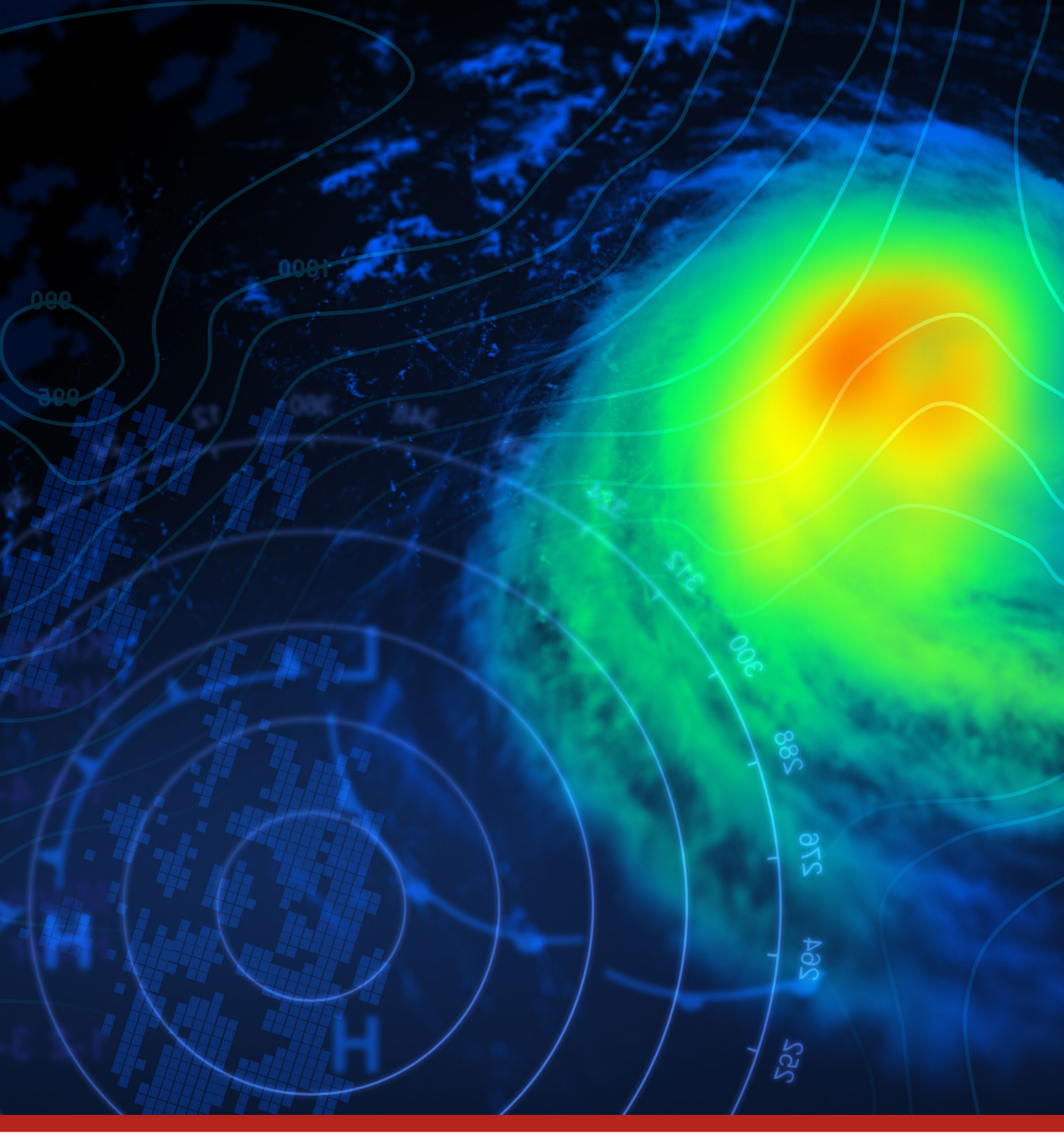

Rural R&D for Profit program
Final Report
Improved use of seasonal forecasting to increase farmer profitability

AgriFutures™ Improved Seasonal Forecasting

Appendix 13

APPENDIX 13

The opportunities and barriers to the use of seasonal climate forecasts.

Addressing activity 5 output 5(a) – for each industry cluster, analyse enabling factors and barriers to the adoption of climate forecasts in farm business decision making.

Peter Hayman SARDI, Jemma Pearl and Chris Sounness BCG

Recommendations

During a facilitated workshop at the 2018 Annual Stakeholder Forum, participants were asked to think about some possible solutions for the barriers mentioned above in this report. Responses can be found in appendix 7.

Recommendations include;

1. making the model better,
2. increasing model skill,
3. education and training,
4. localised forecasts for a physical location,
5. localised forecasts for a point in the business or production cycle,
6. continued understanding of the industries and decisions where seasonal climate forecasting could be of benefit, building on the case studies produced in activity 4 of this project, and the results of the CSIRO ADOPT tool from activity 5 output 5(b),
7. thus, targeting decisions points where seasonal climate forecasting information is relevant and useful, enabling forecasts to be contextualised for growers, advisers and supply chain,
8. decision support tools to assist in this contextualisation of seasonal climate forecasting into business and production cycle decisions for growers, advisors and supply chain,
9. understand that growers will use multiple decision support tools to begin to produce rules of thumb,
10. use understanding of industries and decisions to assist in communicating probabilistic forecasts, giving them a production slant. For example, as one participant responded, ‘chance of a forecast to meet production outcomes based on how much is on the ground, i.e. chance of X tonnes of pasture growth.’

