Smarter Irrigation for Profit 2

RRDP 2012 Beyond Water Smart - Advancing Dairy Irrigation System Performance

Final Report

Australian Government
Department of Agriculture, Fisheries and Forestry

This project is supported by funding from the Australian Government Department of Agriculture Fisheries and Forestry as part of its Rural R&D for Profit program.

Dairy Australia

UNIVERSITY of TASMANIA
TIA
Tasmanian Institute of Agriculture
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Plain English summary

This Smarter Irrigation for Profit Phase 2 (SIP2) project, Beyond Water Smart was led by the Tasmanian Institute of Agriculture (TIA). SIP2 followed on from the Smarter Irrigation for Profit Phase 1 (SIP1) which ran from 2015-2018 and identified the potential for improved irrigation management in the Tasmanian dairy industry. The aim of SIP2 was to take the learnings of SIP1 to a wider audience and improve the irrigation management of more Tasmanian dairy farmers, as well as continuing to conduct irrigation research and development to improve the Tasmanian dairy industry. This was done by working closely with a network of farmers in five key dairy areas from 2019 to 2022, as well as conducting research at the Tasmanian Institute of Agriculture's dairy research facility (TDRF) and several commercial farms.

To improve the irrigation management of Tasmanian dairy farmers, five farms were selected as optimised sites, and these were each supported by a reference group of nearby farmers. These reference groups met regularly through the irrigation season to discuss and learn more about irrigation. In addition to the meetings, the group members were also sent reports weekly during the irrigation season with weather, soil moisture and pasture growth rate information to help them make informed irrigation management decisions. To assist in extending the learnings wider than just the reference groups, several field days were conducted covering the importance of irrigation for good pasture growth and how to achieve this, as well as some of the tools that can be of help, such as IrriPasture. These field days received very positive feedback from attendees. Isaac Korpershoek who farms in the NW of Tasmania participated in the NW IrriPasture field day activities and said, "My team and I all agreed that the field day was a really good mix of new technology and practical activities and IrriPasture is something we will be using this season".

On the optimised farms, one of the centre pivot irrigators on the farm was selected as the optimised site from which data was collected. At the beginning of the project the centre pivot irrigator was audited and recommendations for improvements to the system made. The system was then monitored throughout the irrigation seasons and reaudited at the conclusion of the project. During the irrigation season, weather, irrigation, soil moisture and pasture growth rate data was collected for the weekly reports, as well as for identifying the pasture production yield gap. This information was provided to the optimised sites and their reference groups so that they could improve irrigation scheduling. It was also used to measure the level of improvement made by the optimised sites through the project. The data was collected with a range of technology:

- **Weather** – from an onsite weather station at each of the optimised site.
- **Soil moisture** – from soil moisture probes coupled with tipping rain buckets installed underneath the centre pivot at the optimised sites. The water budgeting tool IrriPasture was also used and tested and compared to the soil moisture probes.
- **Pasture growth rate** – collected both manually with a rising plate meter and automatically from Pasture.io which uses satellite imagery and additional data and algorithms.
- **Irrigation management software** – On two of the sites FieldWise nano units were installed to test the SWAN Systems water management platform for potential use by dairy farms.

In addition, further evaluation of the autonomous system 'VARIwise', developed as part of the first Smarter Irrigation for Profit project, continued under highly controlled experimental conditions at the TIA Dairy Research facility, where the current 24ha pivot is equipped with both variable rate irrigation (VRI) and the autonomous VARIwise system. Details of the outcome of this work are reported in the final report from Joe Foley and Alison McCarthy at USQ.

Three small plot irrigation studies were also carried out at TIA's Dairy Research facility. Two focused on quantifying the effect of the "Green "Drought" on perennial ryegrass growth and the third focused on whether summer-active cocksfoot could increase warm season growth and marginal irrigation responses on Tasmanian dairy farm. Results from the green drought trials suggest that in the cool-temperate Tasmanian climate, delaying the start of irrigation in early spring by one typical growth cycle will likely have minimal effect on pasture production over the growing season. Longer delays, or delays in irrigation during warmer periods when evapotranspiration demand is higher, has a greater effect on pasture performance, with a measured yield penalty of 20% when comparing optimal irrigation with a green drought scenario, which equates to a loss of DM of approximately 2t/ha over a 120-day irrigation season. There was also evidence from the third trial to support the potential wider use of modern summer-active cocksfoot cultivars on Tasmanian dairy farms to increase warm season growth. Such benefits could potentially be obtained from adding a small quantity of cocksfoot seed in autumn-sown perennial ryegrass-based pastures.

This SIP2 project has provided very compelling evidence of the potential positive impacts of improving irrigation scheduling on pasture production and WUE. Those farmers who have been engaged with this project showed significant improvements in their knowledge and indicated that it had an impact on changing their practice on farm. It has become evident however that there is still some way to go in improving the irrigation management of Tasmanian dairy farmers and the service provider community. Dairy farmers tend to prioritise their cows and other farm operations above irrigation, and they often don't realise the impact poor irrigation has on pasture production, given the grass is always green but just not growing to its potential. This presents an opportunity for autonomous systems like VARIwise to make significant social, economic and production improvements for farmers. It should also be noted that in some farm systems, reduced growth at certain times can be a management decision and therefore achieving optimal growth is undesirable. However, this does not mean that when irrigation is required it can be managed poorly. Regarding system performance, there is still a way to go in up skilling not just farmers but also service providers, in what to test, monitor and modify to ensure that systems are fit for purpose and performing to specifications. The project has also reinforced the common mistakes that are made in irrigation management, for example, waiting too long to start irrigating both at the start of the season and after rainfall events.

This project was supported by funding from Dairy Australia, University of Tasmania and the Australian Government Department of Agriculture, Fisheries and Forestry as part of its Rural R&D for Profit program.

Abbreviations and glossary

TIA – Tasmanian Institute of Agriculture

SIP1 – Smarter Irrigation for Profit Phase 1 (2015-2018)

SIP2 – Smarter Irrigation for Profit Phase 2 (2019-2022)

RAW – Readily available water

ET0 – Evapotranspiration

USQ – University of Southern Queensland

TDRF – TIA Dairy Research Facility

Pivot or CP – Centre Pivot Irrigator

1 Project rationale and objectives

Irrigation is a key aspect of the Australian dairy industry, with 58 % of farms being irrigated, and using an average of 586 ML/year per farm (Dairy Australia, 2020). At a local (Tasmanian) level, 76% of Tasmanian dairy farms are irrigated and each using on average 614 ML/year (Dairy Australia, 2020). These systems are predominantly pressurised systems (laterals, centre pivots and hard hose travellers). With the cost of water, pumping and irrigation infrastructure (capital and ongoing costs) associated with these systems, they are a key driver in farm profitability and efficiency through the irrigation season, when pasture growth rates drop without sufficient water availability.

