Evaluation of SoilWaterApp 2018

A report for the
Australian Government's National Landcare Program

Project: New Technology for Tracking Soil Water Availability, Managing Risk and Improving Farm Management Decisions

This report builds on the Grains Research and Development Corporation's Project "New Tools to Measure and Monitor Soil Moisture (USQ00014)"

Author:	Dr Ann Starasts
Affiliation:	University of Southern Queensland
Date:	July 2018

1 EXECUTIVE SUMMARY

1.1 Introduction

This evaluation of the SoilWater app (SoilWaterApp) explored its functionality and usability along with the needs of users in adopting the app. It investigated potential benefits of using the app in management and decision making in Australian agriculture.

SoilWaterApp was developed originally as a smartphone application (app) that simulates soil water balance in fallows and crops by accessing weather, soil and crop data from databases and on-farm records. The app is available on the iOS platform (iPhone, iPad) with supporting information available at http://soilwaterapp.net.au/.

This evaluation is based on three sources of data including:

- Online survey (102 respondents),
- Interviews with SoilWaterApp users (31 participants), and
- User analytics available since January 2016

SoilWaterApp has been adopted throughout the major agricultural areas of Australia, with particular emphasis in the grains industry. There are 1434 registered users of the app at the time of report completion (Table 1.1) and 5-20 new users register weekly.

Table 1.1 Summary of SoilWaterApp statistics (Jan 2016 to June 2018).

Registered users	1434
Sessions to date	20979
Sites established in the app	2300

- Farmers and advisers represent most users,
- Over 60% using an iPhone to access the app,
- Most users (60%) had set up 1-3 sites
- Seven percent (7%) had set up 4-9 sites,
- Two percent (2%) (i.e. 35 users) had set up 10 or more sites,
- Over 30% of registered users had not set up any sites,
- Almost half of users in the study (48%) reported using the app more than five times each year.

1.2 Outcomes

SoilWaterApp is valued among users as a means to estimate stored soil moisture because:

- Data is specific to location and soil type (approximate), crop and fallow conditions, and presents soil water estimates in visual format;
- It is mobile-friendly and portable; and
- It saves travel to distant fields and direct measurement of soil water.

SoilWaterApp estimates are used widely in conjunction with weather data and push soil probe information in Australia (for some, replacing the use of push probes); in some areas of research, app estimates replace gravimetric soil moisture readings. The app's graphical output is used in presentations and discussions throughout Australia.

Use of the app has led to improvements in monitoring and managing soil water and reducing associated risks. Survey responses indicate that:

- Almost half of users (47%) believed the app had helped to better monitor soil water,
- Forty-three (43)% believed the app had increased their knowledge about storing soil water and its losses,
- Forty-two percent believed the app had enhanced their decision making (42%) and enhanced their advice,
- Almost 30% believed use of the app had led to more efficient use of soil water and also had led to decreasing risks of production. Many respondents indicated that the app had somewhat contributed to these.
- Eighty-five percent believed the app had contributed to some extent to maximising production and to reducing risks in production (85%)
- Almost 20 percent believed the app had enabled more reliable yield estimates (42% believed the app had somewhat contributed to this).

Usability statistics from survey data includes:

- Most respondents (93%) were able to install and use the app; 7% found it difficult or somewhat difficult to install the app.
- Fifty-seven percent of respondents found the app easy to use; 33% found it 'somewhat easy'.
- Forty-one percent (41%) found it easy to input rainfall; 19% had difficulties inputting rainfall.
- Thirty-three percent found it easy to choose and input soil type and paddock history (33%). Twenty-eight percent of respondents (28%) had difficulties choosing and inputting soil type and paddock history.
- Seventy-five percent (75%) found it easy or somewhat easy to use SoilWaterApp data in their decisions, 13% of respondents had some difficulties using SoilWaterApp data in their decisions (12% did not know).
- Fifty-four percent (54%) did not know about saving or transferring SoilWaterApp data.

- Sixty-two percent (62%) had not used the Help sections.

1.3 Barriers to use of SoilWaterApp

Limited awareness of the app may be the initial barrier to its use. This occurred among both farming community, agribusinesses and agricultural organisations. Users of the app were often individuals who had seen a presentation of the app, read about or heard of the app and put in the effort to evaluate and become familiar with using the app. There appears very **few local or industry based initiatives to support users** or increase the user base. Participants in this study indicated good support was provided by the developers when they had problems but this evaluation found that some users with problems or who did not understand the graphical output **had not sought help** and some had abandoned the app.

The fact that most users had not sought out user information and help files is a barrier to adoption of this app. While extensive context sensitive "Help" is available within the app and on the home web page (http://www.soilwaterapp.net.au/Library), this information is not being accessed. Information on choosing inputs (especially soil types), entering data (e.g. rainfall) and information on reading graphical output is mostly what users were requiring. It is suggested that existing user information and 'Help' be promoted to users. Possible provision of examples of use (e.g. case studies), and contact with others to discuss how to use the app may facilitate many in using the app.

The main limitation to achieving a reliable and trusted estimate of soil water storage from the app for most users is the **initial choice of soil type and the initial estimate of soil water**, both of which relied on users' own estimation (and both of which for many users were not sufficiently exacting).

1.4 Benefits from use of the app

The following points outline how using SoilWaterApp is contributing to the user outcomes identified in 1.2.

- **Improved knowledge of water storage in soils** and how it is affected by soil type, weather, crop, fallow and cover options.
- Assisting to consider the range of site specific weather and crop scenarios and **their effects on soil water storage**, and including this information in business discussions, planning and decisions.
- Using localised soil moisture storage and weather data to **explain cropping outcomes**.
- Contributing to improving **agribusiness advisory services.**
- Facilitating farm and agribusiness and research **planning, processes and communications**.
- SoilWaterApp has contributed to **communication, learning and decision making**:
  - Within farming businesses,

- Between advisers and clients,
- Enhanced local farmer group engagement, and
- Enhanced agribusiness knowledge and skilling of staff.

1.5 SoilWaterApp – Strengths, Limitations, Opportunities and Risks

Strengths

- Portability
- Graphical output
- Learning and discussion tool
- Efficient method of estimating soil water at local and remote sites
- Soil water estimates were found to be reliable by users (once sites are successfully established) compared with push probe and sensor data. (In addition Freebairn, Ghahramani, Robinson and McClymont (2018) identify successful comparisons between app estimates with current sensor technology).

