

Final report

Forewarned is Forearmed: northern red meat and sugar

Project code: B.CCH.8120

Prepared by: David Cobon, Chelsea Jarvis and Tim Cowan
University of Southern Queensland

Date published: 9 December 2022

PUBLISHED BY
Meat & Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

This publication is published by Meat & Livestock Australia Limited ABN 39 081 678 364 (MLA). Care is taken to ensure the accuracy of the information contained in this publication. However MLA cannot accept responsibility for the accuracy or completeness of the information or opinions contained in the publication. You should make your own enquiries before making decisions concerning your interests. Reproduction in whole or in part of this publication is prohibited without prior written consent of MLA.

Abstract

Red meat and sugar industries in northern Australia have concerns regarding increasing frequency and severity of future climate extremes.

The Forewarned is Forearmed Program was developed to consult with industry and develop products that forecast extreme climate at week to seasonal timescales. The Bureau of Meteorology State Department of Agriculture and Universities conducted research and product development for a range of primary industries to interface the forecasts with agricultural decisions, develop risk management strategies and extend project outputs to producers and advisors.

The Bureau has now five new climate extreme products on its website, risk management frameworks are developed but require further development and application, outcomes were presented at conferences, workshops, multi-topic days and scientific publications and videos produced to explain the terminology and application of the products.

The project provided significant options for a wide range of farm level and agricultural industry operational and investment decisions, as well as decreasing the impacts of extreme climate events on farm and industry profit.

The benefits to the industries through the application of these products in agricultural decision have potential to be substantial. These benefits should now be delivered through an innovative agricultural extension and adoption service.

Further research is required to improve the accuracy of the underlying climate model that produces these products.

Executive summary

Background

Australian farmers and agribusiness operate in one of the most variable climates of any country in the world, with extreme events and climate variability the largest drivers of fluctuations in annual agricultural income and production. This project delivered direct value to red meat and sugar producers in northern Australia through improving the forecast of extreme climate events, equipping farmers with the information and risk management tools to be forewarned and proactively prepared.

Objectives

The University of Southern Queensland (UniSQ) and Department of Agriculture and Fisheries Queensland (DAF) provided support to the Bureau to develop and make operational five climate extremes products by:

- 1) Establishing industry reference groups (IRG's) for northern red meat and sugar industries.
- 2) Facilitating operations of the IRG's to provide feedback to the Bureau to develop and refine climate extreme products.
- 3) Producing an extreme event risk management framework for the sugar and northern red-meat industries.
- 4) Presenting at workshops/conferences and publishing in peer-reviewed literature.
- 5) Contributing to extension and training via the Community of Practice (CoP).
- 6) Preparing a business case for a heat load index for cattle.
- 7) Producing four short videos on explaining deciles, rainfall burst and probability of exceedance products.

Methodology

Establish four Industry specific Reference Groups (three red meat, one sugar) and through a structured process of consultation a) identify the extreme event risks of consequence to their industry, b) identify a number of appropriate response scenarios to each identified extreme event c) provide feedback to the Bureau on the extreme climate products d) contribute to regular CoP meetings e) prepare scientific, workshop and conference materials and f) survey industry regarding need for heat load index, research and prepare prototype product and business case g) prepare story boards, run sheets, take advice from industry, engage a professional videographer and presenters, film, edit and compile videos

Results/key findings

Five climate extreme products were developed and published on the Bureau of Meteorology website. These products were developed in association with industry consultation however they have not yet been subjected to a broad based focused and widespread extension and adoption program. This would improve product awareness, knowledge and application and lead to economic benefits being realised.

Benefits to industry

The potential benefits to the industry of accurately forecasting extreme climate events are substantial. A property in the Gulf during the February 2019 floods stood to save over \$5.5million provided they were given one weeks' notice to move cattle from the floodplain and provide fodder.

Future research and recommendations

The value of these products is limited by climate model accuracy. Providing more research resources to improve model accuracy by reducing the model biases and improving convective parameterisation will help uptake by industry.

Providing more resources for extension and adoption (E&A) to train and support local climate advisers to deliver an innovative service with clear targets to improve awareness, knowledge and application of products #1-5 will improve evidence of impact.

Table of contents

Abstract.....	2
Executive summary	3
1. Background	7
2. Objectives	7
3. Methodology	8
3.1 UniSQ contributions	8
3.1.1 Establish industry reference groups	8
3.1.2 Facilitate operations of the IRG’s to provide feedback to the Bureau.....	8
3.1.3 Produce an extreme event risk management framework	8
3.1.4 Publications in conference and peer reviewed literature	9
3.1.5 Community of Practice (CoP) and WP 4 contribution	9
3.1.6 Business case for a heat load index for cattle	9
3.1.7 Produce four short videos	9
4. Results	9
4.1 Project Outcomes.....	9
4.1.1 Industry reference groups	9
4.1.2 Facilitate operations of the IRG’s to provide feedback to the Bureau.....	10
4.1.3 Produce an extreme event risk management framework	11
4.1.4 Publications in conference and peer reviewed literature	11
4.1.5 Community of Practice (CoP) and WP 4 contribution	12
4.1.6 Business case for a heat load index.....	14
4.1.7 Produce four short videos	14
4.1.1 Project level achievements.....	15
Operational Product #1 – live to public November 2021	15
Operational Product #2 - live to public November 2021.....	15
Operational Product #3 - live to public June 2022	16
Experimental Product #4 - live to public June 2022	17
Experimental Product #5 - live to public June 2022	18
4.2 Collaboration.....	18

4.3	Extension and adoption activities	19
4.4	Lessons learnt	20
5	Conclusion	21
5.1	Key findings	21
5.2	Benefits to industry.....	22
6	Future research and recommendations.....	22
7	References	23
8	Appendix.....	24
8.1	Appendix 1 – Industry Reference Group activities for northern red-meat and sugar.....	24
8.2	Appendix 2 Risk Management Plan for the northern red-meat industry including, Climate Risk Matrix, Risk Response Matrix, Decision analysis (Verbal Decision Analysis) and a Case study	24
8.3	Appendix 3 - Risk Management Plan for the sugar industry including, Climate Risk Matrix, Risk Response Matrix, Decision analysis (Verbal Decision Analysis) and a Case study	24
8.4	Appendix 4 – Lessons learned/observations (from project level – Peter Hayman SARDI) – draft.....	24
8.5	Appendix 5 – Business case for Head Load Index for cattle	24
8.6	Appendix 6 – NACP Extension Use of FWFA Products and Information	24
8.7	Appendix 7 – Project media and communications	24

1. Background

Australian farmers and agribusiness operate in one of the most variable climates of any country in the world, with extreme events and climate variability the largest drivers of fluctuations in annual agricultural income and production. This project delivered direct value to red meat and sugar producers in northern Australia through improving the forecast of extremes, equipping farmers with the information and risk management tools to be forewarned and proactively prepared.