Introduction

An underlying assumption in this project is that the actual use of seasonal climate forecasts (SCF) falls short of the potential. This report captures the response of project members and SCF specialists to the barriers and opportunities. The results should not be read as an industry survey, but rather as a collation of findings from the collective knowledge and expertise that collaborate in this area.

In research on social issues, 'organised common sense' (Punch 2013) is an important early step to systematically categorise the barriers to the use of SCF. Adoption theory usefully distinguishes between the characteristics of the innovation (SCF) and the characteristics of the target populations (farmers and advisors in the grains, livestock, cotton, rice and sugar industries).

In this project we considered the characteristics of the decision context as a third component. The decision context included when the decision was being made, the desired outcomes and the required climate information including lead time and forecast period. In one sense the decision context is just part of understanding the target population and it is difficult to neatly separate the decision context from the messy intertwined real world of the decision maker. However, separating the decision allows clear thinking on the limit due to the decision maker (time, trust, understanding, risk appetite) and the decision context (options available, profit and risk).

Based on the literature relating to the adoption of seasonal climate forecasts, the authors past experience and discussion with farmers and advisers we considered a spectrum of barriers ranging from the nature of the forecast to the capacity of farmers to use the forecast.

1. forecasts are not accurate (low skill)
2. forecasts are not emphatic enough,
3. the spatial precision is too broad,
4. the wrong parameters forecast,
5. insufficient lead time,
6. the decision is being made at a time of poor skill,
7. there are a restricted set of choices to the farmer,
8. farmers and advisers are too busy,
9. forecasts are not effectively communicated,
10. farmers don't understand probabilities,
11. farmers don't trust the Bureau of Meteorology,
12. farmers and advisers don't know how to use probabilities.

Although these barriers interact it is useful to separate them. For example, to pose the question; "what if a forecast was well communicated to a farmer who set aside adequate time and trusted the source?" It may still be that the forecast is of modest benefit because of low skill when the decision is made. If this is the case, it would be unwise to spend time and resources on capacity building and communication.

Appendix one outlines the responses receive from participants in the survey with common themes for decisions for annual crop include nutrition, crop choice, manipulation of phenology by sowing time and cultivar. Pruning for wine grapes was common, while livestock decisions involve matching feed supply and demand including stocking rates, culling and weaning.

In most cases respondents answered yes to the question; "does this decision have flexibility to respond to 1, 3 or 6-month forecasts?". In other words, they didn't view the decision context as the limiting factor. It is not surprising that respondents would select tractable decisions where they perceived the decision maker had flexibility to respond to forecasts.

The accuracy and guidance from the forecast was generally seen as limiting. In many cases this was due to the decision being made at a low skill period or inadequate spatial precision.

Respondents were asked to estimate the change over the last five years in 1) awareness of SCF, 2) understanding of climate drivers and 3) understanding of probabilistic SCF. As shown in Figure 1, awareness was ranked much higher than understanding of climate drivers with the understanding of probabilities consistently ranked as the lowest.

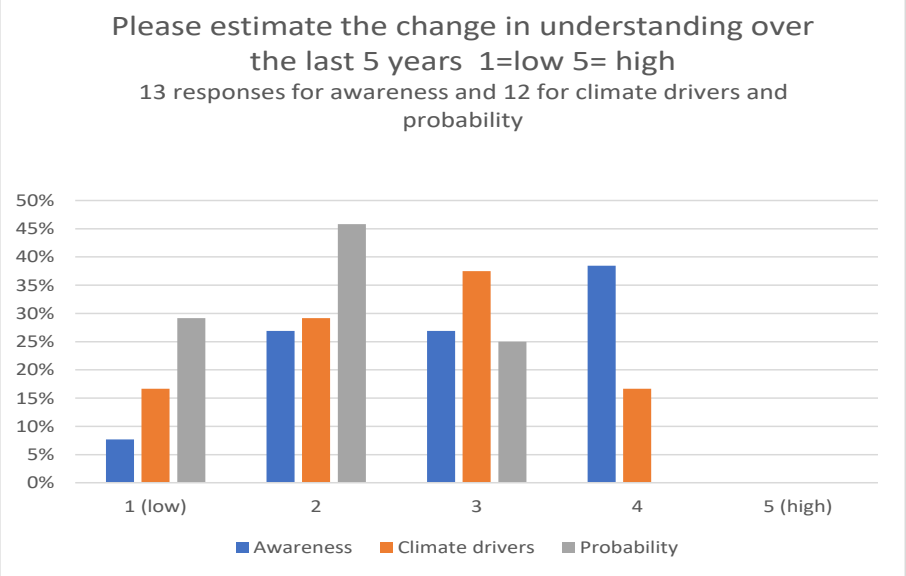

Figure 1. Estimates of the change in awareness, climate drivers and confidence in using probability.