Limitations

- Necessity of logging on and associated errors
- Difficulty estimating initial soil water
- Difficulty choosing appropriate soil types
- Limited suite of inputs (crops and crop condition)
- Unable to monitor more than one fallow–crop-fallow sequence
- Some limitations adding on-farm rainfall data (which would make the app's output more relevant than local weather station data).

Opportunities

- Extend the app to monitor beyond 2 seasons and provide data in format to archive (spreadsheet or database)
- Promote the user information and help sections to users. Explore the possibility of providing further information on understanding graphs.
- Widen range of crops and ability to input crop status (e.g. stressed)
- Provide some regional support and promotion
- Publish the app online (world wide web)

Risks

- Insufficient future support and help for users with problems (which may occur with disjointed project funding) may encourage users to abandon the app.
- Lack of development will result in the app losing currency and innovation.

1.6 Recommendations

1.6.1 Current SoilWaterApp (for developers)

Password input errors – Ensure users can easily see input screens for passwords and no errors occur at this stage.

Ensure rainfall input screen and function has no errors – that data is not removed or moved and that the function to upload rainfall files (.csv or other) is working and adequate user information is available.

Promote available user information and consider further information to help with understanding graphs and to understand how dry conditions affect soil available water.

Promote available information (and develop this further where appropriate) on choice of soil type explaining either that soil type does not have to match exactly (and outline some examples of how to adapt soil type depth and texture) OR provide wider range of soils and mapping assistance for choosing soil type. Also promote available information on estimating initial soil water stored and develop further where appropriate.

Consider iOS mobile device updates and possible interference with app functionality.

1.6.2 Future SoilWaterApp development

Site data rollover and compatibility – Currently each analysis is virtually lost after two seasons as users have to set up a new site to continue to a third season. Provision of the output in report and in spreadsheet format would allow it to be incorporated into other calculators and decision tools as well as maintained in a historical database for each site. Consider enabling the app **to rollover to further seasons** and crops (beyond two).

Regional support base – To facilitate adoption and use of the app it is suggested that key organisations who have a vested interest (grower groups, agribusiness, government) encourage and support relevant staff (e.g. agricultural extension or development, agribusiness advisory) to provide relevant, regional seasonal updates from the app through media or in presentations. Such staff could take on the role of key user in that location, providing examples and some support in using the app. In some areas, this is already happening (e.g. in farmer groups) and is facilitating education and understanding (about why or how to use the app) to a wider community.

Consider **adding wider range of crops** to the app AND the ability to indicate if the **crop was suffering stress or the crop or fallow was invaded with weeds.**

Consider the possibility to link the app to **publicly funded weather (e.g. DAFWA) and soil probe sensor networks** to enable access for users to the best available weather and soil data for their location.

1.7 Final

This evaluation has identified some of the successes from the adoption and application of SoilWaterApp, in decision making and advisory in order to maximise productivity, especially in variable and drier environments, and in improving understanding and learning about fallow efficiencies and soil water storage.

The app is increasingly and successfully used across the grains industry to monitor soil water and inform decision making about planting, crop inputs and irrigation. The app is helping to maximise fallow efficiencies and in-crop water use efficiencies, and is contributing to grazing animal and drought management.

Adoption of SoilWaterApp (a free download) is extremely economic compared with the cost of installing a weather station with soil water sensors (estimated at AUD$2-10 000). It is considered that investment in developing SoilWaterApp is being offset throughout Australian agriculture through more efficient input economies, and more timely management and planning. The app has facilitated increased cropping through enhanced confidence to take advantage of opportunity cropping and higher risk cropping scenarios.

1.8 Acknowledgements

Gratitude and thanks to Associate Professor David Freebairn and Dr David McClymont for provision and access to SoilWaterApp analytics and databases, historical information and statistics. This evaluation would not have been possible without participants and survey respondents giving freely of their time and feedback. We thank them most sincerely. Gratitude also goes to the Australian Government's National Landcare Program under project "New Technology For Tracking Soil Water Availability, Managing Risk And Improving Farm Management Decisions" for funding this evaluation and the Grains Research and Development Corporation who funded the development of the SoilWaterApp.