The Bureau of Meteorology (Bureau) conducted research to deliver forecasts of the likelihood of climate extremes on multi-week and seasonal timescales – beyond the traditional 7-day weather forecast. This provided farmers with the first ever forecasts of extreme climate events weeks to seasons ahead. The project included research, product development and extension teams, representing a range of industries, working directly with farmers and farm consultants, to interface the forecasts with agricultural decisions, develop risk management strategies to proactively prepare for these events, as well as extending project outputs to producers and advisors. The project provided significant options for a wide range of farm level and agricultural industry operational and investment decisions, as well as decreasing the impacts of extreme climate events on farm and industry profit.

2. Objectives

The University of Southern Queensland (UniSQ) and the Department of Agriculture and Fisheries Queensland (DAF) are FWFA project partners that delivered against Work Package 3 (WP3) and contributed to Work Package 4 (WP4). The UniSQ objectives for WP3 and WP4 delivered direct value to farmers through improving the forecast of extreme events, equipping farmers in the sugar and northern red meat industries with the information and risk management tools to be forewarned and proactively prepared.

UniSQ and DAF provide support to the Bureau to develop and make operational five climate extremes products by:

- 1) Establishing industry reference groups (IRG's) for northern red meat and sugar industries.
- 2) Facilitating operations of the IRG's to provide feedback to the Bureau to develop and refine climate extreme products.
- 3) Producing an extreme event risk management framework for the sugar and northern red-meat industries.
- 4) Presenting at workshops/conferences and publish in peer-reviewed literature.
- 5) Contributing to extension and training via the Community of Practice (CoP).
- 6) Preparing a business case for a heat load index for cattle.
- 7) Producing four short videos on explaining deciles, rainfall burst and probability of exceedance products.

3. Methodology

3.1 UniSQ contributions

3.1.1 Establish industry reference groups

Initially, industry workshops were held for the northern red meat industry between July–October 2017 where 38 attended in Charters Towers, and 15 in each of Longreach and Rockhampton. Subsequently a total of 17 participants joined the IRG, four in Charters Towers, seven in Longreach and six in Rockhampton.

Thirty-five key industry stakeholders attended the initial sugar industry workshop in Townsville in November 2017. Subsequently a total of 11 participants joined the sugar IRG representing northern NSW to far north Queensland.

Participation and contribution of the IRG members varied throughout the project with COVID-19 limiting face to face meetings which were more effective than webinars and online meetings. A small number of IRG members continued to provide feedback throughout the project.

An important source of feedback was provided through the Northern Australia Climate Program (NACP) network of Climate Mates and their producer clients in the red-meat industry, and the Drought and Climate Adaptation Program (DCAP) network of sugar industry clients.

3.1.2 Facilitate operations of the IRG's to provide feedback to the Bureau

Between July 2019 and September 2021, four rounds of face-to-face meetings were held with northern red meat and sugar IRG's.

External to the IRG activities other events (workshops, multi-topic days, webinars) were conducted by NACP and DCAP where FWFA products were discussed and feedback collected and provided to the Bureau.

3.1.3 Produce an extreme event risk management framework

UniSQ have contributed to the generic climate extremes risk management package that was led by SARDI by completing five key products each for northern red meat and sugar:

- 1) Climate Risk Matrix - a risk assessment, tactical and strategic responses, and an assessment of the capacity to respond combined with impact to gauge vulnerability to these extreme climate events for beef enterprises located at Charters Towers, Longreach and Rockhampton; and a sugar enterprise in northern Queensland (wet extreme) and southern Queensland (cold extreme). This risk assessment for extreme climate follows the risk management process of Cobon et al. 2009 and the steps required outlined in a workbook (Brundell et al. 2011).
- 2) Risk Response Matrix - for northern red-meat (4 climate extremes each for beef and sheep) and sugar (3 climate extremes) industries in FWFA format suggested discussion paper prepared by Russell Pattinson *Delivering a risk management package as part of FWFA: a discussion paper Version 3*, June 2019 which had significant input from UniSQ and the University of Melbourne (UoM).

This product involves matching the extreme event to a BoM product and other technical information to manage these risks including a gap analysis of the products capacity to deliver industry needs.

- 3) Decision analysis (Verbal Decision Analysis) developed by SARDI to test climate sensitive decisions against climate state and identified a range of outcomes (best, good, tradeoff,

worst). Response scenarios for three climatically risky decisions for the northern red meat and sugar industries were developed

- 4) Case studies showing the financial, environmental and social impacts of extreme climate for the red meat 1) Queensland Gulf floods in February 2019 showing how extreme rainfall, low temperatures and wind caused financial and social devastation including the climatic drivers and the extent to which ACCESS S forecasted the event (see Appendix 8.2) and sugar 2) the extreme wet period during the 2010 sugar cane harvest caused significant financial and environmental loss were completed (see Appendix 8.3)
- 5) Risk Management Plans were prepared for the northern red meat and sugar industries. The products mentioned above in 1–4 are part of this overall Risk Management Plan for both industries.

3.1.4 Publications in conference and peer reviewed literature

UniSQ and DAF have contributed to four conferences in 2021 and 2022, 6 staff presented at the FWFA forum in December 2022 and 8 scientific journal papers have been peer reviewed and published (see section 4.1.4).

3.1.5 Community of Practice (CoP) and WP 4 contribution

UniSQ and DAF have contributed to extension and training by presenting, or organising presenters, for the CoP meetings, and conducting workshops to raise awareness and knowledge of FWFA products #1-5.

3.1.6 Business case for a heat load index for cattle

UniSQ have contributed by completing a survey of industry regarding the need for heat load index, completing research, preparing a prototype product and a business case for further RD&E.

3.1.7 Produce four short videos

UniSQ have produced four videos on explaining deciles, rainfall burst and probability of exceedance products by preparing story boards, run sheets, taking advice from industry, engaging a professional videographer and presenters, filming, editing and compiling videos.

4. Results

4.1 Project Outcomes

4.1.1 Industry reference groups

The engagement with industry has delivered a set of climate extreme products, risk management plans and awareness of these products in the sugar and northern red-meat industries. This was achieved through a structured process of consultation with industry-specific reference groups and other RD&E activities that:

- a) Represent views of northern red meat and sugar producers on extreme climate and weather event risks.
- b) Identified the extreme event risks of consequence to their industry.
- c) Identified appropriate response scenarios to each extreme event.
- d) Provided feedback to the BoM on the products produced.
- e) Within a generic risk framework developed specific risk management plans.
- f) Supported the FWFA community of practice.

4.1.2 Facilitate operations of the IRG’s to provide feedback to the Bureau

Between July 2018 and September 2022 four rounds of face-to-face meetings were held with northern red meat and sugar IRG members (65 red meat members at 12 events, 48 sugar members at 20 events). COVID made more face-to-face activities impossible.

These IRG workshops included discussions around identification and prioritisation of on-property extreme climate event risks, evaluate sets of Bureau forecasting products and provide feedback (via participation in product specific online sessions as well forums and within the BoM FWFA experimental product development site and contributed and commented on the risk management outputs for the project.

A summary of the project level activities with IRG’s are shown in Table 1.

External to the IRG activities other events (workshops, multi-topic days, webinars) were conducted by NACP and DCAP where FWFA products were presented (red-meat 96 participants at 12 events, sugar 333 participants at four events) and feedback collected and provided to the Bureau.

Full results of IRG activities for the northern red meat and sugar industries are shown in Appendix 1.