Awareness of seasonal climate forecasting

Awareness by farmer and advisers is obviously a precursor to use. Although it is likely that there would be universal awareness of weather forecasts, the seasonal climate forecasts are an innovation that has emerged within the working life of many farmers and the application has differed across regions and industries.

Seasonal climate forecasting seems well established within sections of the rural media, especially ABC Landline, but also in newsletters focussed on SCF (e.g. the Break Victoria, Seasonal Climate Outlook WA, Seasonal Conditions Reports NSW, Sugar Seasonal Climate Newsletter Queensland, Moisture Manager Cotton, Milking the Weather Dairy Victoria, Weather Or Not NSW) or more general news (BCG eNews, Seasonal Climate Outlook – Beef Central).

Awareness is increased by difficult seasons, especially recent experiences. Although awareness is likely to accumulate over time, resources are required to maintain awareness as there are new entrants into the industry (especially as advisers).

Participants responses can be found in appendix 4. Participants generally agreed that overall awareness of SCF information had increased, with comments about SCF being increasingly discussed in the media. Comments were also made that awareness also increased during or after a climate driver event, e.g. 2010 La Niña.

Understanding of climate drivers

Seasonal climate forecasts have been available in Australia since the early 1990s. The early forecasts were based on ENSO which remains a dominant driver of climate for much of Australia. Recent decades have seen increased attention and commentary on other drivers including the Indian Ocean Dipole, the Madden Julian Oscillation, the position of the Sub-tropical Ridge and the Southern Annular Mode.

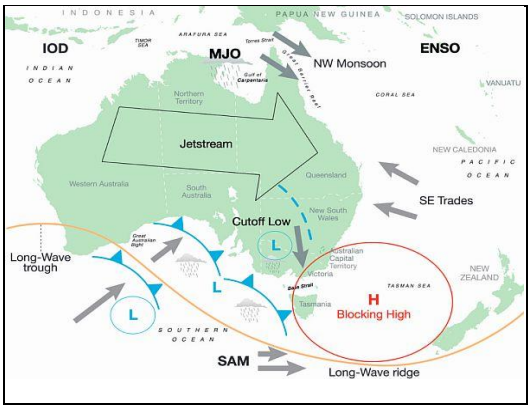

Figure 2. Primary influences on Australian climate (BoM) based on Risbey et al 2008.

An important contribution to the understanding of climate drivers was the Climate Dogs developed by Agriculture Victoria. http://agriculture.vic.gov.au/agriculture/weather-and-climate/understanding-weather-and-climate/climatedogs

Awareness and understanding of climate drivers is influenced by recent experience. Figure 3 shows April to October rainfall for Blythe in the mid-north of South Australia. Growers and advisers have recent memories of the Millennium drought (2002 -2009), during which 2006 as an El Niño and IOD positive event.

The widespread rainfall as part of the 2010 La Niña dramatically ended the Millennium drought. During the life of this project El Niño was discussed through 2014 and the dry 2015 was attributed to an El Niño followed by a much wetter 2016, which was attributed to a La Niña that turned into the strongest IOD positive. By contrast, 2017 was a year with no clear climate drivers, but was dry in many regions. For example, at Blythe the April to October rainfall was 192mm.

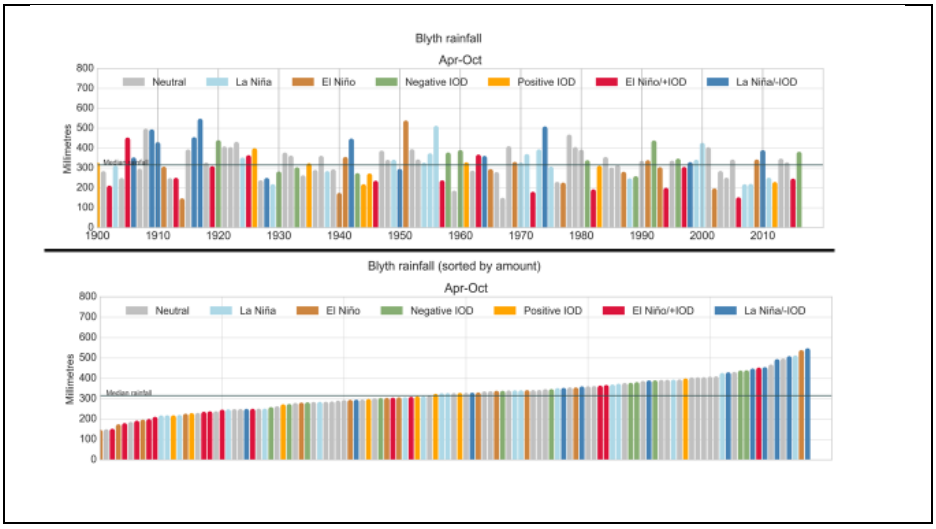

Figure 3. Time series of climate rainfall coloured by IOD and ENSO phase, produced Darren Ray SA BoM

Respondents were asked whether they thought that understanding of climate drivers had increased, which can be found in appendix 5. The general consensus was that while growers may know the names of the climate drivers, understanding how each of them effect their given region was still low.

