) and hover over the box and whisker plot to see the details associated with the plot (M). Read what the 75$^{th}$ percentile is. Hover over or click on the accuracy rating to see the skill rating associated with the point of interest, which is one month from now (the final box and whisker plot on the 4-week forecast). Change the timescale to five months forecast (K) and look at the skill rating associated with the final box and whisker plot on the graph. Compare the two to see if the longer-term forecast has a lower accuracy than the shorter-term forecast.

## Notes

# Case study – wine

## Wine 1: decision making around frost for a wine grape producer in Marananga (SA)

A wine grape producer in Marananga (SA) has had a bad experience with frost affecting the yield and quality of the winegrapes and would like to be more proactive with interventions. The producer wants to use the Bureau tools to be more informed about deciding on the correct timing of irrigation to reduce frost risk, whilst being mindful of an already wet soil profile.

Use the *chance of extremes map for minimum temperatures: chance of extremes – unusually cool*.

- What is the historical median minimum temperature for Marananga for the next month?
- What is the past accuracy of the chance of an above median minimum temperature for Marananga on a 2-week timeframe at this time of year?
- How does this accuracy differ when looking at 3 months ahead?

Use the *probability of exceedance* graph for rainfall (chance of extremes).

- What is the historical median rainfall for the next month?
- Can this producer expect extreme wet weather in the next two weeks?

## Wine 2: timing of pruning for a wine grape producer in Colbinabbin (VIC)

A wine grape producer in Colbinabbin (VIC) has the opportunity to commence pruning next week, or delay the contract pruning crew for 8 weeks. The producer is keen to minimise trunk disease spread by avoiding pruning in wet weather if at all possible.

Use the *chance of extremes map - unusually wet*. Select the *timeline graph* for Colbinabbin (VIC).

- What is the 75th percentile rainfall for each of the next four weeks?
- On the 5 months forecast, is the median rainfall forecast higher for the current month, or in two months' time?

Use the *decile bar charts*.

- For the next two weeks, is the rainfall forecast likely to be above median, below median or around average?
- Similarly, what is the likely rainfall prediction for the second 1-month forecast?
- What is the past accuracy for the chance of being unusually dry for this monthly rainfall forecast?

Use the *chance of 3-day totals* map.

- What is the chance of a bursts event of more than 15 mm rainfall within three days during the next two-week period?

## Notes

# Case study results – wine

## Wine 1: decision making around frost for a wine grape producer in Marananga (SA)

Use the *chance of extremes map* for minimum temperatures, unusually cool. Search for Marananga (X) and select 1 month from the ribbon above the main map (A). As with the *Grain 3* scenario for Pinnaroo, the historical median can be found by using the *decile bar chart* or the *timeline graph*, in this case for the median minimum temperature.

Change the timescale to 2 weeks from the ribbon above the main map (A) and find the accuracy associated with the chance of an unusually cool temperature by looking at the rating next to the probability above the bar chart for unusually cool (*), or by checking the accuracy above the box and whisker plots in the timeline graph (*).

The spread of the forecast outlooks can be assessed by looking at the length of the whiskers. Long whiskers and an elongated box indicate a bigger spread in forecast model outcomes, indicating more uncertainty about the forecast.

Change the timescale to 3 months from the ribbon above the main map (A) and compare the accuracy, between a 2-week and a 3-month forecast.

Use the opportunity to explain that the five FWFA tools cannot indicate frost risk as such, but they can indicate a cooler period, which can prompt us to be mindful of the risk of a frost, and for more certainty check the 7-day weather forecast.

Change maps to *rainfall* and the *chance of extremes map*. Select Marananga in the search tool (X) and select the *probability of exceedance* graph for one month from the ribbon above the main map (A). Read the historical median rainfall for Marananga for the selected period of time (B).

Change the timescale to 2 weeks from the ribbon above the main map (A). Check the position of the forecast line (E) compared to the climatology line (F). If the forecast line is below the climatology line, the graph indicates less than median rainfall can be expected. If the forecast line is above the climatology line, more than median rainfall can be expected.

## Wine 2: timing of pruning for a wine grape producer in Colbinabbin (VIC)

Use the *chance of extremes map*, unusually wet, for the location Colbinabbin using the search function (X). Select the *timeline graph* and choose the 4-week forecast (K). Hover over the four box and whisker plots presented and read the 75$^{th}$ percentiles (M).

Change the timescale to 5 months (K), hover over the first and second box and whisker plots to compare the median rainfall forecast for those months (M).

Use the *decile bar chart* and change the timescale to 2 weeks from the ribbon above the main map (A). Look at the decile bars (D) and determine the decile that has the highest forecast probability, and discuss what that means. Change the timescale to 1 month from the ribbon above the main map (A). Again, check the decile bars (D) and determine the decile that has the highest forecast probability.

Change the *chance of extremes* map to unusually dry and pull the decile bar chart back up for 1 month from the ribbon above the main map (A). Check the chance of unusually dry (C) and hover over the associated probability (*).