1.9 Abbreviations

BOM – Bureau of Meteorology

DAFWA – Department of Agriculture and Fisheries, Western Australia

GRDC - Grains Research and Development Corporation

NLP – Australian Governments National Landcare Program

PAW – Plant Available Water

PPD – Patch Point Data

Table of contents

2 Scope of this evaluation

2.1 Introduction

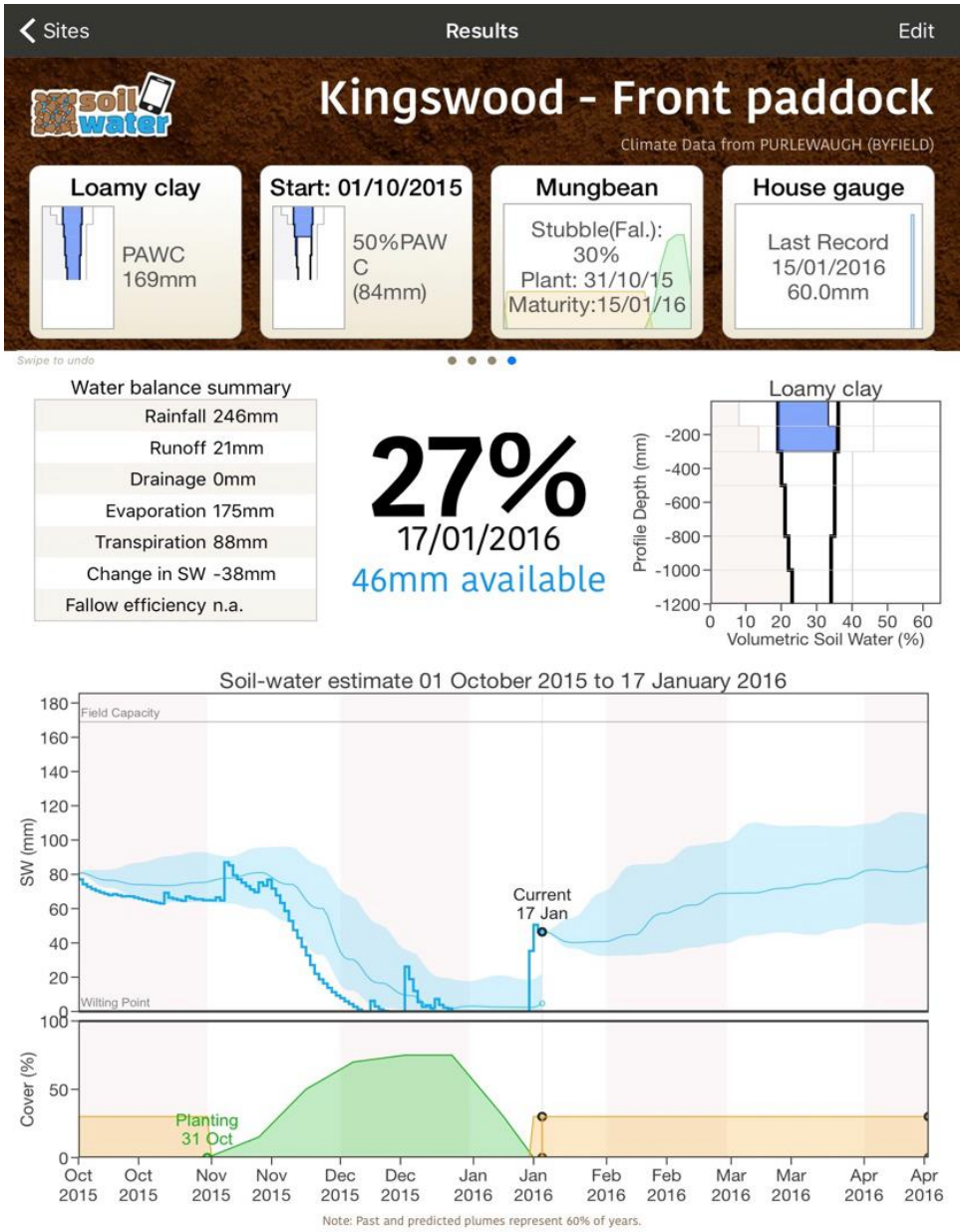
The Soil Water app (SoilWaterApp) was developed to incorporate soil, rainfall and paddock information to enable users to estimate the amount of soil water available to plants over depth. It is available for iPhone and iPad devices to download as an app and is becoming increasingly downloaded by users across Australia. There are now approximately 2300 sites established by 1434 registered users with > 20 979 app sessions.

The app estimates the soil water balance by accessing weather, soil and crop data from databases and on-farm records. Investments in crop production occur at planting time and shortly after, often in situations of an uncertain supply of water for crop growth, making prediction of yield and therefore financial return difficult. Estimating soil moisture status of a paddock can help build an understanding of possible management options and potential farm financial risk profiles.

Alternative means to estimate of soil water are expensive, time consuming, and prone to site variability and technical failure. Through estimating the amount of available soil water in paddocks, farmers are better able to plan options, timing of fertiliser and crop planting decisions, potentially resulting in reduced risk and enhanced profitability.

The app operates on a paddock basis with the user choosing the nearest climate station (or enters individual rainfall records) and representative soil types. Dates and starting soil water are chosen along with fallow soil cover levels and crop planting and maturity dates.

Results are shown as text and graphics. Percentages of plant available water capacity (PAWC) and mm water available take centre stage with the water balance and where the water is in the soil profile on either side. The graphic at the bottom of the screen shows the pattern of water accumulation, soil and crop cover.



SoilWater app output screen

The developers have commissioned this research project to evaluate use of the app in terms of the outcomes of using the app and how well the app is meeting users' needs.

To optimise technical design and future client uptake, such systems require technical development to be blended with an evaluation of the human interface in real world scenarios. Farmers, agribusiness operators, scientists and other users, as decision makers, participated in this evaluation. The idea is to involve potential users, observe their needs and explore how a new technology might help them.

This report outlines an evaluation of the SoilWaterApp, and contributes to an understanding of the needs of users in adoption, and how the app information

contributes to decision making. Feedback on user experience will be used to guide future app developers.

2.2 Research Objectives

This evaluation:

- Collates initial usage statistics and considers implications,
- Identifies areas of application and use of the app and additional functions that could deliver enhanced product,
- Identifies factors associated with usability of the app and its features, and barriers to its adoption and use,
- Identifies examples of value gained from use of the app in areas such as decision making, advisory services, business processes, profitability and sustainability, and
- Considers users' needs with respect to business and production decisions and data management systems and processes.

The project did not quantify economic impacts from use of the SoilWaterApp, or compare app with other available information or apps.

2.3 Overview of methodology

This evaluation investigated farmer and agribusiness use of the SoilWaterApp and considered this in line with outcomes associated with knowledge, skills, attitude, and practice (Radhakrishna & Bowen, 2010; Bennett, 1975). The project used a combination of metrics (to identify evidence of scale), surveys (to explore opinions and perceptions) and case-based narratives (to understand context-based issues and unique examples) (Penfield, Baker, Scoble & Wykes, 2014; Leith & Vanclay, 2017). It explored and validated outcomes and impacts from use of the app, and the concept of impact pathways (Douthwaite, Alvarez, Thiele, & Mackay, 2008) formed a framework for analysis and reporting of outcomes.

Data was collected from one on one interviews, an online survey, and app analytics. It is not intended to provide a comprehensive assessment of the entire or any representative population of SoilWaterApp users, rather it sought to seek opinion from farmers, advisers, and scientists from major areas of use throughout Australia. Appendix 11.1 maps all evaluation participants (interview and online survey) according to their state-based location.

Data sources included:

(i) Online survey of users

A link to an online survey was developed and sent to over 1200 users following pilot testing with agribusiness and farmer representatives. Those who chose to complete the online survey ('respondents' [n=102]) were therefore self-selected and they self-reported their use of SoilWaterApp.

One hundred and two SoilWaterApp users from across Australia responded to the online survey. The range of industries is shown in Figure 2.1 and includes mostly respondents involved in grain production and advisory, and also sheep, wool, and beef production.

The online survey was entirely voluntary and anonymous. No personal data on age, gender or nationality was collected. There were 22 question items in the survey with questions on respondents' reasons for using the SoilWaterApp, value of the app calculations, frequency of use, barriers to use, usability, devices and connectivity, outcomes and benefits from using the app, industry and role.