Understanding of probabilities

Seasonal climate forecasts are commonly expressed as shifts in probabilities. There is ample psychology literature and anecdotal evidence that communicating and using probabilities in decision making is challenging.

As shown in Figure 1, respondents are optimistic about the changes in awareness (about twice as many votes for 3&4 than 1&2), cautious about changes in understanding climate drivers (about as many votes for 3&4 as 1&2) and pessimistic about grasping probabilities (about three times as many votes for 1&2 than 3&4).

It is not surprising that awareness of SCF and understanding climate drivers exceeds ability to understand probabilities. Not only has there been a greater emphasis on understanding climate drivers than use of probabilities, there is plenty of evidence that probabilities are a barrier to the use of information.

Probabilities encourage risk management and as the French mathematician and philosopher Laplace stated “probability is relative in part to our ignorance, in part to our knowledge.” The situation of high awareness and confidence in understanding the climate drivers and less emphasis on probabilities can contribute to overconfidence and causal thinking.

Some of the issues of probability in medicine is addressed in the popular book, Bad Science by Ben Goldacre. He suggests a number of ways to improve the communication and use of probabilities primarily by using frequencies rather than percentage. Frequencies have been used by the climate forecasting community in the past and were one of the communication advantages of analogue years.

Dryland farmers are familiar with deciles and these seem to be interpreted as frequencies in that a decile 3 year is understood as a year that 7 out of 10 years are wetter and 2 out of 10 are drier rather than 30 per cent chance of getting at least x amount of rainfall.

Appendix 6 outlines the responses from participants which shows that they believe that growers find probabilistic forecasts difficult to understand, while also finding the terminology confusing.

It is clear though from the thoughtful responses listed in appendix 1 to 6 that there is still much to be done in awareness and understanding of climate drivers, with probabilities remaining a significant communication challenge.

References

Cliffe N, Stone R, Coutts J, Reardon-Smith K and Mushtaq S (2016) 'Developing the capacity of farmers to understand and apply seasonal climate forecasts through collaborative learning processes' *Journal of Agricultural Education and Extension* published online 10 March 2016

Goldacre B. (2008) Bad Science. Harper Collins.

Hansen J.W (2002) 'Realizing the potential benefits of climate prediction to agriculture: issues, approaches, challenges' *Agricultural Systems* vol. 74 pp. 309-330

Punch, K.F., (2013). Introduction to social research: Quantitative and qualitative approaches. Sage.

Appendix 1

Participants response to; "what are the factors that are barriers to the adoption of seasonal climate forecasts in your industry?"

Skill level, timing - when there is skill to the models - it is too late
Lack of location specificity - likelihood of 10mm in 200km squared isn't very useful if it only rains in 10km squared
Lack of understanding and historically poor experiences with forecasting
Lack of access to people who understand forecasting and could explain it to them (ie. staff in DAF probably wouldn't have the knowledge to help directly)"
Timeliness is good as forecasts are now updated on a fortnightly basis. However, the big question is not just the amount of rain, but when is it going to fall? There is still a big gap between the 5 day forecast and the 1 month outlook from BOM. A 28 day forecast broken down into weekly chunks would be really helpful.
The main factor is that currently, there is no seasonal forecast specific for viticulture. This is a lost opportunity because most growers need information starting in August/September when seasonal forecast skill is generally high.
Greatest barrier is scepticism about reliability of forecasts - much easier to remember failures of forecast than when BoM get it right.
"One minute news grabs are usually too general and often misleading
Lots of info on websites with little support to help understanding and decision making

Poor skill of forecasts at key times and locations

Need to provide a climate service rather than just information on websites etc. so producers build relationships with local advisers to gain confidence and understanding to integrate climate forecasts into decision making"

Limited understanding knowing which ones to use/when having confidence in the forecast"

Probabilistic forecasts is difficult concept

Perceived lack of accuracy

Lack of aggressive forecasts - need 70% plus chances to get greater action

Frightened of consequences if wrong decision"

SCF failures without doubt. 6 out of 7 GCMs and statistical models showed above average rain and cooler temps this summer. The observations were record dry and hot weather. I have lots of discontent users of SCF on file after the extreme and unfavourable growing season making reference to the poor forecast

Limited understanding of probabilistic forecast information specifically by both farmers and particularly key influencers of and informants to farmers, including extension officers etc..

Low climate literacy generally.

Multiple climate model output that provides varying forecast output and therefore mixed messaging.

Low levels of engagement in the sugar industry between Research/Forecasters/Product developers and farmers to customise forecast information and its packaging for ease of use by industry.

Perceived lack of skill in forecasts (linked to low literacy in terms of understanding strengths and limitations of the use of probability based forecasts)

Outright scepticism about forecast value and skill linked to above.

Capacity limitations in farm business

I think one of the barriers is that we consider the forecasts to be entirely separate to the 7 day weather forecast. We really need to move to is a forecast service that starts at today and moves seamlessly to the 3-6 month period.

I question why there is so much emphasis on understanding the intricacies of the models and all of the climate drivers. Naturally the Bureau are technically minded and love to talk about all those things, but do you really need to understand it all to use the forecast? The Bureau employs people to do all of that and consider it in the forecast. I think it is over complicating the issue with using the forecasts, and is a barrier for entry to the vast majority of famers do not have the time

Appendix 2

Participants response to; "what are some factors that have increased adoption of seasonal forecasts by farmers in your industry?"