In Tasmanian the increasing access to irrigation water, milk processing capacity, and global demand for dairy produce has resulted in expansion of the Tasmanian dairy industry which is predicted to continue into the future. Whilst some of the expected future growth is to come from established farms, new and conversion dairies will be required to achieve desired industry growth targets over the next five years. It is predicted that a significant proportion of the expected expansion will be into non-traditional dairy regions, such as the northern and southern midlands of Tasmania. These regions present challenges for dairying as more often than not they have highly variable and difficult to manage soils. Managing irrigation on dairy farms in these regions will require delivery of precision irrigation to maximise production and alleviate unfavourable outcomes such as waterlogging, runoff and soil salinity for these farms to be productive and sustainable.

Achieving optimal performance from the pressurised irrigation systems used within the Tasmanian and more broadly the Australian dairy industry is challenging given the varying climatic, edaphic, and farming systems conditions under which they operate. However, key decisions such as start-up time, scheduling interval, irrigation depth and system performance (uniformity of water distribution and energy efficiency) are often determined by simple rules-of-thumb or gut feel estimates. Detailed benchmarking and analysis of pressurised irrigation systems in Tasmania between 2015 and 2018 as part of the first Smarter Irrigation for profit project showed that there is significant opportunity to enhance performance of irrigation systems in respect of energy and water use efficiency, as well as overall whole farm productivity and profitability.

Therefore, several research questions were proposed to attempt to address these current and expected issues, through the Smarter Irrigation for Profit phase 2 (SIP2) project.

1. Can targeted irrigation based on informed scheduling decisions lead to increased pasture productivity and efficiency?
2. Can a precise measure of the spatial and temporal variability of an irrigated site be used to lead to improved irrigation efficiency?
3. Can engineering design modifications of centre pivots increase irrigation effectiveness through reduced waterlogging and runoff?
4. Does a hub and spoke model of engagement through focus farms and support network groups lead to wider uptake of key findings?
5. Does the implementation of an autonomous irrigation system lead to increased water use efficiency and productivity of irrigated pasture?

2 Method, activities, and project locations

Details of the key team members and partners for this project are given in Table 1.

Following consultation with key stakeholders including Dairy Australia, DairyTas and regional reference groups, suitable optimised farm sites were selected across 5 dairy regions in Northern Tasmania (refer to Table 2 for details)

A system performance check was undertaken initially to determine pump plant efficiency along with an in-site performance evaluation. Following this, the optimised farms were set up with commercially available and proven sensors to capture key information and data flows, including:

a. Climatic
b. Soil moisture
c. Water and energy usage
d. Pasture growth rates (collected weekly by farm staff or consultants, during the irrigation season, using a rising plate meter).

Focus groups associated with each optimised farm were established. These groups included participating farms, as well as industry representatives and researchers. The groups met approximately monthly during the irrigation season to review past, current, and future conditions, discuss seasonal planning objectives, current water usage and scheduling and overall implications on pasture productivity and WUE. Professional development training was also provided as part of the discussion groups.

An irrigation scheduling program (IrriPasture) was developed and then used to help guide decisions for irrigation at each optimised site.

Table 1. Team members and partners involved in the project

Name/s	**Organisation/Business**	**Role**
James Hills	TIA	Lead Researcher
Pieter Raedts	TIA	Research Fellow
Adam Langworthy	TIA	Research Fellow
Rohan Borojevic, Sam Flight, Lesley Irvine and Symon Jones	TIA	Extension Officers
Carlton Gee, Vaughn Coull, Ben Noble and Steve Emmett	TIA	Technical Officers
Marek Matuszek and Reuben Wells	AgLogic	Technical support for moisture probes
Ivor Gaylard	SWAN Systems	Technical support for SWAN Systems
Joe Foley	USQ	IrriPasture development and VARIwise
Alison McCarthy	USQ	VARIwise

Table 2. Locations of all project activities including the location of any commercial farms involved in RD&E activities during the life of the project.

Name & type of site (field site, laboratory, project partner sites, RDC headquarters)	**Street Address**	**State**	**Postcode**
Freshwater Dairy *Optimised site*	345 Houses Road, Lileah	Tasmania	7330
Clear Springs Dairy *Optimised site* *PhD research site*	264 Meander Road, Meander	Tasmania	7304
Forester Lodge Dairy Optimised site	1259 Waterhouse Road, Waterhouse	Tasmania	7262
Woodrising Dairy *Optimised site* *PhD Research site*	773 Delmont Road, Cressy	Tasmania	7302
Glenwood Dairy *Optimised site*	Duniams road, Sisters Creek	Tasmania	7320
TIA Dairy Research Facility USQ collaboration site for autonomous VRI research and a replicated trial focused on the green drought issue	124 Nunns Road, Elliott	Tasmania	7325
Annandale Dairy *PhD research site*	Tunbridge	Tasmania	7120
Remlap Dairy *PhD research site*	Rulla Rd Sisters Creek	Tasmania	7320