Table 1. Summary of Industry Reference Group (IRG) activities at the project level

2018	<p>March – online session where BoM ran through existing products</p> <p>June – F2F workshop at the BoM offices (<i>extremes of most consequence to the industry and the types of impacts, responses, tools in case of those extremes</i>)</p> <p>November - online meeting for BoM presentation and launch of Set #1 prototype products (heat): feedback provided on range of experimental products (<i>being basic POE charts, various decile bars graphs (horizontal/vertical), climagram plots, 2D POE, heatwave probability plots, THI maps, hot day plumes, histograms, top/bottom decile maps, hot days map</i>)</p>
2019	<p>January – online session to further review and provide feedback on the first set of experimental products</p> <p>~July – commented on draft heat event and extended dry event response scenario documents under development in the FWFA project</p> <p>November - online sessions for BoM presentation and launch of Set #2 prototype products (cold): feedback provided on range of experimental products (<i>being cold wave maps, plumes, frost potential, number of frosts, mean number of THI days</i>)</p>
2020 – COVID affected	<p>May - online sessions for BoM presentation and launch of Set #3 prototype products (rainfall): feedback provided on range of experimental products (<i>being top/bottom decile maps, climagrams, number of wet days, wet spell maps, number of dry days, dry spell, probability of exceedance graphs, daily distributions</i>)</p> <p>July – Risk framework session – risk products and decision making</p> <p>October/November – online session for discussion and feedback on BoM operational products 1 & 2 (& 3) (<i>chance of extremes maps, location specific deciles and climagrams</i>)</p> <p>November – online workshop ‘climate decisions’</p>
2021 COVID affected	<p>March – online showcase and feedback session for shortlisting of what will become BoM operational products 4 & 5 (<i>choose between pie charts, POE curves/graphs, Rainfall burst over 3 days, timeseries of the quintile bars</i>)</p> <p>May – industry risk discussion regarding website products (with MLA, DA and IRG members)</p>
2022	<p>April – online session for discussion and feedback on BoM operational products 4 & 5 (<i>POE graphs and 3-day rainfall maps</i>)</p>

Source: Ann-Maree Graham, University of Melbourne

4.1.3 Produce an extreme event risk management framework

Full details of the Climate Risk Matrix, Risk Response Matrix, Decision analysis (Verbal Decision Analysis), Case studies described in the overall Risk Management Plans for the northern red-meat and sugar industries are shown in Appendices 2–3.

These products have been assessed by some members of the IRG's and MLA and SRA but require further testing, development and application.

4.1.4 Publications in conference and peer reviewed literature

UniSQ, DAF and Bureau staff from FWFA contributed papers or sessions at four conferences and four industry events shown below:

- FWFA Forum Melbourne (December 2022) – six UniSQ staff from FWFA and NACP contributed to 4 sessions including panel session on key learnings from FWFA, NACP key E&A outputs to date, NACP 3 Extreme climate products and FWFA videos c. 40 participants
- AMOS Conference Adelaide (November 2022) – 2 presentations on FWFA – rainfall burst, deciles, videos and heat load index c. 60 participants at each session
 - Cattle and heat: a case for developing a cattle-specific heat stress forecast product. Tim Cowan, Matthew Wheeler, Morwenna Griffiths, Jillian Jackson, John Gaughan
 - Impactful communication of new climate forecast products for extreme events. Chelsea Jarvis, David Cobon, Sally Foreman.
- Northern Territory Cattlemen's Association Conference, Darwin (24-25 March 2022) – FWFA Products #1-5 displayed and discussed at a FWFA/NACP sponsored booth – conference attendance c. 250 red-meat industry
- Australian Rangelands Conference, Longreach (October 2021) – five presentations relevant to FWFA: Products #1-5, rainfall burst, chill index, Queensland Floods and DCAP
 - Developing and Using Climate Products for Practice Change. Chelsea Jarvis, David Cobon
 - Extreme climate forecasting tools for the northern red meat industry. Christa Pudmenzky, David Cobon and Debbie Hudson
 - The meteorology and forecast potential of the February 2019 northern Queensland floods. Matthew C. Wheeler, Tim Cowan
 - Introducing some rangeland-relevant prediction products: Northern Rainfall Onset and Rainfall Bursts. Tim Cowan, Matthew C. Wheeler, Catherine de Burgh-Day, Hanh Nguyen
 - Managing drought in Australian rangelands through applied research and extension; The drought and climate adaptation program. Neil Cliffe
- Beef 2021, Rockhampton (May 2021) – Product #5 (rainfall burst) was featured by MLA and during 7 presentations attracted over 200 participants
- NT Cattleman's Association Conference (March 2021) – FWFA/NACP stand at the conference in Alice Springs where climate extremes products were demonstrated - conference attendance c. 250 red-meat industry
- Next Gen Sugar Conference, Bundaberg (February 2021) – a presentation on FWFA products to 130 participants
- Sugar Project Catalyst Forum, Mackay (February 2020) – a presentation on FWFA products to 190 sugar producers and advisers

UniSQ, DAF and Bureau staff from FWFA published eight peer reviewed scientific journal papers shown below:

Cowan T., Wheeler M., de Burgh-Day C., Nguyen H., Cobon D (2022). Multi-week prediction of livestock chill conditions associated with the northwest Queensland floods of February 2019. *Scientific Report* 12: 5907 | <https://doi.org/10.1038/s41598-022-09666-z>

Cowan T., M. C. Wheeler, S. Sharmila, S. Narsey and C. de Burgh-Day (2022), Forecasting northern Australian summer rainfall bursts using a seasonal prediction system. *Weather and Forecasting*, 37(1), 23-44, doi: 10.1175/WAF-D-21-0046.1.

Domeisen, D. I. V., White, C. J., Afargan-Gerstman, H., Muñoz, Á. G., Janiga, M. A., Vitart, F., Wulff, C. O., Antoine, S., Ardilouze, C., Batté, L., Bloomfield, H. C., Brayshaw, D. J., Camargo, S. J., Charlton-Pérez, A., Collins, D., Cowan, T., del Mar Chaves, M., Ferranti, L., Gómez, R., González, P. L. M., González Romero, C., Infanti, J. M., Karozis, S., Kim, H., Kolstad, E. W., LaJoie, E., Lledó, L., Magnusson, L., Malguzzi, P., Manrique-Suñén, A., Mastrangelo, D., Materia, S., Medina, H., Palma, L., Pineda, L. E., Sfetsos, A., Son, S., Soret, A., Strazzo, S., & Tian, D. (2022). Advances in the Subseasonal Prediction of Extreme Events: Relevant Case Studies across the Globe, *Bulletin of the American Meteorological Society*, 103(6), E1473-E1501. <https://doi.org/10.1175/BAMS-D-20-0221.1>

Matt Hawcroft, Sally Lavender, Dan Copsey, Sean Milton, José Rodríguez, Warren Tennant, Stuart Webster, Tim Cowan 2021 The Benefits of Ensemble Prediction for Forecasting an Extreme Event: The Queensland Floods Monthly Weather Review, 2021, 149, 2391-2408, DOI: 10.1175/MWR-D-20-0330.1