Good trusted commentary by The Break and also they get to lots of field days and speaking sessions and each time I learn a bit more. Weather is critical for farming but not many trusted messengers we usually either have BoM or nothing.

Unsure. Some workshops starting to happen. We are keen to run more but generating interest is difficult. Reliability of forecasts would increase adoption

Greater awareness of the 3 month climate outlook service by BoM. More frequent update's of the 3 month outlook information provided to producers that puts the seasonal outlook information into context (i.e. including BOM forecast information as part of an overall package with info on current pasture condition, livestock condition, historical rainfall data etc.)

Explanation of the benefits of seasonal forecasts/improved climate driver prediction at growers meetings.

Climate advisers located in regional towns.
Building trust and relationships with producers.

Using local data and showing when forecasts are and are not likely to be useful
Showing how a forecast can be used in decision making

Local relevant examples of other farmers using them and how they have used them

Better communications - BoM, The Break etc
People seeing climate variability and more recently climate changes
Increased need to produce quality product (FAQ not good enough now)

Farmers having some tough seasons - and production failures prompting increased awareness of SFC info.

Workshops, USQ monthly update and weekly weather/climate email updates (which are now ceasing due to lack of funding support by industry).

In general the skill of forecasting has increased over the last 10 years, particularly with the introduction of dynamical modelling. The broader reach of the forecasts, particularly through videos on Landline may have also helped. There still remains a very large portion of the Ag sector that does not use seasonal forecasts at all, so there is plenty more work to be done.

Appendix 3

Suggested decisions and comments on decision context (flexibility to respond) and forecast information (accuracy and timeliness)

	List decisions in your industry where the outcomes are sensitive to the climate over the next 1 to 6 months.	Does this decision have flexibility to respond to 1, 3 or 6 month forecasts?	At these decision timings can the forecast offer guidance with sufficient accuracy and timeliness? Why or why not?
1	What to sow and area to sow	Yes	If this decision is in April for most of the grainbelt (becuase growers are dry seeding more and more) ENSO is in the predictability barrier in March and IOD doesn't come into play until May. The models do not have much skill at this time for the grianbelt of WA
1	How much fertiliser to apply at seeding	Yes	Again if seeding is May then ok, but if seeding earlier then no
1	How much fertiliser to apply - top dressing 6 or more weeks after seeding	Top dressing can be earlier as late May through to July	Forecast is out of the predictability barrier, however I found that seasonal forecasting is not better than using July-September median rainfall to make decisions about in season top dressing
2	Water budget	Some	No forecast can be guaranteed. When stronger signal for drier then we look at plan B scenarios when known water is low…
2	Feed budget	Yes	No forecast is guaranteed. When more confident in a forecast for downside plus lower feed estimates we look at plan B scenarios
2	Nitrogen budget	Yes	Use soil moisture and crop modeling and longer term perhaps around budgeting or ordering
3	Weaning	Yes - wean early or leave calves on cows (less supplement cost but risk of decreasing cow BCS)	No. Accuracy is not good enough and can be in a worse position if you trust them and they don't turn out to be true. False hope is also crushing to emotions in a drought.
3	Selling cull cows or reducing stock numbers	Selling culls in poor condition for less returns vs selling when fat and market is good or whether to sell pregnant cattle too if season is really poor.	No. Accuracy is not good enough and can be in a worse position if you trust them and they don't turn out to be true. False hope is also crushing to emotions in a drought.
4	Stocking rates (i.e. decisions around selling/ buying livestock)	It depends a bit on the type of operation, but generally speaking yes.	Timeliness is good as forecasts are now updated on a fortnightly basis.

		- The shorter terms forecasts are arguably most helpful when conditions are tight and you are looking at offloading stock. - the longer term forecasts (3-6 months) are helpful in terms of looking ahead and assessing risk in terms of increasing stocking rates, but I suspect producer confidence in long-term forecasting is low.	In terms of accuracy, I think the biggest issue is that the further ahead the forecast period, the less confidence producers have in the prediction. As such, for longer term decisions producers draw on a range of factors including current soil moisture, current pasture conditions, long-term historical rainfall trends etc.
4	Purchasing of supplementary feed (decisions around the amount required)	Yes, the purchasing of supplementary feed is highly flexible and sensitive to forecast information.	Yes, again, the timeliness is good with fortnightly updates now provided by BOM. Longer term forecasts are probably more of a rough guide in helping decisions around supplementary feed due to lower confidence with these forecasts. Probably not as critical as stocking rate as getting the decision wrong has less impact.
4	Sowing of pastures and crops	Yes. Decisions around cropping and sowing pastures are highly flexible and responsive to forecasts.	Yes, but again, would question the accuracy with longer-term forecasts. Short-term forecasts are important with timing of sowing, fertiliser, grazing etc and confidence is higher. Longer-term forecasts might influence the decision on whether to sow, what to sow etc, but confidence in the forecast is lower. As such, long term forecasts would be a factor in the decision, but many other factors also come into play.
5	When to irrigate	Irrigation: Sometimes Yes...If little to no winter/spring rain is expected (for recharge,) especially if water needs to be purchased No: If a heatwave suddenly comes up	Possibly...if a hot dry season is expected to follow a dry winter, than some seasonal management changes can be made
5	When to plan harvest	Maturity will occur earlier in the season with a hot/dry spring, so knowing the seasonal forecast by August can help plan harvest operations later that season.	Seasonal forecasts being released in late winter/early spring can help plan for the growing season ahead, provided they are relatively accurate (above 50%)
5	When to prune For viticulture	Yes/Possibly. If it is known that there is going to be a hot/dry growing season, pruning can be delayed or double pruning can be planned to help extend	As long as the forecast is relatively accurate. For example, if the forecasts predicts a hot/dry season and vines are double pruned and then the season is cold/wet...it would be probably mean big losses in profit and quality.