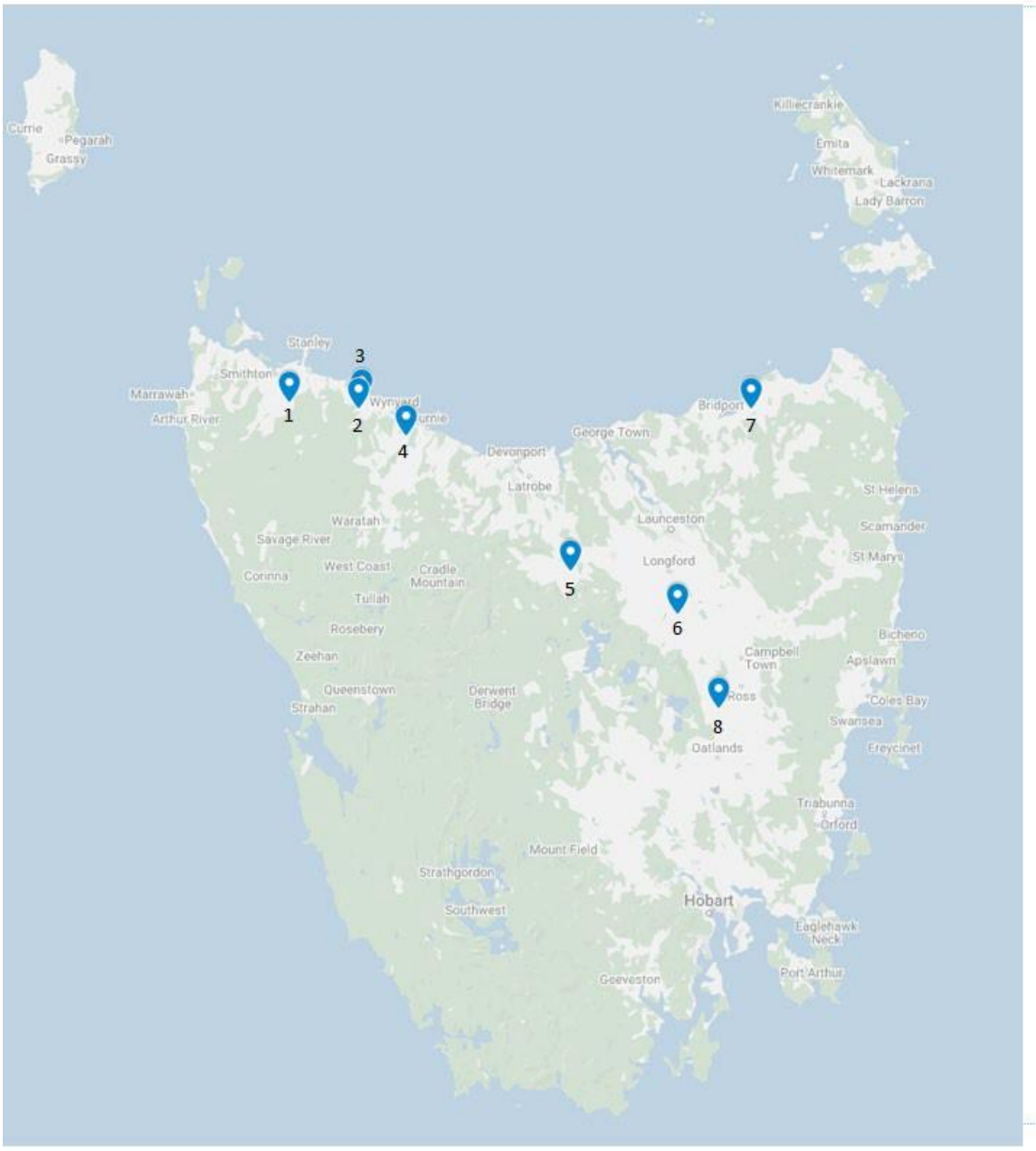

Figure 1. Site Locations. Freshwater, Lileah (1). Remlap, Sisters Creek (2). Glenwood, Sisters Creek (3). Tasmanian Dairy Research Facility, Elliott (4). Clear Springs, Meander (5). Woodrising, Cressy (6). Forester Lodge, Waterhouse (7). Annandale, Tunbridge (8).

All of the sites above are centre pivot irrigated perennial pastures used for dairy production. Therefore, the research that has been conducted through the project is highly applicable to the dairy industry in Tasmania and Australia more broadly. Some of the learnings are also highly applicable to other irrigated livestock production such as beef and sheep as well as pasture seed production.

3 Project Outcomes

3.1 Project level achievements

Output and KPI numbers and description	**Summary of achievements**
Activity output 5.3(c) Validate the benefits of strategies to close the productivity yield gap, including autonomous irrigation and modified engineering design technologies on 5 Tasmanian dairy irrigation focus farms.	5 optimised sites were selected, benchmarked, and monitored from 2019-2022. System modifications, and practice change took place during this period on these sites. Follow up evaluations and site-specific yield gap analysis was done to validate improvements. Strategies implemented were improving irrigation scheduling, soil moisture monitoring, water budgeting, systems modifications, measuring pasture growth rates including using an automated system (Pasture.io) and determining RAW from soil texture and effective root depth. This resulted in improved pasture production (improvements on average 11%, with the largest improvement of an individual site 28%), and a reduced yield gap when comparing growth rates measured on farm with modelled potential growth rates (mean yield gap reducing from 27.9% to 19.9%, i.e., an improvement of 11%). These results are based on measurements of pasture biomass using a manual Rising Plate Meter (still the gold standard in research), as well as satellite-based biomass assessments (Pasture.io). Autonomous and Modified Engineering: the USQ collaborative project tested both VARIwise (an autonomous variable rate irrigation control platform) and a machine vision system to determine pasture biomass for improving automated irrigation decisions. Findings are reported as part of the USQ final report.

KPI Final report. Provide a brief and final report on the economic and productivity benefits of addressing the yield gap for each focus farm, associated satellite farms and the economic benefits of autonomous irrigation decision making technologies and engineering design modifications. (Activity outputs 5.3c and 5.2g).	A brief report on the economic and productivity benefits of addressing the yield gap using a variety of technology including autonomous technology has been completed (6.4.1 Metrics Technical report). An analysis of the yield gap in pasture production showed that the learnings from the first full season resulted in an average increase across all optimised sites of 11% in pasture growth in the final season of the project. If the Glenwood optimised site is excluded, which had a non-irrigation related slight decrease in pasture growth due to pugging damage and a root aphid infestation, the average pasture growth rate increased by 15%, which is 8.9 kg DM/ha.d when corrected for the different sizes in pivots, or for the 7 month season 1,885 kg DM per hectare extra. The average pivot size for these 4 pivots is 68.8 ha, resulting on average in an increase in pasture production of 129.7 tonne DM per farm. If we use a replacement feed value of $300 per tonne DM ($250 plus $50 handling and feed-out costs per tonne DM), that is an average value of $38,910 per farm and per annum. This is only for the pivots involved in this project. These farms have more irrigated pasture (at least double or triple the area of the project pivots), and if the growth rate improvement was achieved on these other irrigated pastures, on average the total benefit could double or triple to $77,000 or $105,000 per annum per farm. A cost analysis of underperforming irrigation systems showed an annual farm cost risk ranging from $2,766 to $6,483 per year (on 3 sites), due to not resolving inefficiencies in the pump and pivot system. The autonomous VRI system (VARIwise) was trailed by USQ at TDRF. By using a more dynamic mapping process that includes near real time updates of soil, climate, and pasture growth, VARIwise has been shown to generate additional benefits of up to 1 t/DM/ha per irrigation season compared to standard VRI. These trials have also shown that VARIwise further enhances the in-field irrigation water use efficiency (WUE) by up to 5% to 10% compared to standard VRI. If we assume a pivot size of 68 ha (the average pivot size of our five project sites), an