Question types ranged included multiple choice, category selection, 4 and 5 point Likert type scales (Allen & Seaman, 2007) and open-ended responses. Data analysis included descriptive statistical analysis, frequency counts, as well as cross-tabulation of findings based on user industry or role. Visual representation of open-ended survey responses are presented as word clouds depicting the main text-based categories of responses in proportion with word size.

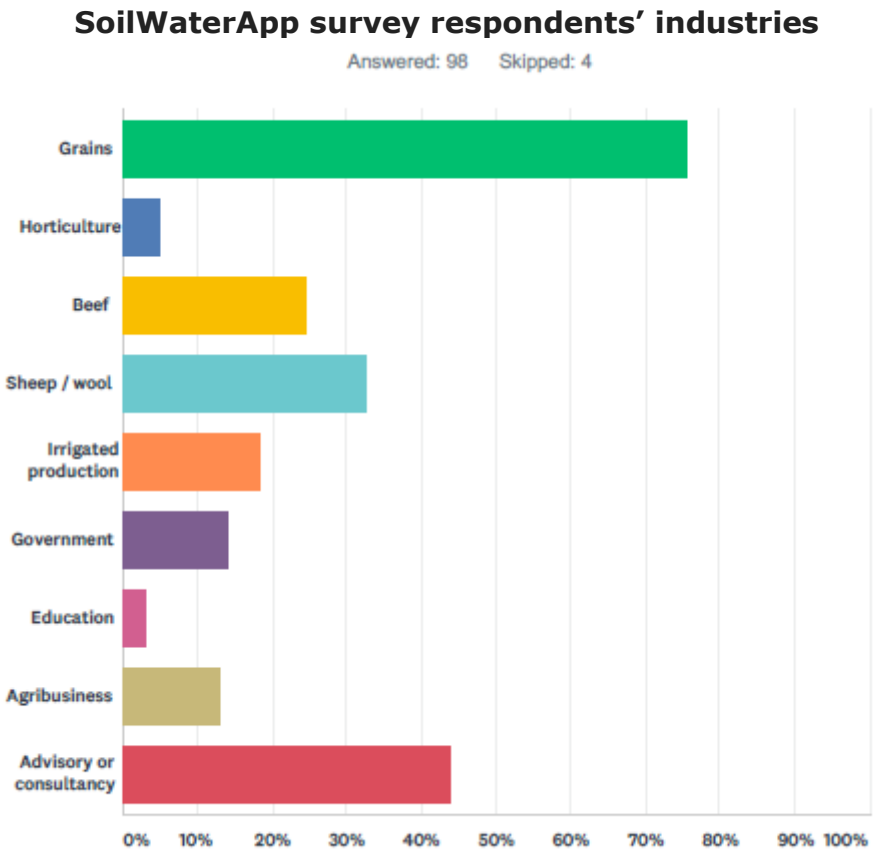


Figure 2.1 SoilWaterApp survey respondents - Industries (%) (n=102)

(ii) In-depth interviews with app users.

Following pilot testing, in-depth interviews were held with a purposively selected sample of 31 users from across Australia to represent farming, agribusiness, and science sectors, and a range of locations. This sample of users was not intended to be fully representative of all SoilWaterApp users in terms of location, industry, or demographic factors.

Following an introductory email from developers to all users about the study, potential participants (who ranged from avid to novice and some non-users) were contacted by email inviting them to participate in an interview. Many users who were initially contacted did not respond. Those who did formed the sample of participants in the interviews. Interviews were recorded and transcripts produced and analysed.

Interview participants were asked to describe how they use the SoilWaterApp in their role. Qualitative iterative analysis of interview transcripts investigated participants' use of and attitudes to the app, ensuring that findings were strongly grounded in the data (Corbin & Corbin 1990; Corbin, Strauss & Strauss, 2014) and considerate of user contexts. Categories were identified from within the data and explored to allow a depth of description. Quotes from interviews and survey responses are presented in italics, and where available, the participant's role and location (state) are provided.

(iii) Collation of app analytics

Collation and description of use statistics available from the system itself. These included data on users, sites and platforms and on their use of the various App queries.

The project operated in accordance with and approved by University of Southern Queensland Ethics Guidelines.

3 Adoption and value

3.1 How SoilWaterApp is used

3.1.1 All users – use of SoilWaterApp

An overview of the range of activities undertaken using the SoilWaterApp is provided in Figure 3.1. Survey respondents indicated that they mostly used the app to monitor soil water (73% of survey respondents) and estimate soil conditions (39%) in relation to planting decisions and fertiliser application decisions. The app was also being used to better understand how rainfall and irrigation move in soil (31% respondents) and also for advisory (32% respondents) and teaching about soil water (27%).

This review found that the SoilWaterApp is being used for monitoring and learning about soil water, cropping decisions (planting, fertilising, finishing),

irrigation decisions, pasture management and grazing decisions, advisory, research trial management, group learning, and remote monitoring.

The following section lists comments and categorises these range of contexts.

Monitoring and learning about soil water

(Understanding) WUE linked to stubble retention.

To see how the water moves through different soil types.

Understand different soil types we farm.

The program understands fallow efficiency very well and has helped me understand more about filling a profile.

I have learnt a lot about the value of rainfall, how much we need to make a difference and how quickly moisture depletes.
Better understanding of soil water relationships

Cropping decisions – planting, fertilising, finishing

Monitoring my systems trials, as a guide to when planting triggers have been reached

Should I plant a crop at all?

Where we are tracking in deciles in the season. What sort of inputs to put in and risk to take. How long can we last before running out of water.