		maturity timing and/or reduce vintage compression pressures.	
6	The area of winter crop to plant (May-June)	Yes - it would only proceed if there is sufficient stored soilwater and reasonable outlook climatically (and the likely price).	Growers more reliant on existence of stored soilwater as the first priority. Availability of water in ringtanks would be another consideration (for irrigated crops)
6	The area of summer crop to plant (Sept-Oct)	Yes - the summer crop area decision is dependent on available soil water, ringtank water and likely crop price. The forecast might influence to area of irrigated vs dryland cotton grown (and associated row configurations) combined with available water supplies.	Forecasts are too broad in the summer cropping regions - growers respond with management strategies that minimise risk in relation to summer storm events.
6	From end of wet season (May), stock numbers to carrying through dry season May-December (beef in north Australia)	Flexibility often determined by amount pasture e.g. high pasture more flexible to hang on and use forecasts. Generally though TSDM in May determines stocking rate until Dec, so 1,3 forecasts not useful on their own, but 6 month could be useful if supported in the interim by 1, 3 forecasts (e.g. wouldn't get through if all rain fell in Nov)	Not aware of 1 and 6 mth forecasts, or their skill, but generally winter spring should be okay
7	Forecast of wet season Nov-Mar issued in May/June	Feed budgets can be done in May/June for dry season, but stock lose weight from August, so not ideal to be selling after August. From August reliable (with consistency between) forecasts of combinations of 1, 3 ,6 mth may get through to Feb, when some rain would be expected	Current forecasts Nov-May are of limited skill west of Richmond.
7	Forecast of rain in dry season (June-Sept)	Unseasonal rain in dry season has positive outcome on beef production, so relatively low risk to hold stock (May/June) based on consistent 1,3 ,6 month forecasts of well above average rainfall June-Nov, provided good feed base to start with	Probably okay but less confidence moving west
8	Joining	Yes	not at the moment as too unreliable and forecast over too large an area to be accurate for my specific property

8	weaning	Yes	not at the moment as too unreliable and forecast over too large an area to be accurate for my specific property
8	supplementary feeding	Yes	not at the moment as too unreliable and forecast over too large an area to be accurate for my specific property
9	Rainfall and buying decisions	Yes	Currently accuracy gives a guide but is not sufficient to influence decision totally
9	Rainfall and selling decisions	Yes	Currently accuracy gives a guide but is not sufficient to influence decision totally
9	Onset of autumn break	1 or 3 months preferred	Currently accuracy gives a guide but is not sufficient to influence decision totally
10	Selecting fields for winter crop vs summer crop	Yes	Timeliness - Yes. Accuracy - No. The key drivers: IOD and ENSO are not settled for the growing season at the decision time in March/April/May. However, a strong ENSO or IOD signal can aid in decisions.
10	Timing of pre-plant N applications	Yes	Timeliness - Yes. Accuracy - Yes. The key drivers: IOD and ENSO are more settled for the N application decision time in June/July/August. A strong ENSO or IOD signal can aid in more confident decisions.
10	Summer crop planting opportunities in spring	Some flexibility, although planting forecasts are useful, the growing season forecasts are not there yet.	The forecasts are useful to determine planting decisions in Sept/Oct/Nov but the growing season summer cropping seasonal outlook has very low accuracy.
11	Harvesting (Wet harvest can lead to standover of crop and potential damage to soil through compaction etc. when harvesting wet blocks)	Yes. Harvesting (choosing to harvest wet or dry blocks depending on the climate forecast)	Late winter and spring provide most skill particularly when ENSO phase locks into El Nino or La Nina.
11	Irrigation (particularly in regions where only supplementary irrigation is present rather than full irrigation)	Yes. Irrigation (choosing to use or defer water use depending on forecast, and potential to purchase higher/extra water allocation when that exists - depends on region...)	Late winter and spring provide most skill particularly when ENSO phase locks into El Nino or La Nina.
11	Nutrient management (N)	Yes. Nutrient management (Matching N application and choice of N product type to seasonal outlooks)	Late winter and spring provide most skill particularly when ENSO phase locks into El Nino or La Nina.

Appendix 4

Participants response to; "on a scale of 1 to 5 (1 being the lowest and 5 being the highest), over the last 5 years how much has the awareness of seasonal climate forecast increased/ Why?"