Nguyen H, Wheeler MC, Hendon HH, Lim E-P, Otkin JA 2021 The 2019 flash droughts in subtropical eastern Australia and their association with large-scale climate drivers. *Weather and Climate Extremes*, 32, 100321

Cobon David, Jarvis Chelsea, Reardon-Smith Kate, Guillory Laura, Pudmenzky Christa, Nguyen-Huy Thong, Mushtaq Shahbaz, Stone Roger (2021) Northern Australia Climate Program: supporting adaptation in rangeland grazing systems through more targeted climate forecasts, improved drought information and an innovative extension program. *The Rangeland Journal*, <https://doi.org/10.1071/RJ20074>

Nguyen H, Otkin, Wheeler, Hope, Trewin, Pudmenzky (2020) Climatology and variability of the evaporative stress index (ESI) and its suitability as a tool to monitor Australian drought *Journal Hydro Meteorology* 21, 2309-2324. <https://DOI: 10.1175/JHM-D-20-0042.1>

Cowan, Wheeler, Alves, Narsey, de Burgh-Day, Griffiths, Jarvis and Cobon (2019). Forecasting the extreme rainfall, low temperatures, and strong winds associated with the northern Queensland floods of February. *Weather and Climate Extremes* (vol 26), <https://doi.org/10.1016/j.wace.2019.100232>

4.1.5 Community of Practice (CoP) and WP 4 contribution

UniSQ, DAF and Bureau staff from FWFA provided contributions to the CoP and FWFA extension and adoption (WP4) in the following ways:

Contribution to CoP until December 2021

- UniSQ and DAF FWFA have initiated or presented 18 webinars.

Workshops until December 2021

- NACP MCV workshops or multi-topic days - FWFA products have been shown at 34 events to 357

red-meat producers and advisers

- DAF DCAP MCV workshops - FWFA products have been shown at two events to 23 sugar producers and advisers

UniSQ, DAF and Bureau staff from FWFA, in addition to the above, have conducted the following events in 2022:

- 6-7 December 2022 – FWFA Forum – Use of FWFA products #1-5, business case for heat load product and short videos describing deciles, rainfall burst and POE graphs presented to stakeholders – c. 40 participants
- 30 November 2022 – MLA launched a world-first grazing management tool the Australian Feedbase Monitor at the MLA Updates event, Toowoomba. FWFA products #1-5 and NACP were represented - 375 participants - 17 producers engaged with FWFA/NACP material
- 7-11 November 2022 – NACP Annual Project Meeting, Darwin. FWFA products #1-5 presented to NACP researchers and Climate Mates – 50 participants
- 26 October 2022 - DCAP Showcase, Brisbane. FWFA products #1-5 presented to DCAP stakeholders – 90 participants
- August 2022, 5 Stanbroke Cattle Company properties in the Gulf area of Queensland, FWFA products #1-5 shown during at climate workshops - 50 attendees
- August 2022, Young Live Exporters Network meeting, Darwin, NT. Presentation of Burst forecast - 23 attendees
- July 2022, Future Farming Forum, Rockhampton, Queensland. Discussion of burst product to 22 producers and 18 in the related supply chain
- 1 June 2022 - Precision Agriculture field day Proserpine, FWFA presentation, 50 participants
- 7th April 2022, Sugar Research Australia Webinar – presentation of FWFA products Debbie Hudson. <https://sugarsearch.com.au/resources-and-media/media/>
- 8th April 2022, Sugar Research Australia Webinar – presentations by Robert Quirk and Tom Bowditch on how they are using FWFA products.
- 13th April 2022, Healthy Land & Water/Noosa Landcare – Climate Adaption workshop Pomona, new FWFA products and how to use them. 24 participants.
- 24-25 March 2022, FWFA products displayed, demonstrated and presented at booth at NTCA Conference, Darwin – 250 attendees
- 23 March 2022, Climate Forecasting for Decision Making Workshop, Daly Waters, FWFA products #1-5 presented – 22 participants
- 8-11 Mar 2022, FWFA products #1-5 presented to NACP researchers and Climate Mates - 35 staff
- 24th March 2022, Peter Crawford Climate mate presentation at Wondai. Explanation of FWA products. 8 participants.
- 11th Feb 2022, Teleconference with Sugar Research Australia staff to organise webinar for new FWFA products.

Extension and Adoption by NACP

The information and products generated by FWFA have been useful and well-integrated into the Northern Australia Climate Program's (NACP) extension and adoption activities. Producers participating in NACP activities frequently communicate interest in learning more about extreme events and also want to know if a forecast is available for extreme conditions. FWFA has been instrumental in meeting these producer needs and NACP has communicated the new products developed and made operational by FWFA (see Table 2). More detail of the NACP contribution to FWFA extension and adoption is provided in Appendix 6.

Table 2. Activities, number of attendees, and FWFA products showed by NACP extension in late 2021 and 2022

An * indicates an estimated number

Type	FWFA Product	Number of activities	Attendees Producers	Attendees Others
NACP Climate Workshops	Mainly burst, some others	16	195	85
Other Presentations	Burst and decile	28	294*	237*
One-on-one	All	5	13	4
Webinar	Burst and decile	7	35*	86*
Totals		56	537	412

4.1.6 Business case for a heat load index

The northern Australian beef sector supports close to 15 million head of cattle, with livestock experiencing a highly variable climate (e.g., heat waves, flash flooding, drought). One of the biggest risks to cattle health is heat load accumulation, which can lead to a decrease in feed intake, low fertilisation rates, and calf losses. Currently, there are no official warnings given out by the Bureau of Meteorology if an extreme heat event is forthcoming that could impact cattle. Here, we propose the development of an Accumulated Heat Load (prototype) forecast product for cattle, for lead times of up to 7 days, based off the Bureau's high resolution (6-12 km) numerical weather prediction systems (e.g., MetEye and/or ACCESS-G3). Additionally, we propose the further development of a Cattle Comfort Index (i.e., feel-like temperatures for cattle) forecast product for the (5 km) multi-week temporal scale using the Bureau's ACCESS-S2 seasonal forecast system. A recent Heat Load Survey of northern graziers suggests a strong need for forecast/outlook products like these that encompass all of northern/northwest Australia – these are regions that are currently under-represented in available forecast services.

The full business case and links to prototype products are shown in Appendix 5.

4.1.7 Produce four short videos

The funding for extension and adoption of FWFA products was limited and videos are a useful tool to provide ongoing awareness, knowledge and demonstrate their use in agricultural decision making. These videos will be a useful tool and legacy that explains the FWFA products for agriculture extension advisers, consultants, banks, corporate managers, producers and other supply chain operators.

Four short videos were professionally produced to demonstrate how to interpret deciles, read rainfall burst and probability of exceedance products, as well as show how producers from the red-

meat, sugar, grains and cotton industries use these products in decision making. These videos will be posted on the nacp.org.au website.

4.1.1 Project level achievements

The Bureau, working with its research partners with expertise in different agricultural industries, developed a large set of experimental forecast products of the likelihood of climate extremes on multi-week to seasonal timescales. The products are focused on heat, cold and rainfall extremes. Owing to the involvement of several agricultural industries in FWFA, the forecast products are generic in nature and not tailored to a particular industry.