Use the *chance of 3-day totals* tool and select 15 mm (H). Select 2 weeks from the ribbon above the main map (A). Zoom into Colbinabbin (I) to better see the colour shading the area around Colbinabbin, and read the chance of a burst event using the colour scale beside the map (J).

# Case study – sugar

## Sugar 1: conserving on-farm water storage in Farleigh (QLD)

During the warmer months, a canegrower in Farleigh (QLD) uses supplemental irrigation. During the cooler months, irrigation is used to establish the plant cane and ratoon crops. The canegrower wants to know the rainfall outlook. If it is dry, the canegrower will conserve water in the dam for next season.

Use the *chance of extremes map for unusually dry.*
- What is the chance of unusually dry conditions over the next three months?

Use the *decile bar chart.*
- Are unusually dry (decile 1&2) conditions the most likely across the five bars over the next three months?
- What is the past accuracy of this forecast?

Use the *probability of exceedance* graph.
- The canegrower estimates a need for 150 mm of rainfall to recharge the dam. What is the forecast probability of getting sufficient rainfall over the next three months?

## Sugar 2: timing of fertiliser applications in Mossman (QLD)

A canegrower based in Mossman (QLD) is considering their upcoming fertiliser applications and wants to know to chance of an extreme rainfall event within the next 3-4 weeks after application to minimise mobilization of nutrients and nutrient loss.

Use the *decile bar chart.*
- What is the historic median rainfall for Mossman in the period of the next two weeks?
- What is the probability of an extreme wet (decile 9&10) event?

Use the *chance of 3-day totals* map.
- What is the chance of a burst event with more than 75 mm in three days for Mossman in the next two weeks?

## Sugar 3: conserving soil moisture under legume break crops in Farleigh (QLD)

A canegrower in Farleigh (QLD) planted a cowpea cover crop. The cover crop will be incorporated into the soil when it reaches maturity. The canegrower wants to keep an eye on the soil moisture profile after planting of the cover crop has taken place. If there is a risk that rainfall will be low, the cover crop will be sprayed out early.

Use the *chance of extremes map for unusually wet.*
- What is the historical median rainfall for Farleigh over the next three-month period?

Use the *timeline graphs.* Select the 5 months forecast.
- Does the forecast show a wetter than usual outlook?
- Look at the box and whisker plots, is there a large range of forecast outlooks? If yes, what does this mean? If no, does the forecast suggest a drier or wetter than usual forecast?

Use the *probability of exceedance* graph.
- Is the forecasted rainfall for the next three months above, below or neutral relative to the historical observations?
- What is the probability of receiving 110 mm of rainfall (estimated legume water use) in the next three-months?

Use the *chance of 3-day totals* map.
- Can this grower expect more than 75 mm in three days (which would be great for recharging the soil profile) over the next two weeks?
- What is the chance of such burst event?

## Sugar 4: considering frost risk over harvest in Casino (NSW)

A canegrower based in Casino (NSW) is planning the harvest schedule, and wants to know the likelihood of an extreme cold event during harvest to plan the harvest schedule by prioritising harvest of high-risk areas.

Use the *chance of extremes map for minimum temperatures: chance of extremes – unusually cool.*
- What is the historical median minimum temperature for the period of one month?
- How does that differ from the median minimum temperature for one week?
- Is there a difference in accuracy between the two?

Use the *decile bar chart.*
- What is the upper limit of the decile 1&2 for minimum temperature?
- What is the chance of an extreme cold (decile 1&2) event one week ahead?
- Is this much different from the chance of an extreme cold event over 1 month? And 3 months?

Use the *timeline graphs.*
- Select the 5-month forecast; is the outlook warmer or cooler than median temperatures for Casino?
- What is the lowest median minimum temperature forecast?
- Comparing the 10th percentile figures on the 5-month forecast, do you think it is reasonable to expect an extreme cool event?

# Case study results – sugar

## Sugar 1: conserving on-farm water storage in Farleigh (QLD)

Use the *chance of extremes map*, unusually dry. Select 3 months from the ribbon above the main map (A). Use the location search function (X) to locate Farleigh, but exit the pop-up box (click on the exit-cross in the top right hand corner) to have a clear view of the map. Determine what colour the area around Farleigh is shaded, and how this colour relates to the chance of an unusually dry period over the next three months (N).

Use the *decile bar chart* for Farleigh (X). Compare the bars (D) and hover over them to see the associated probability with the deciles. Note that the probability of an unusual dry event can also be read from the table above the bar charts (C). Hover over the star-rating next to this probability to view the associated accuracy (*).

Use the *probability of exceedance* graph for Farleigh (X) for 3 months from the ribbon above the main map (A). Look for 150 mm on the X-axis of the graph and hover the mouse over the lines above the 150 mm mark (G). Compare the forecast (E) and climatology (F) lines. If the forecast is above the climatology line, a wetter outlook is expected. If the reverse, a drier outlook is expected.