	improvement by VARIwise of 0.5 t DM/ha per season, and a replacement feed value of $300 per tonne DM, this would represent a benefit of $10,200 per annum. The improved WUE value will depend on the cost of water, and if the farm has access to "unlimited" irrigation water or not. If we assume that the farm has limited access to irrigation water (i.e. the water saved due to improved WUE is used to increase the area irrigated), a pivot size of 68 ha and a 5% increase of area irrigated, that would be 3.4 ha extra irrigated. Assuming a production increase of 5 tonne DM/ha (irrigation compared to dryland; cage harvest on our 5 sites found a difference of 6 to 7 tonne DM/season), this would represent an additional benefit of $5,100 at a replacement feed value of $300 per tonne DM for the average pivot of 68 ha.
Activity output 5.3(d) Conduct two field days each year and two professional development workshops on the software and technology being demonstrated for the Tasmanian dairy industry.	6 field days and 6 professional development workshops. • SIP2 Ready, Set, Go Irrigation Field Day, 23 September 2020. • Realising your irrigation potential (System maintenance and management) Field Day, 5th of July 2021. • 3 IrriPasture Field Days/workshops in Smithton, Montana, and Waterhouse on the 28th, 29th and 30th of September 2021 respectively. • Dryland and irrigated pasture legumes, Field Walk, November 2021. • An agribusiness professional development workshop covering IrriPasture was held on the 12th of November 2021. • SIP2 Combined irrigation workshop on the 15th of December at Peppers, Launceston. • IrriPasture presented to participants at the Pasture Management Workshop at Dairy Plains (June 8th and 15th).

3.2 Contribution to the SIP2 program objective

The biggest impact on productivity identified in this project is associated with maintaining soil moisture in the RAW zone for optimum pasture production. Differences between modelled potential yield and actual yield in the first full season was approximately 28%, on average across the five sites, but this decreased to approximately 20% in the second season. Whilst this improvement is promising, it also shows that significant improvements can still be made.

Across all five optimised sites there was an 11% increase in pasture production between the two full seasons monitored. Removing the one site where there was a reduction in pasture growth rates due to factors other than irrigation, the increase in pasture production was 15%. The average pivot size for the 4 pivots on these optimised sites was 68.8 ha, resulting in an average increase in pasture production of 129.7 tonne DM per farm. If we use a replacement feed value of $300 per tonne DM ($250 plus $50 handling and feed-out costs per tonne DM), that is an average value of $38,910 per farm and per annum. This calculation is only based on the pivots involved in this project. These farms have more irrigated pasture (at least double or triple the area of the project pivots), and if the growth rate improvement was achieved on these other irrigated pastures, on average the total benefit could double or triple to $77,000 or $105,000 per annum per farm.

3.3 Contribution to SIP2 program outcomes

1. Improved on farm water productivity/water use efficiency through use optimised irrigation practices, precision irrigation technologies and autonomous irrigation systems on participating farms.

Indicators:

- *20% increase in water productivity on SIP2 optimisation and key learning sites.*

The GPWUI (total rain and irrigation) increased on average across the 5 sites from 1.32 to 1.49 t DM/ML, although when only effective rainfall (GPWUIe) was taken into account there was no measured change on average for the 5 sites between the two seasons. For two of the sites however, where nutrient factors were identified that limited growth rates, correcting these limitations increased the GPWUIe (1.33 to 1.79 tDM/ML for Meander and 1.14 to 1.4 t DM/ML for Waterhouse) by 22% and 34% respectively.

- *80% of participating producers adopt or intend to adopt precision irrigation strategies and technologies.*

As a result of this project, 88% of participants indicated that they had made changes to their irrigation scheduling practices and 69% of participants indicated that they had changed their irrigation application rates to reflect available soil moisture and plant requirements.

2. A more knowledgeable and skilled irrigation community with greater confidence in their ability to optimise irrigation performance.

Indicator

- *Extent to which service providers and producer's express confidence in their capacity to optimise irrigation performance.*

Based on a final survey that asked participants to rate their knowledge about irrigation practices and technologies before and after involvement in the project, scores out of 10 increased from an average of 5.07 to 7.7.

3. ***Improved project RD&E efficiency through knowledge sharing, integration and collaborations between researchers, project participants, and commercial partners.***

Indicator

- *Changes in the number and type of partnerships between SIP2 irrigation research organisations, industry partners and commercial technology providers.*

As a result of the SIP 1 and 2 programs new collaborations and relationships have been developed between the following organisations.

University of Southern Queensland
Department of Agriculture Victoria
SWAN Systems
iCD Project Services
Sapphire Irrigation Consulting
Revington Technical Services

Ongoing relationships have also been strengthened for the following organisations

Dairy Australia
AgLogic
Pinion Advisory
FarmPulse

5. Increase in the number of cost-effective precision irrigation technologies able to be integrated into autonomous irrigation systems/platforms.

Indicator

- *Number and type of new precision irrigation technologies and/or fully automated irrigation systems developed/refined as a result of your projects research activities.*

A new free water budgeting tool (IrriPasture) specifically developed for irrigated dairy pastures was developed as part of this project and is now being used by the industry.

The use of FieldWise, technology to ultimately measure water flow and location of irrigation water applications under a pivot, was developed for use within the Swan system platform, in collaboration with Swan Systems and AgLogic. This is now available for use by dairy farmers and the wider industry.

4 Collaboration

4.1 Project collaborations

This project involved funding from the Commonwealth Government, Dairy Australia, and the University of Tasmania. Through the project TIA also developed several key technical collaborations. These collaborations were predominantly with service providers working in the technology and advisory space with irrigators across a range of industries. By fostering these relationships, learnings from other industries were able to be applied to the project to improve irrigation practices in the dairy industry and vice versa.

AgLogic

AgLogic is a local Tasmanian company that specialises in precision ag and monitoring. TIA has a longstanding collaborative relationship with Ag Logic, which has continued through the SIP2 project. Through the project AgLogic provided technical support in relation to the use of EnviroPro probes for soil moisture monitoring, tipping rain buckets for rainfall and irrigation data and Wildeye for telemetry and data display on the Wildeye platform. All of the 5 Tasmanian optimised sites had this technology installed with the optimised site farmers having open access to the data, which they all found beneficial. AgLogic consultants also provided support to the broader project on the Australian mainland. Working with AgLogic was also highly beneficial because they have a significant amount of experience in applying these technologies to Tasmanian dairy farm systems. They also brought with them a large network of dairy clients within Tasmania. It is hoped that these clients will continue to benefit from SIP2, as a result of TIA's collaboration with AgLogic beyond the completion date of the project. It is expected that TIA will continue to collaborate with AgLogic on future projects. AgLogic are also keen to work with their farmer clients to help them make use of the water budget tool 'IrriPasture' that was developed as part of this project.