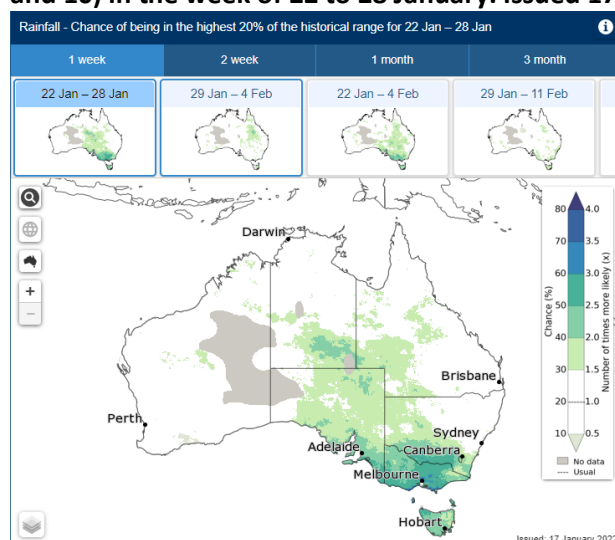
A subset of five forecast products was selected (in a staged approach) to become official, operational products and have been delivered to the public via the Bureau's website. The choice of the five products was informed by industry engagement. All five products have been operationalised and are accessible on the Bureau's website.

Operational Product #1 – live to public November 2021

Maps showing the chance of having extreme rainfall, extended dry periods, maximum or minimum temperatures for the weeks, months and seasons ahead. For these maps “extreme” has been defined as being amongst the driest, wettest, hottest or coldest 20% of periods (weeks/months/seasons) from the climatological (historical) period (i.e., deciles 1 and 2 (bottom 20%) or deciles 9 and 10 (top 20%)).

For example, Figure 1 shows the forecast issued on 17 January 2022 of the chance of having unusually wet conditions for the week of 22 to 28 January 2022. The map shows the chance of having rainfall totals in highest 20% of the historical range. In any given outlook period, the usual chance of high rainfall is around 20%, (shown for much of Northern and Western Australia below). In contrast, much of south-eastern and into central Australia has an increased chance of unusually wet conditions. The probabilities of between 50% and 60% chance over large parts of Victoria, indicate 2.5 to three times the normal risk. Fortnightly, monthly and seasonal periods ahead can be selected.

Figure 1: Extreme rainfall map. Chance of unusually high rainfall for weeks and months ahead. This map shows the chance of having rainfall totals in highest 20% of the historical range (decile 9 and 10) in the week of 22 to 28 January. Issued 17 January 2022



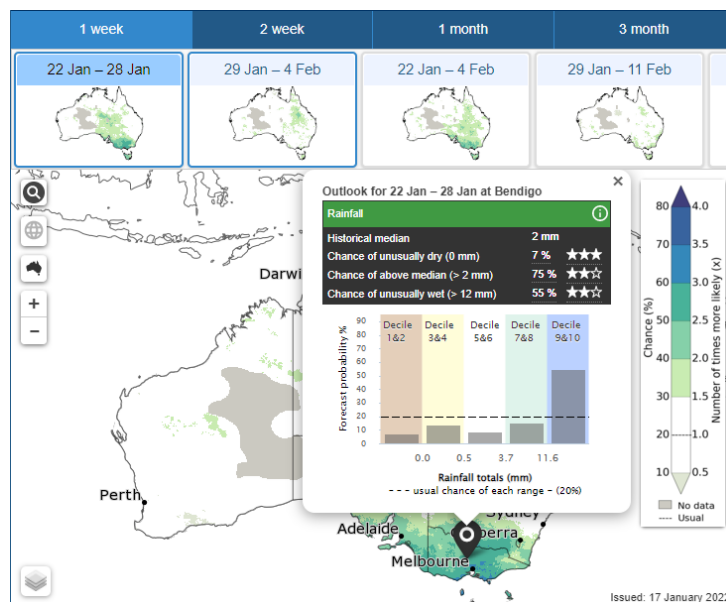
Operational Product #2 - live to public November 2021

These are location-specific ‘decile bars’ that indicate the shift in the probabilities compared to usual across the deciles. Available for rainfall, maximum and minimum temperatures for the weeks,

months and seasons ahead. One of the most popular products in consultation with producers and advisors.

Figure 2 shows an example of the bars for a forecast of weekly rainfall. On average over the historical period it is expected that usual chance for each category would be 20% (given that there are 5 categories) The bars show that for the week of 22 to 28 January 2022, the odds are stacked towards having a wetter week than usual in Bendigo, with over double the usual risk of having a decile 9 or 10 period (rainfall greater than 11.6mm). The chance of having very dry conditions is reduced compared to usual (probabilities are less than 20%). However, an outcome in any one of the categories is still possible, it is just that there has been a revision in the odds which make it more likely that there will unusually wet conditions.

Figure 2: Decile bars. Rainfall forecast for Bendigo in central Victoria for 22–28 January (generated on 17 January 2022). The forecasts show the probabilities across five different decile ranges. The long-term average probability (“usual chance”) for each category is 20% and the forecasts show the shift in the odds compared to usual

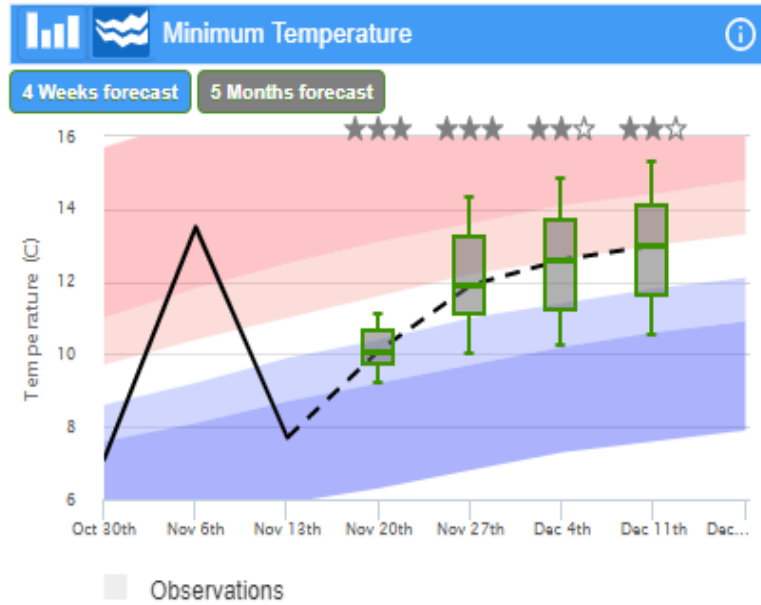


Operational Product #3 - live to public June 2022

The third product to be operationalised by the Bureau is the “climagram”. These are location-specific timeseries graphs showing the forecast of rainfall totals, maximum and minimum temperatures respectively, for the coming weeks and months. Past observations are also shown on the graph. Insight from producers and advisors really drove the creation of this product due to the strong desire to visualise the forecast as a time-series for a given location (rather than having to look at multiple maps). The forecasts of rainfall totals and temperatures (rather than departures from normal) facilitates flexibility for temperature/rainfall threshold-specific decisions (Figure 3).