4 - 2017 was a dry season for the northern and central WA grainbelt so awareness of seasonal forecasting increased. This project has enabled me to talk to more growers and get more exposure

4 - It is getting better but varies depending on the year. Good commentary from The Break is great. Best to be sceptical when using them. Make decisions on what's known.

2 – current job with DAF but still have limited understanding about the limitation of forecasts, which ones are best to use, when and why.

I would estimate 4. In my job I've seen a big increase over the last 3-4 years in the number of producers who are aware of the 3-month climate outlook from BOM and are referring to the information.

2 – unsure. There isn't a seasonal forecast for viticulture, so I doubt many even think about it.

3 - Uncertain of this - suspect that awareness has increased but there remains considerable scepticism about their accuracy and usefulness amongst the cropping sector in northern Australia.

Sugar = 3. Beef, cotton, hort and grains = 2, others = 1. Not a lot of funding for climate work in the north for last decade

3 – there has been a bit more about them in the media but not a lot.

4 - There is a lot more focus on BoM SCF. Livestock markets now waiting for their release.

4 - People have experienced large variations in production and seeking out better ways to better manage and anticipate their businesses knowing this extreme variation exists

2-3 In the sugar industry following the 2010 La Nina, the industry from farmers to marketers saw very significant economic losses. Immediately or in the couple of years after the event I might have scored high (3-4) as a number of climate risk workshops to increase climate literacy and use of forecasts were sponsored by industry. I think awareness may have diminished slightly since then. Very difficult to generalise across the industry when the spectrum of awareness is highly variable.

There appears to have been an increase in the awareness of seasonal climate forecasting over the last 5 years. The Bureau's monthly video is being broadcast on Landline on Sunday mornings and this has enhanced the awareness of the forecast, but we have not quantified the reach to specific industries.

Appendix 5

Participants responses to; “on a scale of 1 to 5 (1 being the lowest and 5 being the highest), over the last 5 years how much has the understanding of climate drivers increased? Why?”

This hasn't changed - farmers are still confused about the influence of ENSO and SOI in Western Australia - which is minimal. This needs to be talked about more on the Bureau website.

4 - Each year learn something new. Eg 2014 Elnino that didn't happen but was bone dry, 2015 the ElNino that di happen was bone dry, 2016 the IOD-ve great year, 2017 ok but forecasts not clear due to no clear driver etc

2- still limited understanding about the limitation of forecasts, which ones are best to use, when and why

This is a bit harder to estimate, but at a guess I would say a 3. I think general understanding of the major climate drivers would have increased largely due to initiatives such as 'climate dogs', the VIC DPI 'Fast Break' and general commentary/explanation of climate drivers within the BOM video updates.

3 - Some growers are becoming more aware of things like the IOD. Lots still focus on ENSO, even though ENSO years don't seem to have that much influence on the growing season for viticulture.

3 – uncertain of this- haven’t been working specifically in this space with growers. Have been more focused on managing limited water supplies amongst irrigators.

Sugar 3, Beef, cotton, horti and grain 2, others 1. Not a lot of funding for climate work in the north for last decade.

2 - People know a bit about what they see and hear but still don't really understand them or which ones are most relevant to them

4 - largely due to The Break etc in Victoria at least

3 - Some growers go to the next level to understand causation, but the majority are only interested in probability maps or colour forecasts"

In Queensland early in that period would have been high 3-4 but perhaps has dropped off again to 2-3. Very difficult to generalise across the industry when the spectrum of understanding is highly variable.

There appears to have been a general increase in the understanding and literacy of climate drivers, but it is not something that we have been able to quantify, and not something we have tested extensively. There has been a general increase for more services around ENSO, SOI and MJO, which suggests an increase in understanding of the drivers.

Appendix 6

Participants responses to; "on a scale of 1 to 5 (1 being the lowest and 5 being the highest), how much in the past 5 years has the understanding of probabilistic seasonal climate forecasting increased? Why?"

Not changed – I think farmers in WA know this
2 - Not sure if many people understand what to do with probabilities. Need to have a range of ways to frame what forecasts are trying to tell us.
Not sure what question is referring to so 1.
I would estimate 3. I find that producers still struggle to understand the 'chance of above median' rainfall charts and what this actually means. Quite often I'll refer to the 'chance of at least x mm' chart as this is much easier to comprehend.
2 - Unsure...I think lots of growers just do the same thing every year. Again, there isn't a specific forecast for viticulture, so no one really bothers to explain probabilistic forecasting to the industry.
3 - I assume growers still finding this a difficult thing to grasp - particularly when most forecasts are only reported as a 50 to 70% likelihood.
Sugar 3, Beef, cotton, horti and grain 2, others 1. Not a lot of funding for climate work in the north for last decade
2- People know a bit about what they see and hear but still don't really understand them or which ones are most relevant to them estimate 2
2 - I still think it is a difficult concept for many to grasp, and saying things like a 50% chance of average rainfall leads people to discount them"
3. Growers seem to want deterministic forecasts and probabilistic forecasts and awareness is still quite low
1-2 This area is still highly challenging and I would say that it has not increased significantly, broadly, across the industry.
I don't think there has been a noticeable change in the understanding of probabilistic information used in the forecast. We did some work prior to the upgrade of the Climate Outlooks service that showed low to average levels of understanding. Subsequent work, while not as quantified, has not shown a significant increase in the understanding of probabilistic information. This is also an issue in weather forecasting for the 0-7 days service, particularly for the chance of rainfall.