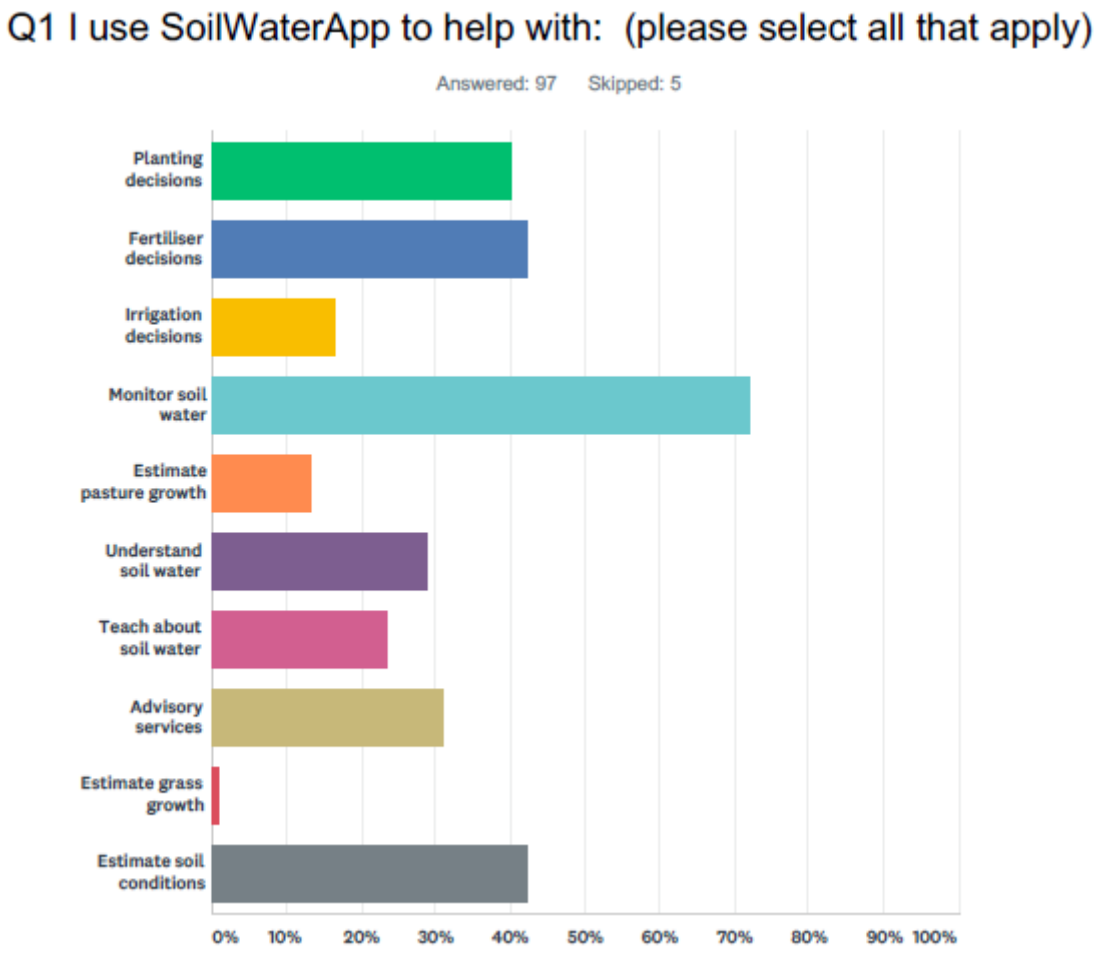


Figure 3.1 Areas of application and use of SoilWaterApp in agricultural decision making (%) (n=102)

Irrigation

The app is being used by some to schedule irrigation through monitoring soil moisture.

I've used it under a pivot, a lateral irrigator to get the grower to self-schedule irrigation. It's been pretty handy, especially where we have some challenging soil types; the probe saying we need to irrigate; the grower saying not; the app saying we do. Where we've had two pieces of information telling us we do need water, we've gone with that. People who have no scheduling tools – (SoilWaterApp) is a general guide and is pretty handy for that. Agronomist, QLD

'We've got to trust the technology, that it is a little better than gut feel'. We had the moisture probe in the same paddock telling us (also) and the grower telling us there was no need to irrigate. (SoilWaterApp has helped).

(The outcome has been) definitely improvements in knowledge and skill and knowing that we need to trust our information a bit better.

Many growers don't have moisture meters in their paddocks, they should be using the app to give them a bit more information rather than 'we irrigated this time last year' (they are scheduling by gut feel). It would be the first step in getting better with scheduling.

Easy to use, simple and robust inputs - output is easily understood. We use the app to decide when to irrigate.

Irrigation budgeting, and checking the timing of irrigations after the event. Also use SoilWaterApp to improve understanding of water balance of rain-fed crops. Planning irrigation requirements for wheat research projects.

Remote monitoring and decisions

As the city based partner in a NW NSW cattle operation I see the advantage in being able to get moisture information remotely and thus be able to discuss management decisions more effectively.

To remotely monitor soil water changes over multiple locations over time. Helps me determine which fields may be suitable for trials for the up-coming season.

Pasture management and grazing

Looking at probable moisture profiles under pasture to determine likely future growth and correlation with on farm observations.

Quick guide to soil moisture levels in the areas I am advising in. Current soil moisture levels to plan pasture growth and predict animal intake and growth rates.

Estimating yield potential

It's a simple tool that gives an estimate of soil water and that is our single biggest driver of grain yield in the environment I work in.

Looking at yield potential of crops after such a dry winter.

Yield potential estimates and understanding plant water root up take amounts per day during different weather conditions.

Estimate if in an area there is sufficient soil moisture to finish crops off.

Extension and group activities

Our project is using the app and the bluetooth rain gauge to demonstrate to growers how this type of decision support tool can help make decisions, especially pre-planting.

Largely to educate growers on what has happened to the rainfall in certain soil types, over time.

I am an industry service provider so we have used the app with our farmer groups too.

Decisions / risk management

We don't need to crop every year so it assists with our risk planning.

We didn't have onsite monitoring and my husband is reluctant to install technology this offered useful information to inform my input into decision making.

Other

Deciding on the suitability of certain plants for revegetation works at a variety of sites.

Assessing soil water levels for successful crop growth for insurance purposes.

(For) rainfall recording.

3.1.2 All users – Word frequency data

A word frequency representation of the main reasons provided by survey respondents for using the SoilWaterApp is provided in Figure 3.2, showing the most focus on 'decisions' and including 'planting' along with 'Crop' and 'Pasture'. 'Nitrogen application' and 'Irrigation scheduling' were also commonly referred to.