SWAN Systems

SWAN Systems is a Western Australian based company that focusses on providing all-in-one water and nutrient management solutions. Through the project the SWAN Systems weatherwise forecast data was used to provide project participants with 7 day weather forecasts, which was included in the weekly irrigation reports. This was something that the optimised site and reference group members found highly beneficial in informing their irrigation scheduling decision making. It was also something that in feedback sessions people said that they would continue to use.

In addition to the weatherwise forecasts, the SWAN Systems decision support platform was also trialled. This involved installing FieldWise Nano units on two of the pivots in Tasmania monitored through the project as well as two pivots on the mainland that were part of the "closing the yield gap" project. The Tasmanian sites were Woodrising at Cressy, and Clear Springs at Meander. The FieldWise Nano units collected pressure, flow rate and GPS data to determine when, where and how much irrigation was applied to the site. In addition, soil moisture (Wildeye) and climate data (WeatherMation) from each site was collected. These data

streams are then ingested by SWAN Systems to give retrospective, near real-time and forecast (based off the SWAN Systems weatherwise forecast) information on irrigation requirements.

Pinion Advisory

Pinion Advisory water resources consultant David McLaren who was formally a member of the SIP2 project team at TIA was involved in several aspects of the project. Whilst working at TIA he undertook the technology installation at the optimised sites, and the initial irrigation system evaluations. Because he had the skills and experience in conducting the system evaluations, he was also contracted to complete the irrigation system evaluations at the conclusion of the project. In addition to this technical work, he also presented on the importance of system maintenance and benchmarking at the 'realising your irrigation potential' field day.

5 Extension and adoption activities

5.1 Project extension & adoption activities

Through SIP1 it was identified that there was room for improvement in regard to irrigation management in the Tasmanian dairy industry. Therefore, there was a need to continue to extend the findings of SIP1 to the Tasmanian dairy industry through SIP2. Throughout the project a range of extension activities were carried out with the aim of extending the findings from SIP1 and improving the irrigation management of Tasmanian dairy farmers through participatory extension activities. These activities are outlined below with further details contained in the appendix.

Reference group meetings

For the five optimised sites, reference groups made up of nearby farms were established. These reference groups met regularly (approximately monthly) throughout the irrigation season to discuss and learn about irrigation. All staff working on these farms were welcome at the meetings with particular emphasis on those involved in irrigation attending. At the beginning of each season these groups met to brainstorm topics to discuss for the season. These groups then met regularly through the irrigation season to address these topics, as well as season and or group specific issues. As a result of these reference group meetings, a number of people changed their irrigation practice. For example, after a reference group meeting one of the optimised sites changed from off peak power irrigation to irrigating when required to maintain readily available water and pasture growth rates. Several reference group members also invested in soil moisture probes to assist in their irrigation management after group meetings. The groups themselves were also seen as management tools by some of the reference group members as they used the discussion in the group chats as well as the learnings to inform and improve their irrigation management.

Weekly reports

In addition to the regular reference group meetings, reports were sent to the group members on a weekly basis during the irrigation season via either email or social media group chats (WhatsApp and Messenger). These reports contained:

- Weather data (evapotranspiration, rainfall, temperature, humidity, wind speed and average soil temperature) for the last 7 days at the optimised site.
- SWAN Systems 7 day weatherwise forecast for the optimised site and several nearby regions (evapotranspiration, chance of rain, rainfall estimate, temperature, humidity, and wind speed)
- IrriPasture water budget and estimated readily available water (RAW) for the optimised site.
- Pasture growth rates from the optimised site (both measured with rising plate meter and from Pasture.io) and from the reference group farms.
- Comments surrounding the last week, the forecast for the upcoming week, soil moisture and pasture growth rates.
- Information around the details of the next reference group meeting.

Field days

Over the life of the project several field days were conducted. These field days were aimed at delivering project extension to a wider audience than just those directly involved in the project and covered several subjects including:

- Irrigation start-up and scheduling
- Irrigation system maintenance and checks
- Technology such as IrriPasture

These days were well attended with positive feedback, particularly from the IrriPasture field days. At the IrriPasture field days the University of Tasmania's Mobile Interactive Learning Environment (MILE) truck was utilised which allowed engaging technology demonstrations to be combined with linked in field activities (Figure 2). Isaac Korpershoek who farms in in the NW of Tasmania participated in the field day activities and said, "My team and I all agreed that the field day was a really good mix of new technology and practical activities and IrriPasture is something we will be using this season". These days were attended by farm managers, farm staff and also service providers.