## Sugar 2: timing of fertiliser applications in Mossman (QLD)

Use the *decile bar chart*, selecting the location Mossman (X), and look at the historic median rainfall (B) for the next 2 weeks, selected from the ribbon above the main map (A). The probability of an extreme wet can be either read from the table above the chart (C) or by hovering over the decile 9&10 bar (D).

Use the *chance of 3-day totals* map, select 2 weeks from the ribbon above the main map (A) and select 75 mm for the burst-event (H). Select the search function to find Mossman (X) and once found, exit the location-based pop-up by clicking the exit-cross on the top-right corner. Zoom into Mossman (I) to see the shading over the area around Mossman, and read the chance of a burst event using the colour scale beside the map (J).

## Sugar 3: conserving soil moisture under legume break crops in Farleigh (QLD)

Use the *chance of extremes map*, unusually wet. Search for Farleigh (X) and select 3 months from the ribbon above the main map (A). Select the *decile bar chart* to find the historical median rainfall for this three month period (B).

Use the *timeline graph* and select the 5 months forecast (K). Check where the box and whisker plots sit on the graph. If the majority of the boxes are situated on the higher end of the graph, in the green and blue ribbons, a wetter than usual outlook is forecast. If the box and whisker plots are situated towards the bottom of the graph, in the yellow and brown ribbons, a drier than usual outlook is forecast. The spread of the forecast outlooks can be assessed by looking at the length of the whiskers. Long whiskers and an elongated box indicate a bigger spread in forecast model outcomes, indicating more uncertainty about the forecast.

Use the *probability of exceedance,* select Farleigh as location (X) and 3 months from the ribbon above the main map (A). Compare the forecast (E) and climatology (F) lines. If the forecast is above the climatology line, a wetter outlook is expected. If the reverse, a drier outlook is expected.

Hover the cursor over the 110 mm point on the X-axis (G) and read the associated probability of exceedance for the forecast.

Use the *chance of 3-day totals* map and select 75 mm, and 2 weeks from the ribbon above the main map (A). Zoom into Farleigh (I) to see the shading colour for the area around Farleigh, and read the chance of a burst event using the colour scale beside the map (J).

### Sugar 4: considering frost risk over harvest in Casino (NSW)

Use the opportunity to explain to workshop participants that the tools do not indicate the chance of a frost like the weather forecast would. Instead, it gives an idea if a period of unusually cool weather can be expected, which can form a prompt to keep an eye out on the weather forecast for frost risks.

Use the *chance of extremes map* for minimum temperatures, unusually cool. Search for Casino (X) and select one month from the ribbon above the main map (A). The historical median can be found by using the *decile bar chart* or the *timeline graph*, in this case for the median minimum temperature. Change the timescale to 1 week from the ribbon above the main map (A), to see the median minimum temperature is much different for a 1 week versus a 1 month forecast.

Find the accuracy associated with the chance of an unusually cool temperature by looking at the rating next to the probability in the table above the decile bar chart for unusual cool (*), or by looking at the accuracy above the box and whisker plots in the *timeline graph* (*).

Use the *decile bar chart* for Casino (X) and select 1 week from the ribbon above the main map (A) and check the upper limit (P) for the decile 1&2 bar (D). The probability of an extreme dry (decile 1&2) can be read from the table above the charts (C) or by hovering over the decile 1&2 bar (D).

Change the time scale to 1 month and 3 months, from the ribbon above the main map (A) and compare the probability of an extreme dry (decile 1&2) for both timeframes.

Use the *timeline graph* and select the 5-month forecast (K). Check where the box and whisker plots sit on the graph. If majority of the boxes are situated on the higher end of the graph, in the red and pink ribbons, a warmer than usual outlook is forecast. If the box and whisker plots are situated towards the bottom of the graph, in the light blue and darker blue ribbons, a cooler than usual outlook is forecast.

Hover over the box and whisker plots for the months ahead and compare median minimum temperatures to determine which month has the lowest median minimum temperature forecast. Also compare the $10^{th}$ percentile figures to see if they are close to the median. If this is the case, and the box and whisker plot looks condensed (as opposed to stretched out), the model outcomes suggest a cooler than usual event and for more certainty check the 7-day weather forecast.

The spread of the forecast outlooks can be assessed by looking at the length of the whiskers. Long whiskers and an elongated box indicate a bigger spread in forecast model outcomes, indicating more uncertainty about the forecast.

## Notes

# Event evaluation

FOREWARNED IS FOREARMED
Forecasting tools for informed decision making

**Name** *(optional)*: ______________________________

Thank you for attending today's FWFA workshop. We'd greatly appreciate your feedback, so we can further improve it for future events. Please answer this survey using the rating scales where 1 is low and 10 is high.

**1. How likely are you to use the FWFA tools in future?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Further comments *(if required)*...

**2. How confident do you feel using the FWFA tools after the workshop?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

What else would be needed to help you become more confident?

**3. How satisfied were you with the workshop?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**4. How valuable was the workshop for your business?**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**5. Do you have any other feedback or suggestions for improvement?**

## Thank you

## Notes

# Notes

# Notes

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