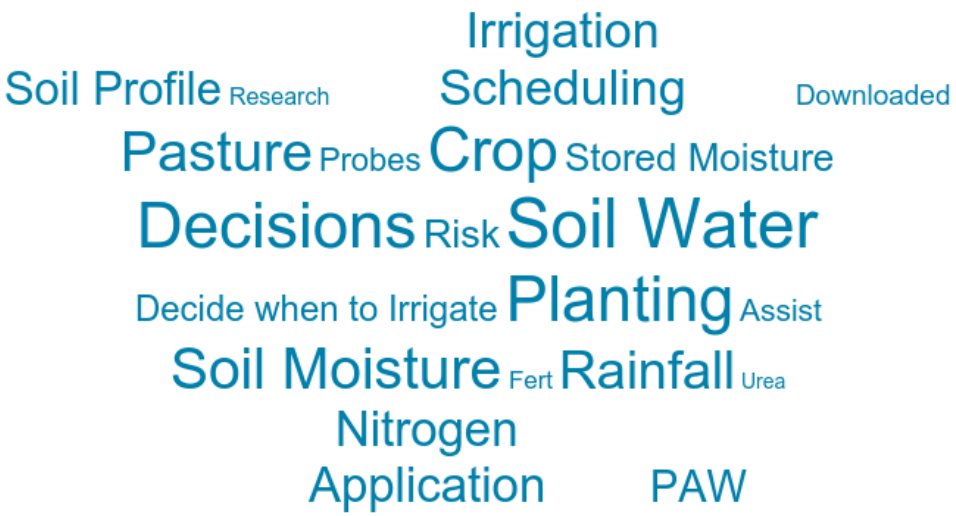


Figure 3.2 Word cloud - relative frequency of word mentions in user responses about why they used SoilWaterApp (n=102).

Respondents also indicated what they were hoping to achieve by using the SoilWaterApp (Figure 3.3). Responses alluded to 'simple' and 'accurate' 'estimates' in relation to 'push probes'. They were hoping to 'estimate' 'soil water' and 'PAW' and 'understand' 'rainfall' storage in the soil 'profile'.

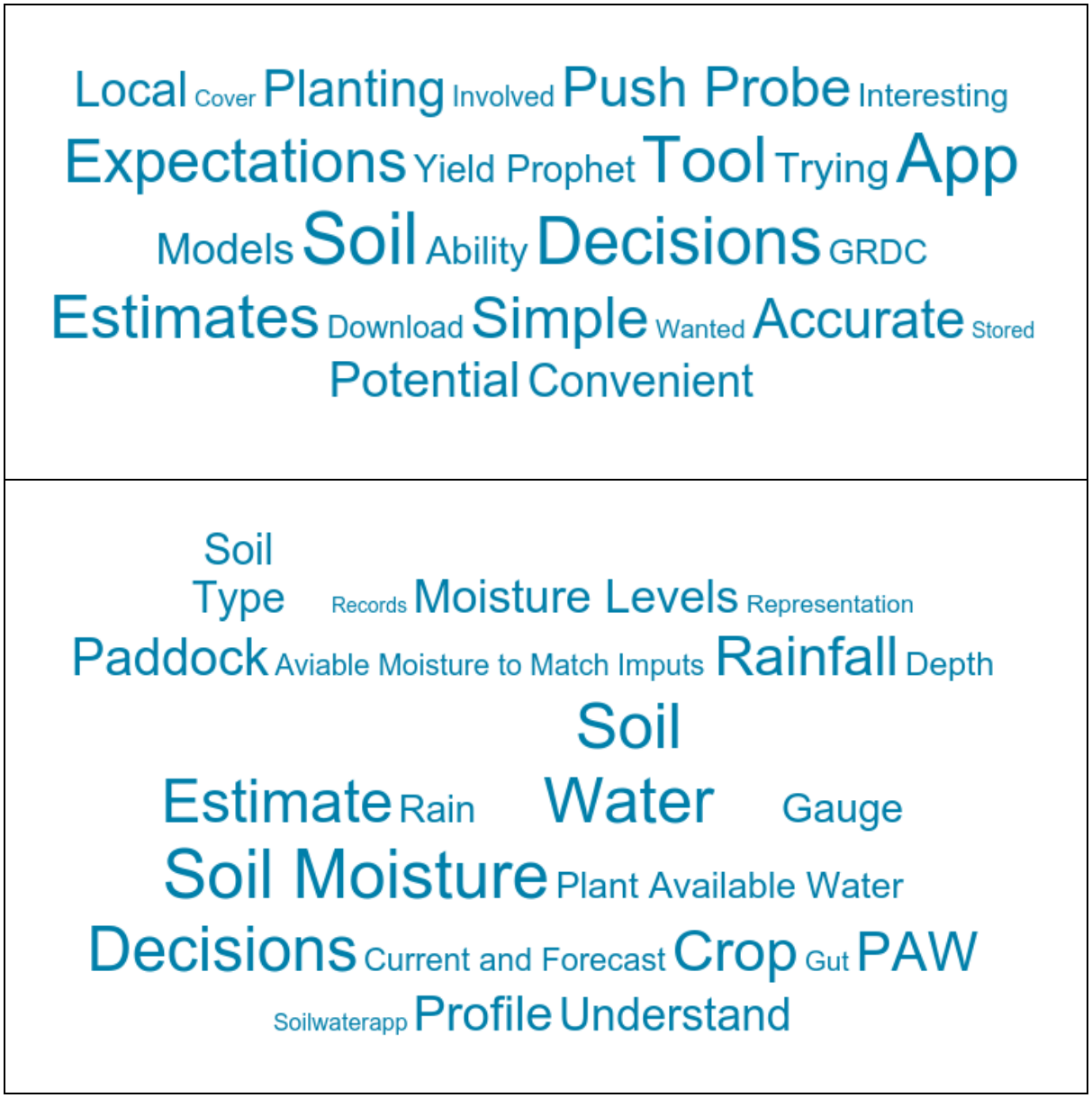


Figure 3.3 Word Cloud – relative frequency of words in survey responses about their expectations in using the SoilWaterApp (n=102).

3.1.3 Advisers – use of SoilWaterApp

Advisers indicated that the app is a relatively simple, inexpensive tool with which they can remotely monitor clients' soil water storage. They are using the app as a basis for communication and education with growers.

I needed an App that was quick and easy to set up. One's clients could repeat on their own phones. I could oversee their correct use.

To monitor soil water over time so grower clients are aware of where yield potential sits in relation to seasonal decile outlooks.
Gave me a basis to help communicate with the grower when selecting crops or timing for sowing.

I use it primarily to get an estimation of the plant available moisture available for crops for clients based in various locations. I set up "standard" cropping or fallow scenarios in locations where clients are based to gauge how much moisture is available, what yield targets are achievable and how much nitrogen should I apply based on this.