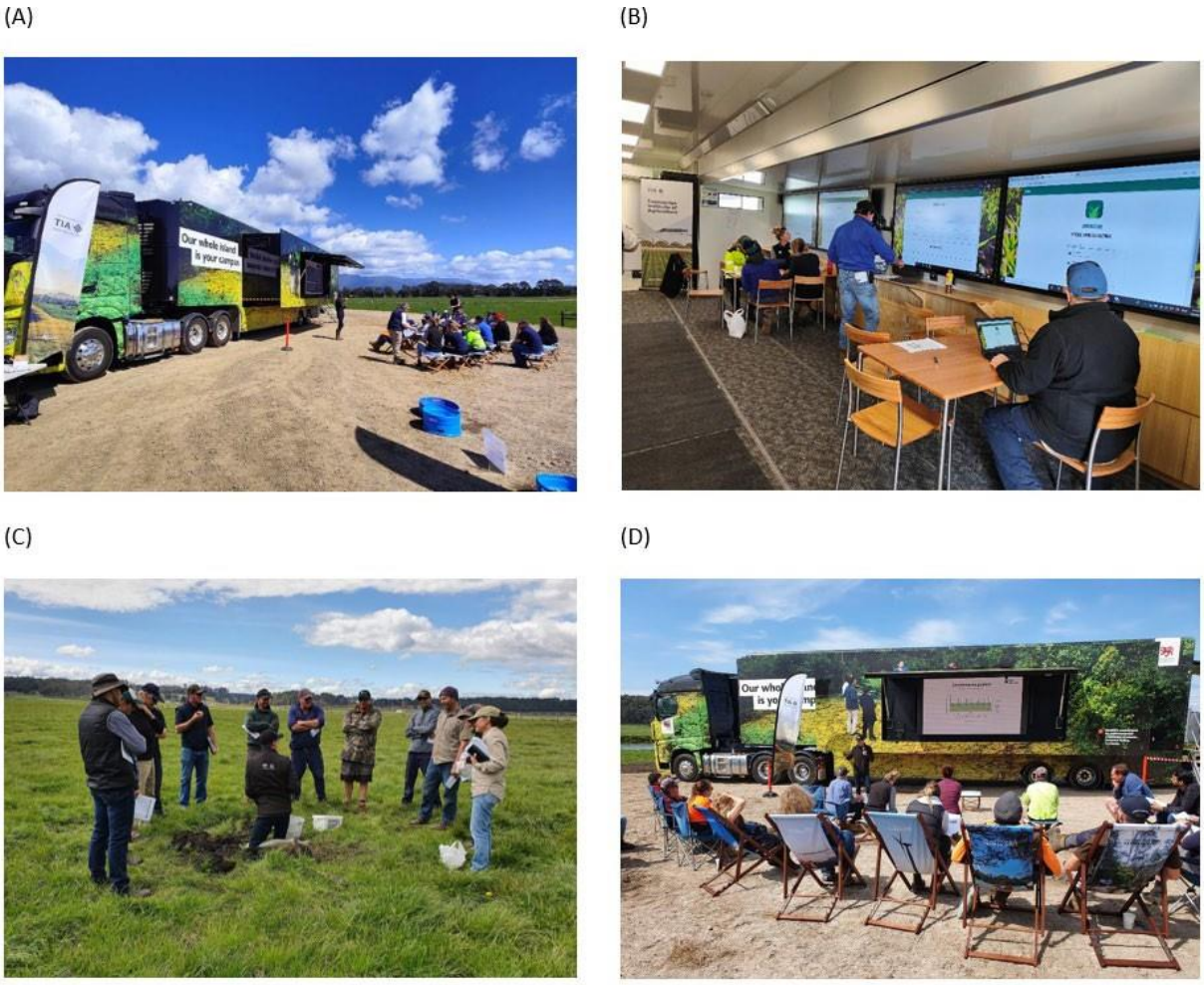

Figure 2. (A) The University of Tasmania's MILE truck onsite at the IrriPasture field day at Montana. (B) Farmers getting signed up to IrriPasture inside the truck. (C) Practical activity in the paddock at the Montana Field Day. (D) The University of Tasmania's MILE truck onsite at the IrriPasture field day at Smithton.

Fact sheets, webinars and other legacy content

In collaboration with Dairy Australia several fact sheets, webinars and other legacy items were produced that covered a range of topics.

Fact sheets

- Determining RAW from soil texture information.
- 5 irrigation start-up checklist fact sheets. These covered Travelling, K-Line, Solid set, Bike shift, Centre pivot and Lateral systems.
- Beyond Water Smart and the Tasmanian optimised sites.

Case studies

- Investing in improved irrigation scheduling to increase pasture growth in northern Tasmania.
- Investing in Variable Rate Irrigation and improved scheduling to increase pasture growth and save energy and water.

Webinar topics

- Using weather forecasting and soil information for irrigation decisions.
- Irrigation scheduling to make the most of every ML.
- Pump performance – using energy data to optimize irrigation system efficiency effectiveness and operating costs.
- Using pasture.io on your farm – the impact of monitoring yield under irrigation.

Videos

- Beyond Water Smart: Advancing Dairy Irrigation System Performance video featuring Dr James Hills.
- Two videos were also produced with two of the optimised sites managers as well as extension officers and project collaborators. (Yet to be published)

5.2 Lessons learnt and recommendations for future extension.

Throughout the life of the project a number of key learnings were identified through the delivery of the extension activities outlined previously. By analysing these learnings, future extension can be more effective, targeted, and improved.

Engagement and communication

Over the lifetime of the project, farmer engagement was difficult to sustain. Those farmers that came to the extension activities found them interesting and valuable, but often they were too busy to attend. There are a couple of possible underlying reasons for this.

One is that irrigation is often not seen as a high priority and so other jobs will be preferentially completed before attending a reference group meeting. COVID-19 also played a major part in reducing engagement in the 2020/21 irrigation season with lockdowns preventing face-to-face extension activities. During the lockdown periods extension went from in-person to online which caused several issues with engagement. In the 2021/22 season COVID-19 infections in staff and other group members as well as organisational rules and regulations reduced frequency and attendance at reference group meetings.

Two different methods of communication were used with the reference groups for weekly reports and organising meetings. These were social media group chats (WhatsApp and Messenger) and email. The social media group chats saw the most engagement and interaction, but this varied between groups. One of the group chats was very active and two of the others were hit and miss with the occasional interaction only when prompted. For future extension, the use of group chats for small group communication is a great way to engage farmers with the process but doesn't work for all groups.

Delivery

Having several changes in staffing through the project made consistent delivery of extension difficult, especially given the irrigation season is reasonably short and rapport needs to be built with participants. COVID also made the delivery of face-to-face extension difficult. Offering both online and in-person delivery options was trialled with mixed response. COVID has shown that online delivery is an option and works well in certain situations and content. However, there is no substitute for being able to get together and discuss and workshop topics in person. In the delivering of extension activities a large range of topics were discussed. These included but were not limited to:SWAN Systems weatherwise forecast

- Irrigation system management
- IrriPasture
- Water requirements of pastures
- Application rates
- Evapotranspiration
- Soil structure
- Infiltration rates
- Water limits and supply issues
- Irrigation system types and their associated management
- Pumping infrastructure modifications
- Wheel Rutting
- Dry wheel packages
- Variable rate irrigation (VRI)
- Soil moisture probes
- Readily available water (RAW)
- Uniformity

Technology

Technology can be highly beneficial in providing data to inform irrigation decision making. However, it also comes with inherent issues and so a certain level of scepticism and critical

thinking is required. A sound understanding of technology and interpretation skills is key to its usefulness in decision making. This is something that was learnt through the project particularly in relation to the interpretation of soil moisture probe data. Most of the optimised site farmers used the summed graphs from the soil moisture probes, which in most situations doesn't give a true representation of what is occurring in the root zone. If they did use the stacked graphs, they also tended to use the traffic light system which can be great but requires the field capacity, refill, and stress points to be manually set and adjusted through the season. Therefore, if they are not adjusted, farmers can be easily misled in their irrigation decision making. This is where good quality extension from both the public and private sectors can assist in improving the understanding of farmers using moisture probes, allowing them to be able to properly interpret, question and utilise the data to make best practice irrigation decisions.