Appendix 7

Barriers and proposed solutions from respondents at the 2018 Annual Stakeholder Forum, 16 May.

Industry	Barrier	Solution
Livestock	More localised forecasts	ACCESS-S will help
Livestock	Need to explain scale of forecasts	Greater communication on scale and local variability
Livestock	When are forecasts useful	Matrix needed of product, existing conditions, forecast and skill
Livestock	Seasonal climate forecast drivers vary in affect on location	Location specific probabilities for seasonal forecasts
Livestock	Climate change is making seasonal climate forecasts harder and probably less reliable	Keep giving this message, simply and clearly
Livestock	The majority of farmers are eternally optimistic. The "it will rain tomorrow" syndrome. This will make them really bad risk managers who tend to look for a scape goat when it goes wrong.	No easy solution to this
Livestock	Understanding of what forecast is issuing (what forecast is and skill)	Chance of...' forecasts to meet production outcomes (pasture) based on how much is on the ground, i.e. chance of X tonnes of pasture growth.
Livestock	Understanding when/when not to use a forecast	Periods of low skill < time space ENSO years - high skill
Livestock	Lack of producers understanding of probability theory	Education and training
Livestock	Lack of ability to utilise seasonal climate forecasts with decision making processes	Education and training
Livestock	Do producers want a seasonal forecast to make decisions (us 28-day and weekly forecast)	Continue to understand psyche of producers and the information they require and the form it should be delivered.
All industries	Technical language needs to be converted so farmers and stakeholders can understand it.	
Rice	Adoption of delayed permanent water at sowing	Improved prediction toll for September to December months on rainfall - southern NSW and Northern Victoria
Rice	Trust	Simple clear communication of forecast meaning. Explanation of 'bad' seasonal forecast. Local regional affects, not necessarily included in forecast.
Cotton	Expectation of perfection with technology and climate forecasting	Explain the complexity of climate processes and difficulties associated with prediction

Cotton	Integration of climate forecast information into decision making.	This will be increasingly picked up in decision support tools and will be contextualised.
Cotton	Disunity of a loss (in response to a forecast) > unity of a gain	Difficult really - seems to be a fact of life
Cotton	To know probability	Explain after an event what was most likely reason what happened.
Grains	People need to be removed further from the decision process	Automated systems should interpret the information and provide clear options.
Grains	Farmers (and the rest of us) can't use probabilities in decision making.	So what are the heuristics (rules of thumb) the top farmers use in relation to seasonal climate forecasts?
Grains	Timeliness of forecast relating to the winter cropping decision	Increased skill at right time of year
Grains	Greater info on skill timing	Probabilistic and deterministic both useful than one alone
Grains	Probability communication	Use the Yield Prophet decile approach to show shift in distribution for BoM seasonal forecast
Grains	Hard to interpret probabilities	Represent probabilities as betting odds
Grains	User understanding of probability/probabilistic forecast.	So better communication around this, and what it means in terms of forecasting outputs. Maybe an explanation from time to time when a forecast is wrong, why this has been predicted poorly, what happened/changed.
Grains	Growers don't understand the basis of forecast skill	Targeted communications around what drives forecast skill and how it's assessed.
Grains	Better representation of the spatial reality of seasonal climate forecast	More communications around what and where the forecast covers and underlying variability.
Grains		Establish more channels closer to industry
Grains		Work closer with industry to develop more targeted communication
Grains		Evaluate the value of centralised broad forecasts - trying to suit everyone pleases no-one?
Grains		Assess value of better science vs. new model
Grains		More case studies - extended the good work done here
Grains		Financial evidence for future investment decisions
Grains	People have greater interest in forecasts when they are put to the sword.	Communicate more after this happens. Communicate more when forecast doesn't happen, why if known.

Grains	Confusion of a neutral 50:50 forecast	This has been partly resolved with the Bureau's recent video on their website. However, need to educate people more. Neutral does not mean average.
Grains	Users don't understand when is the best time to use a seasonal forecast	Greater emphasis on skill and climate drivers and climatology confidence
Grains	Lack of understanding around probability and how to hedge decisions accordingly.	Real life examples/case studies of how others used information successfully. Climate champions!
Grains	Climate drivers relevant to regions. Why are WA farmers following the SOI?	Education and extension
Grains	Better visual representation and communication of seasonal climate forecast and probability	Training for news and communication
Grains	Support and training for agricultural media in communicating seasonal climate forecasts	Media possible inclusion in CoP. Builds understanding and trust while not adding to information overload and using channels that farmers are familiar with.
Grains	Use machines and models to unsure forecasts used as an input into decision support systems	To give options
Sugar	How to seamlessly incorporate seasonal climate forecast/multiweek outlook into customised industry decision support tools. E.g. linking tools like fertiliser/rates and product type into outlook at relevant scales	Linking short-term outlook into irrigation management software (and decision tress cover pesticide application)
Sugar	Industry training in improvement in literacy - support service	Regional climate advisors over next 5 years to guide application to industry strategic/tactical decision making.