I use SoilWaterApp to explain to growers and Ag advisers the value in knowledge of many soil properties, PAWC, PAW subsoil constraints etc. and their relationship with landscape position. Therefore how can we spatially transfer soil water information to take on-farm decisions.

To assess plant available water throughout the growing season, a good visual model to discuss with growers to help them understand soil water and make informed decisions particularly nitrogen top ups.

Adviser survey respondents are using the app largely to estimate soil water in their clients' actual paddocks (66% of adviser respondents) and in example paddocks or cropping scenarios (61%) (Table 3.1). Fifty percent of advisers were using the app for ongoing monitoring or soil water in their clients' paddocks. Fifty percent (50%) of adviser respondents were using the app to update their skills related to soil water storage.

Only seven percent of advisers indicated they were creating and sharing sites with their clients using the 'share' function (although many advisers interviewed indicated they were screen capturing and emailing clients). Twenty-five percent were using the app to estimate soil water and distribute this online or in presentations (Table 3.1).

Table 3.1 Advisers – SoilWaterApp use (n=44).

SoilWaterApp Activity	Percentage of adviser respondents
Estimate soil water for clients' actual paddocks	66
Estimate soil water in example paddocks and cropping scenarios	61
Ongoing monitoring of clients' paddocks	50
Update skills in soil water storage	50
Create and share sites with clients using share function	7
Distribute example soil water estimations through email, social media, presentations	25

Note – the low number of advisers sharing sites with clients may indicate lack of awareness or difficulties with this function.

Additional examples of advisers' use of the SoilWaterApp are provided in the Outcomes and impacts Section 4.2 and the case studies in Appendix 11.2.

3.1.4 Farmers – use of SoilWaterApp

Farmers were using the app to monitor soil water storage and use and to support decisions in relation to sowing, fertilising and other crop inputs, irrigation, pasture management and to identify possible seasonal outcomes.

Monitoring through the season

I was using this quite often last year, through the growing season, to see what I had left. How many more days I had until it ran out. Graingrower, WA

It has given me a bit of confidence. This year I wanted to ground truth it with what actually happened. Just want to have a bit of confidence that those other variables such as rooting depth etc. you set up are right. We came out of a pretty unique situation last summer – overland flooding last spring and then had probably almost 1 percentile autumn rain. We knew we had a lot of moisture there, couldn't get on the paddocks to sow, interesting to use the app with that situation and see how it drew down the moisture during the season. From what I've seen its' pretty well bang on with what I've seen through the season and what the app has been talking about.

Confidence in stored water for sowing

The outcome that (friend) got for me was interesting – it was encouraging for me to plant some crops with very little moisture – we had a most crazy year in 2017…. (A climatologist) said what are you planting for – and I said I have a friend who has the SoilWaterApp and I have a fair bit of water in the soil from the 250 mm that fell in 3 rainfall events in February. The app said I had 90 mm – I have loams, 1.5 m deep – I can store 180 mm of rain….. I can do that in my head but I think I'm probably out by 30%. This app I think got me within 10%. It would have been closer (than I could have estimated) I would think. Graingrower, WA

Confidence for applying crop inputs

I think I got it late 2015 or early 2016 and started using it because I wanted to know how much moisture my crops were pulling out and how much moisture was there at certain times so I could make decisions for more fertiliser. Graingrower, VIC

During the growing season, I probably set my sights on how well we're going to finish and try to tailor some inputs around that. I try to model, looking forward what likelihood what yield levels we might be expecting and try to match nitrogen decisions during the growing season to that. Graingrower, VIC

3.1.5 Researchers – use of SoilWaterApp

The app was used by broadacre researchers across Australia to plan experiments, identify planting time, choose crops and rotations, estimate water use efficiency and to understand water movement and storage in soils. It is also used in scheduling irrigation in research trials. Researchers were using the soil water estimates from the app to include in reports and presentations.

From my work I can set up an experimental site, select the PAW for the site, then when I am writing the reports I can refer to the water balance for the experimental site – for this particular year we've had drainage of 100mm. It can calculate the water balance for my sites which can be used for reporting or to write a conference paper.

It saves me doing gravimetric soil probe. I have done soil probe and a few random cores to see what the app suggests is there in terms of soil water. I am reasonably comfortable to use the app as the site is a fair distance.

I use the SoilWaterApp in my research to predict soil water status to inform planting decisions in my experiments - this is coupled with soil sampling and other methods (e.g. EM38) where available. It is also a useful tool to promote understanding of dynamics in soil water and how this might drive the farming system.

Used it to evaluate water use efficiency in trials of a range of crops in FNQ to understand water balance, residual stored moisture and run off.

To help better understand the soil water below our experiments.

(To) plan trial work.

Modelling crops in new environments.

3.2 Testing and comparing SoilWaterApp estimates

3.2.1 Setting up SoilWaterApp

Most users reported that downloading and initial setup were easy, however choosing and inputting appropriate soil types and (to a lesser extent) inputting rainfall was a drawback for many users, especially those who had little agronomy experience.

There's a big gap in soil classification knowledge (among the farming community)….It's not the technology, it's the understanding of soils. People probably want (to choose) exactly (the soil type) they've got. Extension Officer, VIC

Maybe the soils were not well representative. With my grower's property, I couldn't pick a soil that accurately represented his. With our focus paddocks we've actually gone out and taken soil cores and developed good soil profiles and I know what it's like and I didn't find one (in the app) that is a good fit. So either we'd be under estimating the bucket or over estimating it, I'm not sure. Agronomist

Had some issues fairly on about how applicable some of the soil types were. You're never going to get it 100% right. I've sat down with all the data and still can't get it right. We can't have a database for every soil type and paddock in Australia. It's also my skill and how I interpret it – it looks like this soil – and then you run the models – Yield Prophet / APSIM you realise you are a fair way out compared with what the farmer is yielding in the paddock….You pick as close as the soil bucket looks like, crop rooting depth. Make allowances. It's just the limitation of it. Agronomist, VIC

Further participant comments in relation to inputting soil types, rainfall and crops are listed in Appendix 11.3.

3.2.2 Testing and trusting the data

Users reported that in order to trust the app soil water estimates, they initially tested and monitored app data in relation to their own experience, rainfall amounts, push probe information, and local or regional established soil sensor data. Scientist users often had the advantage of undertaking simultaneous gravimetric moisture testing to initially calibrate the app and their understanding of app estimates. Some farmers, often in conjunction with their agronomists were adjusting soil types and cover types in order to obtain a closer alignment of their push probe data and their experiences with the app output.