IrriPasture also presented issues around the understanding and interpretation of data from technology. The main feedback was that IrriPasture indicated that irrigation was required when it was still at field capacity at the start of the season or after a major rain event. When coming out of winter IrriPasture would indicate that irrigation was required, but farmers would say that it was still that wet they couldn't drive in paddocks. This can be explained by water from capillary rise and lateral flow not being captured by IrriPasture. A feature has now been included in IrriPasture to easily reset the water budget to field capacity if required. To better support farmer decision making, it is important to build farmer capacity to understand where the data is coming from and what it means. Once this is understood, the data and information provided can be used effectively for decision making. This is something that can be done by skilled people working with farmers from both the public and private sector that have sufficient knowledge in the area.

Take home messages/summary

- Engagement was difficult to sustain over the three years of the project.
- Social media can be a great way to engage with some farmer groups.
- Irrigation as a standalone topic is often hard to get farmers to buy into after they already have attended several sessions.
- Optimised site and reference group member selection should be done carefully and scoped out to stimulate positive engagement.
- There was an increase in knowledge surrounding best practice irrigation as a result of the project.
- Practice change was observed on a number of farms through the life of the project.

6 Appendix - additional project information

6.1 Sub-project, media and communications material and intellectual property

6.1.1 Journal papers published/in preparation

Three papers are in preparation – Two accepted for the Irrigation Australia conference 2022, "Beyond Water Smart - Optimising irrigation for pasture production on Tasmanian dairy farms" and "Automated daily pasture growth and grazing detection using low-cost infield machine vision system". Another paper has been submitted to the Australian Dairy Science Symposium to be held in November 2022, titled "Summer growth, nutritive value and marginal irrigation responses of a modern summer-active cocksfoot (*Dactylis glomerata* L.) ecotype relative to perennial ryegrass (*Lolium perenne* L.).

6.1.2 **Extension materials** (guidelines, websites, videos, podcasts, reports, tools, economic case studies, fact sheets etc – *please provide links)*

Type	**Number**	**Details**
Weekly reports	280	2019/20 season – 58 2020/21 season – 123 2021/22 season - 99

Webinars and podcasts	4 webinars 1 podcast	Using weather forecasting and soil information for irrigation decisions. Available at: https://youtu.be/IFx5KWNPaFc Pump performance – using energy data to optimize irrigation system efficiency effectiveness and operating costs. Available at: https://youtu.be/m_2DfT4Vt5c Irrigation scheduling to make the most of every ML. Available at: https://www.youtube.com/watch?v=Pwrr5Uy97Ws&feature=youtu.be Using pasture.io on your farm – the impact of monitoring yield under irrigation. Available at: https://youtu.be/lJ2a0Xl8tjs Irrigation dairy Podcast DairyPod series. Available at: https://www.dairyaustralia.com.au/resource-repository/2020/09/01/podcast-27-how-smarter-irrigation-can-boost-production#.X7dWfGgzYuU
Fact sheets	12	5 start-up factsheets developed with Dairy Australia on Travelling, K-Line, Solid set, Bike shift, Centre pivot and Lateral systems. 5 factsheets on the Tasmanian optimised sites. Understanding RAW Understanding VRI options

6.1.3 **Extension activities** (workshops, field days, forums etc)

Type	**Number**	**Details**
Field days, expos, field walks	6 Field days/walks 1 Expo	SIP2 Ready, Set, Go Irrigation Field Day, 23 September 2020. Realising your irrigation potential (System maintenance and management), 25th of May 2021. 3 IrriPasture Field Days in Smithton, Montana, and Waterhouse on the 28th, 29th and 30th of September 2021 respectively. Dryland and irrigated pasture legumes, Field Walk, November 2021. Display at AgFest in Tasmania, July 2021
Reference group meetings	40	23 in the 2019-20 season. 5 in the 2020-21 season (COVID-19 impacted). 12 in the 2021-22 season (somewhat COVID-19 impacted)

Stakeholder forums, meetings, presentations,	3	Agribusiness professional breakfast with a presentation on the SIP2 project – November 2019 SIP2 Combined irrigation workshop on the 15th of December at Peppers, Launceston Agribusiness professional breakfast with a presentation on IrriPasture – December 2021

6.1.4 Media/social media activities

Type	Number	Details
TV	1	ABC Hobart – November 26 Dr James Hills on irrigation scheduling systems for farming MediaView (tveyes.com).
Radio	1	IrriPasture Field Days – The Country Hour Tasmania. Available at: https://www.abc.net.au/radio/programs/tas-country-hour/tasmanian-country-hour/13556126
Print and online media	1 print 8 online	Circular Head Chronicle (Print version) - 14 October 2021 Event wrap: Farmers from Irishtown and surrounds are taught about measuring moisture in soil. Irrigation tool helps farmers get more crop for their drop - GetINDUSTRY. Available at: Irrigation tool helps farmers get more crop for their drop - GetINDUSTRY farmonline: Tasmanian Institute of Agriculture to host test day for IrriPasture. Available at: https://www.farmonline.com.au/story/7446836/technology-helps-irrigation-methods/ Ausveg. Learn about the IrriPasture tool at TIA's irrigation field days, TAS. Available at: https://ausveg.com.au/articles/learn-about-the-irripasture-tool-at-tias-irrigation-field-days-tas/ HortiDaily: Irrigation Tool helps farmers get more crop for their drop. Available at: Irrigation tool helps growers get more "crop for their drop" (hortidaily.com) Tasmanian Institute of Agriculture to host test day for IrriPasture – The Advocate. Available at: https://www.theadvocate.com.au/story/7441362/technology-predicts-better-water-use-for-farmers/

		IrriPasture Field day write up. Beyond Water Smart – IrriPasture Field Days Tasmania (smarterirrigation.com.au) The TIA is helping irrigators maximise their water use – Stock and Land. Available at: The TIA is helping irrigators maximise their water use | Stock & Land | Victoria (stockandland.com.au) Smart irrigation technology hailed as 'game changer' by researchers – ABC Rural. Available at: Smart irrigation technology hailed as 'game changer' by researchers - ABC News
Social media	8 Facebook 1 Twitter	7 posts in the TIA dairy Discussions Facebook group 1 post from the TIA Facebook page promoting the IrriPasture field days https://twitter.com/TasInAg/status/1440594231358226437
Webpages	4	https://www.utas.edu.au/tia/news-events/news-items/2020/using-weather-forecasting-and-soil-information-for-irrigation-decisions Smarter Irrigation for Profit - Phase II | Tasmanian Institute of Agriculture (utas.edu.au). Innovations and research by Tasmanian Institute of Agriculture as part of Smarter Irrigation for Profit Beyond Water Smart – IrriPasture Field Days Tasmania (smarterirrigation.com.au)
Videos	3	Dr James Hills on Beyond Water Smart: Advancing Dairy Irrigation System Performance – SIP2 website. Available at: Dr James Hills on Beyond Water Smart: Advancing Dairy Irrigation System Performance (smarterirrigation.com.au) 2 x Site videos covering the project and key learnings from the site. Woodrising and Clear Springs. (Yet to be published)

6.2 Equipment and assets

The only capital items purchased as part of this project included the WeatherMation weather stations located at each of the five optimised sites

6.3 Monitoring and evaluation

Feedback was collected from project participants after significant events such as field days and at the end of the season. The final project survey was conducted through an online SurveyMonkey survey. There were 18 responses from the Tasmanian groups which is a small sample size, so results should be interpreted with caution as they may not be truly representative.