Figure 3: Climagram – chance of unusually cool – 4 weeks forecast. Timeseries of observed (black solid line) and forecast (grey box plots) minimum temperature (y-axis) for consecutive weekly periods (x-axis) for Beulah. The box plots indicate the range in the expected outcomes from the forecasts. The coloured shading indicates the usually expected temperatures for that time of year (based on 1981–2010). The thresholds shown for the box plots and the shading are the 10th, 25th, 50th (median), 75th and 90th percentiles

Outlook for Beulah



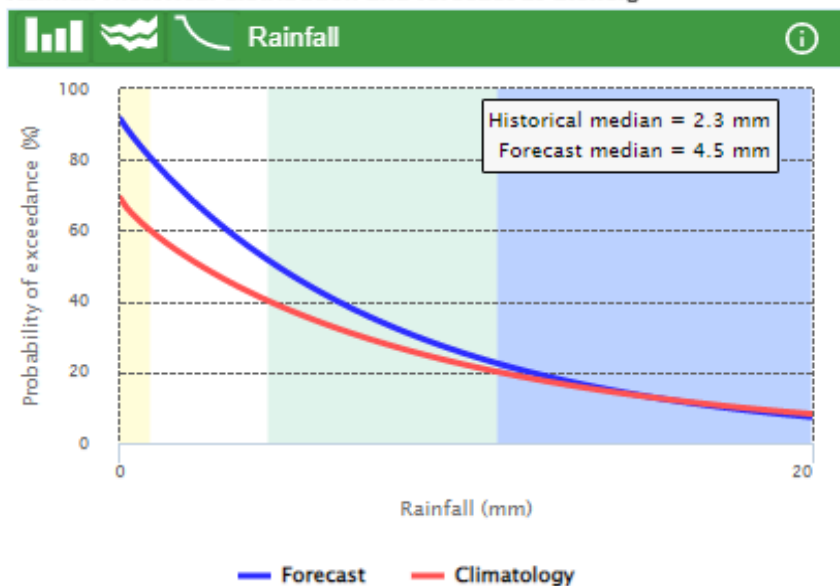
Experimental Product #4 - live to public June 2022

Probability of exceedance (POE) graphs for rainfall were the fourth product chosen to be operationalised by the Bureau and are probably the most complex of the new tools to understand. However, once understood, the overwhelming feedback was that this tool is valuable and will allow users to delve deeper into the forecast information. It forms part of a hierarchy of complexity of forecast tools. Insight from the producers in the reference groups indicated that for some users this information is too detailed, but for others, it could provide very useful input into their decision-making. Figure 4 shows an example of a POE forecast.

Figure 4: Probability of Exceedance.

Example forecast for rainfall, showing the forecast (blue) and usual conditions (red) for Glenelg during the period of 37 November to 3 December 2022.

Rainfall Historical distribution and forecast at Glenelg



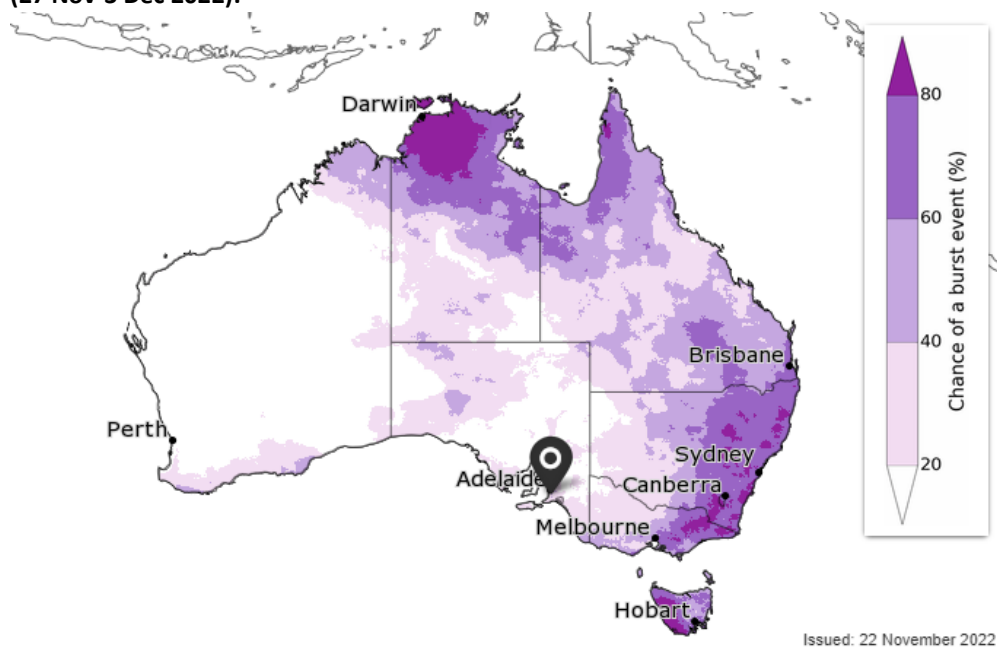
The POE curves give the probability (y-axis) that different thresholds of rainfall (x-axis) will be exceeded at the location in question. The curves slope from the top left down to the bottom right, because as the rainfall totals increase, the chance of exceeding those totals decreases. The blue curves are the forecast POE and the red curves are the historical POE (i.e., climatology). Comparing the blue and red curves indicates how different the forecast is from usual conditions. The forecast product gives users the flexibility to identify the rainfall threshold that they are interested in on the x-axis, and then read the associated probability of exceeding that threshold on the y-axis (or vice versa).

Experimental Product #5 - live to public June 2022

The fifth product operationalised by the Bureau is the 3-day rainfall accumulation (or “burst”) forecast which is a map-based product and available for multi-week forecasts (Figure 5). The forecast product shows the likelihood (probability) of receiving a pre-selected threshold of rainfall over three consecutive days in the upcoming weeks or fortnights. The product has four thresholds that can be selected (15mm, 25mm, 50mm and 75mm). The example in Figure 5 shows that parts of western Tasmania and eastern Victoria and NSW have a greater than 80% chance of receiving more than 15mm of rainfall in three days during the week of the 27 November to 3 December.

Figure 5: 3-day rainfall accumulation (burst) product.

A forecast map showing the probability of receiving an intense ‘burst’ of rainfall over a short period of time (27 Nov-3 Dec 2022).



4.2 Collaboration

Collaboration has occurred on several levels as a result of the Forewarned is Forearmed project:

- Northern Australia Climate Program (NACP) technical officers and Climate Mates regularly use FWFA products like Heat Extremes, Temperature Humidity Index (THI) and Chill Index when engaging with producers at workshops, multi-topic days and one-on-one events.
- NACP has conducted MCV workshops where the FWFA products were presented and discussed with red meat producers and advisers (see Table 2).
- There has been project level collaboration between FWFA, NACP and DAFQ in the four IRG regions particularly with other DCAP funded projects including Grazing Futures.
- DCAP has held climate risk workshops with sugar industry stakeholders where prototype FWFA

products were presented and discussed with sugar producers.