In general, there was positive feedback on the SIP2 project from the survey. There was an increase in knowledge as a result of the project, on the following topics (Figure 3).

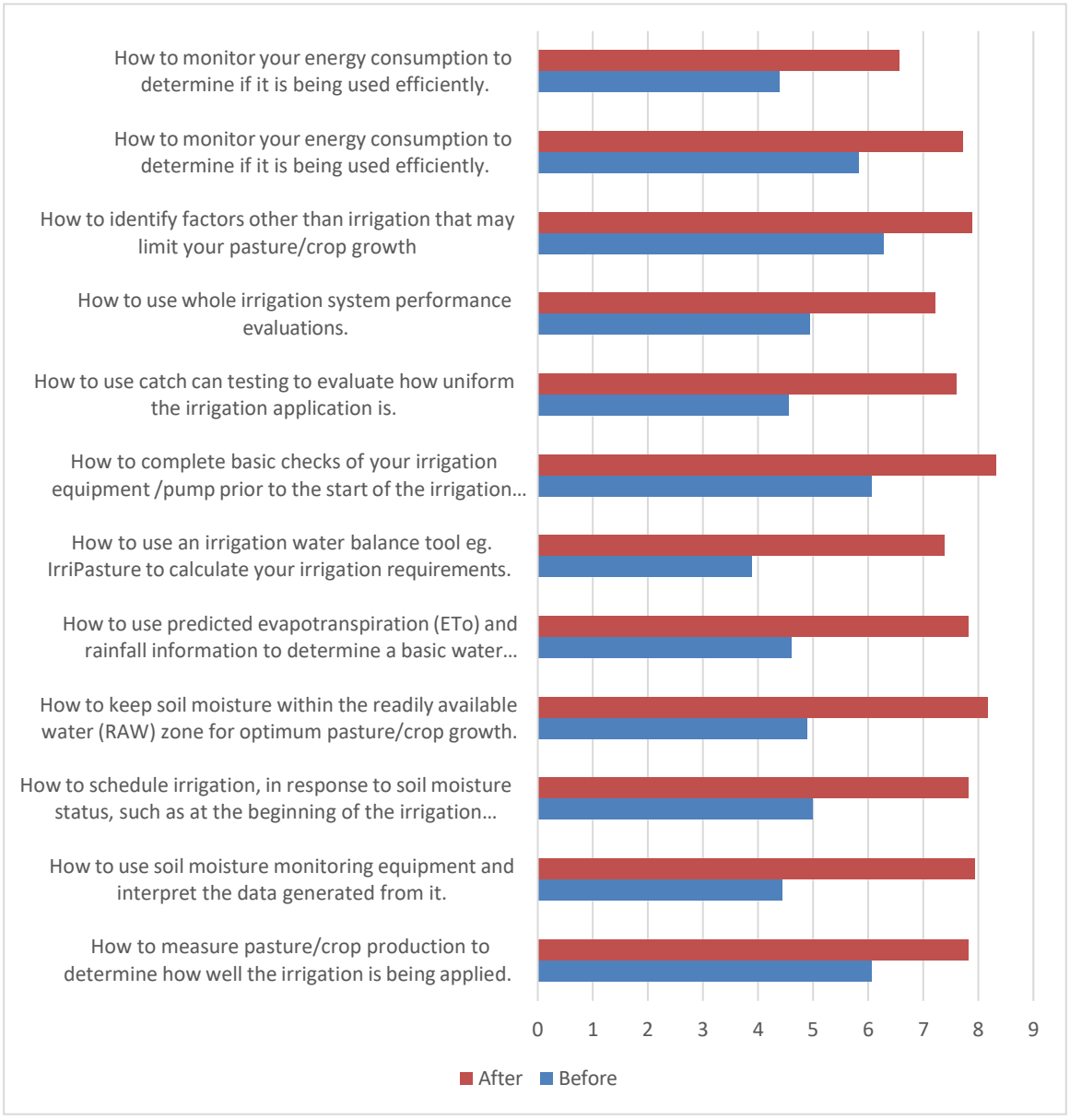

Figure 3. Weighted average of survey responses from Tasmanian optimised sites and associated reference group members.

In addition to increasing knowledge participants have also changed their practices. In response to the question "as a result of being involved in the SIP2 project have you" respondents answered the following (Table 3).

Table 3. Changes in practice by participants involved in the SIP2 project.

	YES	NO	UNSURE	TOTAL	WEIGHTED AVERAGE
Changed your irrigation start-up time at the beginning of the season	50.00% 8	37.50% 6	12.50% 2	16	1.63
Changed your start-up time after major rainfall events	68.75% 11	25.00% 4	6.25% 1	16	1.38
Changed irrigation application rates to reflect available soil moisture and plant requirements	68.75% 11	25.00% 4	6.25% 1	16	1.38
Increased productivity under irrigation	62.50% 10	12.50% 2	25.00% 4	16	1.63
Become more energy efficient and/or reduced energy costs	18.75% 3	6.25% 1	75.00% 12	16	2.56
Become more water efficient and/or reduced water costs	50.00% 8	12.50% 2	37.50% 6	16	1.88

6.4 Technical reports

6.4.1 Metrics Technical report
6.4.2 IrriPasture Technical report
6.4.3 Pasture.io Technical report
6.4.4 SWAN Systems Technical report
6.4.5 Soil Probes Technical report
6.4.6 Uniformity tests Technical report
6.4.7 Small Plot irrigation trials TDRF
6.4.8 PhD Project update
6.4.9 Yields gap modelling – Tasmania
6.4.10 Clear Springs Technical report

6.4.11 Forester Lodge Technical report
6.4.12 Freshwater Technical report
6.4.13 Glenwood Technical report
6.4.14 Woodrising Technical report
6.4.15 Final Survey results
6.4.16 SIP2 Database Summary
6.4.17 Optimised Sites System Assessments