- DCAP were invited to the Project Catalyst Forum in Mackay 23-25 February 2020 and presented and received feedback on the FWFA products from 85 sugar producers and 105 on-ground service providers / sponsors / partners.
- Project leaders collaboration between research providers, namely the BoM, Universities (University of Melbourne, University of Southern Queensland, Monash University), state governments (DEDJTR, SARDI, DAF- Queensland) and the Birchip Cropping Group (BCG).
- Project level collaboration between DAF- Queensland in the four regions as well as MLA, SRA, BoM, UniSQ, stakeholders and producers from the sugar and northern red meat industries.
- Ongoing engagement between the FWFA project and DCAP.
- NRM groups and FDF Hubs in NNSWQLD, North Queensland and NTNWA.

4.3 Extension and adoption activities

UniSQ, DAF and Bureau staff from FWFA provided contributions to the CoP and FWFA extension and adoption (WP4) in the following ways:

Contribution to CoP until December 2021

- UniSQ and DAF FWFA have initiated or presented 18 webinars.

Workshops until December 2021

- NACP MCV workshops or multi-topic days - FWFA products have been shown at 34 events to 357 red-meat producers and advisers
- DAF DCAP MCV workshops - FWFA products have been shown at 2 events to 23 sugar producers and advisers

UniSQ, DAF and Bureau staff from FWFA, in addition to the above, have conducted the following events in 2022:

- 6-7 December 2022 – FWFA Forum – Use of FWFA products #1-5, business case for heat load product and short videos describing deciles, rainfall burst and POE graphs presented to stakeholders – c. 40 participants
- 30 November 2022 – MLA launched a world-first grazing management tool the Australian Feedbase Monitor at the MLA Updates event, Toowoomba. FWFA products #1-5 and NACP were represented - 375 participants - 17 producers engaged with FWFA/NACP material
- 7-11 November 2022 – NACP Annual Project Meeting, Darwin. FWFA products #1-5 presented to NACP researchers and Climate Mates – 50 participants
- 26 October 2022 - DCAP Showcase, Brisbane. FWFA products #1-5 presented to DCAP stakeholders – 90 participants
- August 2022, 5 Stanbroke Cattle Company properties in the Gulf area of Queensland, FWFA products #1-5 shown during at climate workshops - 50 attendees
- August 2022, Young Live Exporters Network meeting, Darwin, NT. Presentation of Burst forecast - 23 attendees
- July 2022, Future Farming Forum, Rockhampton, Queensland. Discussion of burst product to 22 producers and 18 in the related supply chain
- 1 June 2022 - Precision Agriculture field day Proserpine, FWFA presentation, 50 participants
- 7th April 2022, Sugar Research Australia Webinar – presentation of FWFA products Debbie Hudson. <https://sugarresearch.com.au/resources-and-media/media/>
- 8th April 2022, Sugar Research Australia Webinar – presentations by Robert Quirk and Tom Bowditch on how they are using FWFA products.

- 13th April 2022, Healthy Land & Water/Noosa Landcare – Climate Adaption workshop Pomona, new FWFA products and how to use them. 24 participants.
- 24-25 March 2022, FWFA products displayed, demonstrated and presented at booth at NTCA Conference, Darwin – 250 attendees
- 23 March 2022, Climate Forecasting for Decision Making Workshop, Daly Waters, FWFA products #1-5 presented – 22 participants
- 8-11 Mar 2022, FWFA products #1-5 presented to NACP researchers and Climate Mates - 35 staff
- 24th March 2022, Peter Crawford Climate mate presentation at Wondai. Explanation of FWA products. 8 participants.
- 11th Feb 2022, Teleconference with Sugar Research Australia staff to organise webinar for new FWFA products.

4.4 Lessons learnt

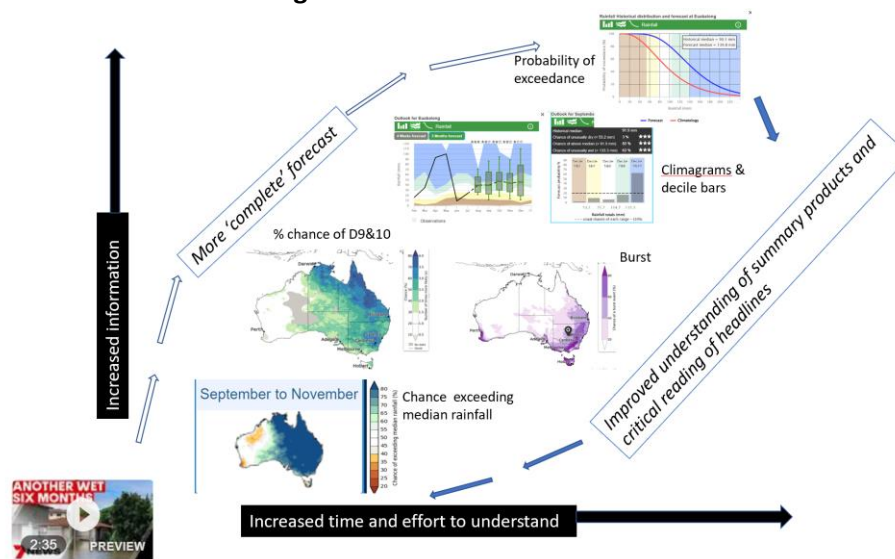
Lessons learnt from a communications viewpoint (from UniSQ and DAF):

- Challenges associated with maintaining interest, motivation and participation of IRG's over long periods. Maintaining interest was difficult, some of this was due to COVID, nonetheless some members were difficult to engage prior to COVID.
- COVID-19 played a role in reducing face to face discussions and connectivity.
- Raising awareness, knowledge and practice change require different (and increasing) levels of extension effort.
- Use of product and practice change can be motivated and driven by a need to make a decision (and knowing of a products existence and someone to advise) e.g. should I muster early to avoid boggy roads and missing the liveEx boat, how do I time transport of bulls in order to avoid heat stress?
- Explaining these products in order to gain understanding goes way beyond explaining more common terms such probabilities or weather forecasts.

Lessons learned/observations (from project level – Peter Hayman SARDI) have been summarised under the following findings (Appendix 4):

- 1) Growing interest in information on climate extremes.
- 2) Generic forecast products answered most of the climate risks raised by industry
- 3) It is naïve to assume that farmers all want forecasts in a certain way or even that a farmer wants the same type of forecast all the time but layering detail can be effective (walking up Figure 6).

Figure 6. Relationship between the amount of information in products #1–5 and time needed to understand their meaning.



An interesting unintended consequence of FWFA forecasts is improved understanding of probability (walking back down Figure 6).

- 4) The skill of forecasts remains a challenge
- 5) Moving from i.) awareness to ii) understanding climate drivers to iii) understanding probabilities to iv) using probabilities in decision making is hard work – but we have made some steps.

5 Conclusion

Although Products #1-5 represent useful tools for forecasting risk of extreme events across a range of sectors the extension and adoption is in the very early stages and will need to be continued to gain adoption and impact.

The accuracy of these products is always questioned by farmers and scientific community. The underlying accuracy of the model has not been improved during this project. The accuracy of the forecasts in these products declines rapidly as lead time increases which is evident in product #3 demonstrated by comparing the forecast with the historical data in the background. Improving accuracy of these products will improve uptake by end-users – more research into model improvement is recommended starting with a value statement that clearly shows the likely benefits, costs and impact.

5.1 Key findings

Products #1–5 represent useful tools for forecasting risk of extreme events across a range of sectors.

The northern red meat and sugar industries found the rainfall burst product very useful.

Maintaining effective and engaged industry reference groups proved difficult over long periods.

Resourcing for E&A of products #1–5 was limited in this project.

Resourcing of a multi-agriculture industry E&A program to increase the awareness, knowledge and application of these products is likely to provide significant economic, environmental and social impact.

Collaboration with similar projects (NACP, DCAP) and organisations (NRM, Drought Hubs, State Dept of Agriculture in NT and WA) provided significant leverage to FWFA through feedback on products #1-5, E&A activities, input into FWFA CoP and general FWFA awareness and promotion.

Products #1–5 take time and are difficult to explain to many people. The use of short videos explaining how some producers used the products has been an effective tool to motivate potential users to seek expert advice in order to use in decision making.

5.2 Benefits to industry

The potential benefits to the industry of accurately forecasting extreme events are substantial.

As an example, the north of Queensland has had four natural disaster flood events in the last four years (TC Trevor, March 2019; North and Far North Queensland Monsoon Trough Jan/Feb 2019; TC Penny Dec/Jan 2018/19; TC Owen December 2018) and these events are projected to become more frequent.

In January 2019, a stalled MJO embedded in a monsoon trough brought rain in the Gulf catchment locations of Richmond, Julia Creek and Cloncurry started on the 29 January 2019 and lasted 13 days finishing on the 10 February 2019. During this period these locations received 3 times their median rainfall for January and February and twice their median annual rainfall.

This event caused widespread flooding and about 500,000 cattle were lost from drowning and others from hyperthermia. The seasonal and monthly forecasts did not pick up this event, but in hindsight, the weekly prototype forecast, identified it (but not to its extreme extent) with one week lead-time, but this information was not available to the public.

An economic case study of one property in the Gulf that lost 6,000 head of cattle shows a gross benefit of \$5,550,000 from this one event had the owner had one weeks notice to move cattle to higher ground and provide fodder prior to the event

The value of accurate forecasts of extreme climate events to mitigate the economic impacts of disasters is significant. The total cost of the 2019 floods was \$5.68 billion with only 7% attributed to agriculture losses and a massive 40% attributed to health and social impacts (Deloitte 2019).

6 Future research and recommendations

These products #1–5 are possibly a world first, but a key limitation is model skill. Nothing in this project improved the skill of the underlying model on which these products were developed. To address producers key concern about model accuracy needs more research resources in global model development and evaluation to reduce the model biases and improve convective parameterisation

The continued uptake of these products #1–5 by industry will rely on awareness, understanding the product message, having a decision to make that's relevant. To do this requires resourcing a team of trained climate advisers to deliver a E&A service that has a clear set of KPI's related to improved awareness, knowledge, and practice change that shows impact.

Improving accuracy of these products will improve uptake by end-users – more research into model improvement is recommended starting with a value statement that clearly shows the likely benefits, costs and impact.

7 References

- Carter, J, Bruget, D Stone G (2019). Exposure as captured by a chill index as a contributing factor to livestock losses in Northern Queensland. Department of Environment and Science, Brisbane (unpublished notes).
- Colin A. Carter, K. Aleks Schaefer, Daniel Scheitrum (2021). Raising cane: Hedging calamity in Australian sugar, *Journal of Commodity Markets*, Volume 21, 100126, <https://doi.org/10.1016/j.jcomm.2020.100126>.
- Cobon, D.H., Stone, G.S., Carter, J. O., Scanlan, J., Toombs, N. R., Zhang, X., Willcocks, J., and McKeon, G. M. (2009). The climate change risk management matrix for the grazing industry of northern Australia. *Rangl. J.* 31 (1), 31-49.
- Cowan, Wheeler, Alves, Narsey, de Burgh-Day, Griffiths, Jarvis and Cobon (2019). Forecasting the extreme rainfall, low temperatures, and strong winds associated with the northern Queensland floods of February. *Weather and Climate Extremes* (vol 26), <https://doi.org/10.1016/j.wace.2019.100232>
- Deloitte (2019). The social and economic cost of the North and Far North Queensland Monsoon Trough 2019. Queensland Reconstruction Authority June 2019
- Donnelly JR (1984). The productivity of breeding ewes grazing on Lucerne or grass and clover pastures on the Tablelands of southern Australia. III. Lamb mortality and weaning percentage. *Australian Journal of Agricultural Research*, 709-721.
- June Brundell, David Cobon, Grant Stone Neil Cliffe (2011) Climate change risk management matrix: a process for assessing impacts, adaptation, risk and vulnerability – Workbook. Queensland Centre for Climate Change Excellence, Department of Environment and Science, Brisbane.
- Hall, Trevor (2020), Pasture recovery, land condition and some other observations after the monsoon flooding, chill event in north-west Queensland in Jan-Mar 2019. Department of Agriculture and Fisheries, Brisbane.
- McCosker, D., G. Fordyce, P. K. O'Rourke and M. R. McGowan 2020. Reproductive performance of northern Australia beef herds. 2. Descriptive analysis of monitored reproductive performance. *Animal Production Science*. <https://doi.org/10.1071/AN17495>
- McGowan, M., McCosker, K., Fordyce, G., Smith, D., O'Rourke, P., Perkins, N., Barnes, T., Marquart, L., Jephcott, S., Morton, J., Newsome, T., Menzies, D., Burns, B.; 2016, Technical synopsis: CashCow findings - Insights into the productivity and performance of northern breeding herds, Meat & Livestock Australia Limited.
- Nixon-Smith WF (1972). The forecasting of chill risk ratings for newborn lambs and off-shears sheep by the use of a cooling factor derived from synoptic data. *Working paper 150, 40/145 of April 1972, Bureau of Meteorology, Australia*.
- T. L. Mader, L. J. Johnson, and J. B. Gaughan (2010) A comprehensive index for assessing environmental stress in animals. *J. Anim. Sci.* 2010. 88:2153–2165, doi:10.2527/jas.2009-2586
- Rogers, John (2014). High yielding Cane Booklet. SRA Indooroopilly Queensland
- Roger Stone, Matt Kealley (2012). Climate Variability Tools for Primary Producers in the Queensland Sugar. CANEGROWERS and Rural Resilience Industry Grants Program Queensland Government.

8 Appendix

8.1 Appendix 1 – Industry Reference Group activities for northern red-meat and sugar

8.2 Appendix 2 Risk Management Plan for the northern red-meat industry including, Climate Risk Matrix, Risk Response Matrix, Decision analysis (Verbal Decision Analysis) and a Case study

8.3 Appendix 3 - Risk Management Plan for the sugar industry including, Climate Risk Matrix, Risk Response Matrix, Decision analysis (Verbal Decision Analysis) and a Case study

8.4 Appendix 4 – Lessons learned/observations (from project level – Peter Hayman SARDI) – draft

8.5 Appendix 5 – Business case for Head Load Index for cattle

8.6 Appendix 6 – NACP Extension Use of FWFA Products and Information

8.7 Appendix 7 – Project media and communications