Many participants in the study indicated they were still in this phase of evaluating the app for their own use.

The first season when I was a bit less confident with this sort of stuff I actually did more gravimetrics just leading up to planting. That years' experience has given me enough confidence that the variability in SoilWaterApp is less than gravimetrics. R&D officer, QLD

No it doesn't match very often with what's in the field which is interesting….I use a weather station rainfall and when it tries to predict what the profile would be its not always right. We're doing some work on that. That particular field we've had trouble with. .. my agronomists are spending a lot of time on it to get it right – the soils. Graingrower, NSW

I have done soil probe and a few random cores to see what the app suggests is there in terms of soil water and checked the push probe. I am reasonably comfortable to use the app as the site is a fair distance. Researcher, QLD

My agronomist helped set up my initial one. I've got a soil moisture probe in the paddock and we were trying to compare this program with it initially, but the soil moisture probe broke. Graingrower, WA

I track and compare (what) I'm seeing in the app with the push probe. I can put that data in and match up how it compares, out of curiosity. Agronomist, NSW

(I use the app for) snapshots. Sort of see how close it is. Out west, Murgon, and on the Downs. I refer to those, push the moisture probe in to see how close it is. It is a very good indication…..(I set up) example paddocks to use for clients in the area. Agronomist, QLD

Adjusting the app to match expectations and other estimates

Users reported choosing different soil types or stubble cover (sometimes different to actual) in order to gain soil water estimates in the app that better match what they expected and what they had measured through probe or gravimetric data.

Estimating stubble cover has a great impact on PAW accumulation. Adjusting cover has improved my confidence in the forecast PAW.

Moderate cracking clay's total PAWC is probably a bit lighter than my site has been measured at, but in terms of the extraction and my comfort it is reasonably accurate. Deep cracking clay 300mm soil type doesn't correlate as well as the slightly lighter soil type does. Researcher, QLD

3.2.3 SoilWaterApp in relation to other soil water estimations

Most participants indicated that SoilWaterApp estimations complement existing information rather than replace any. Figure 3.4 indicates that 78% of respondents believe that SoilWaterApp complements a weather station. Only three percent of respondents believed that SoilWaterApp could replace the need for a weather station (Figure 3.4).

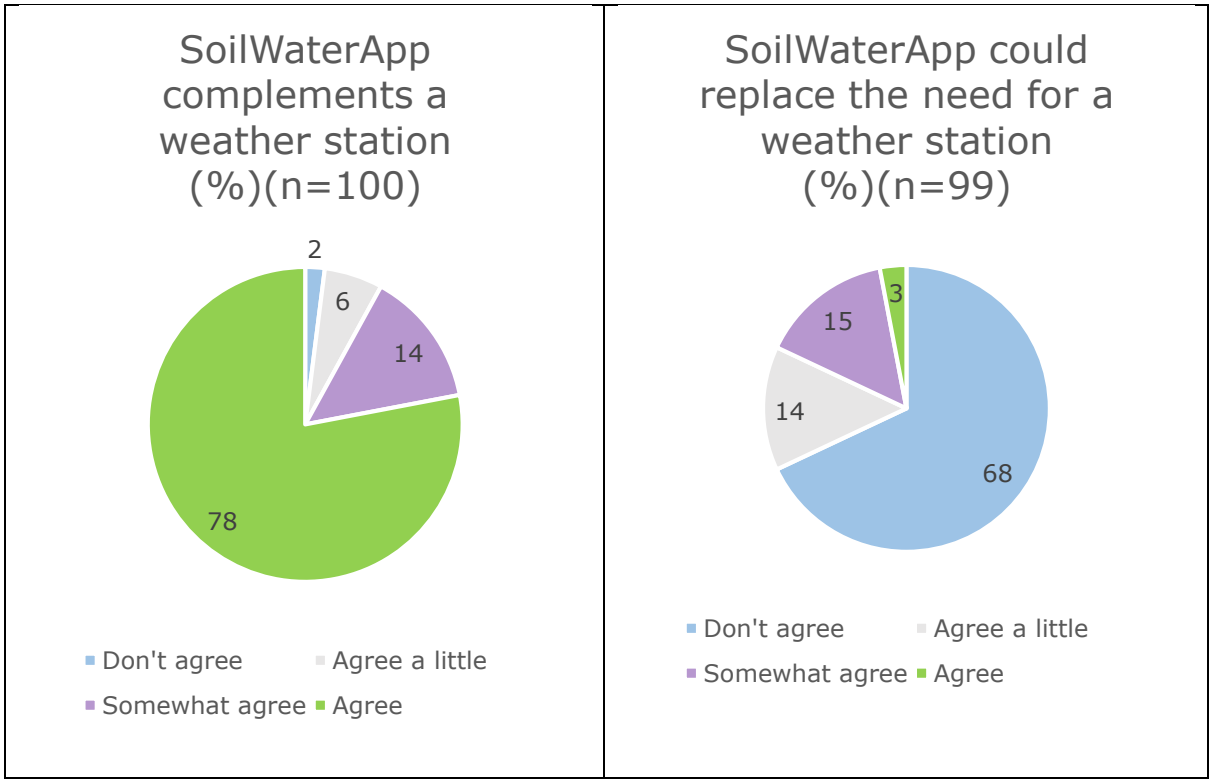


Figure 3.4 Respondents' opinions in relation to SoilWaterApp and the need for weather stations

SoilWaterApp in relation to push probes

Participants in the study indicate how they ground-truthed SoilWaterApp estimates by using push probes.

Another advantage, with (the CliMate version of How wet?) you could only put your starting water, with this, you can say whether it is top, bottom or distributed. I can't go back and show you but about here it was full at the bottom, full at the top and that section was like that (drier). That's where you go and get your probe and see if it's a dry band or just moist.

For our sites I have a good idea that push probe on this soil means so many mm.

When you are looking at dry bands and that sort of stuff, the push probe is still the only way to go.

I use the mm figure (in the app) – it is better because the push probe is only a rough guess, you can't tell how full it is, most soils are different, and require a different amount of pushing; some soils are soft and you can push even when they are dry; some clays are rock hard. Agronomist, NSW

SoilWaterApp in relation to soil moisture sensors / probes

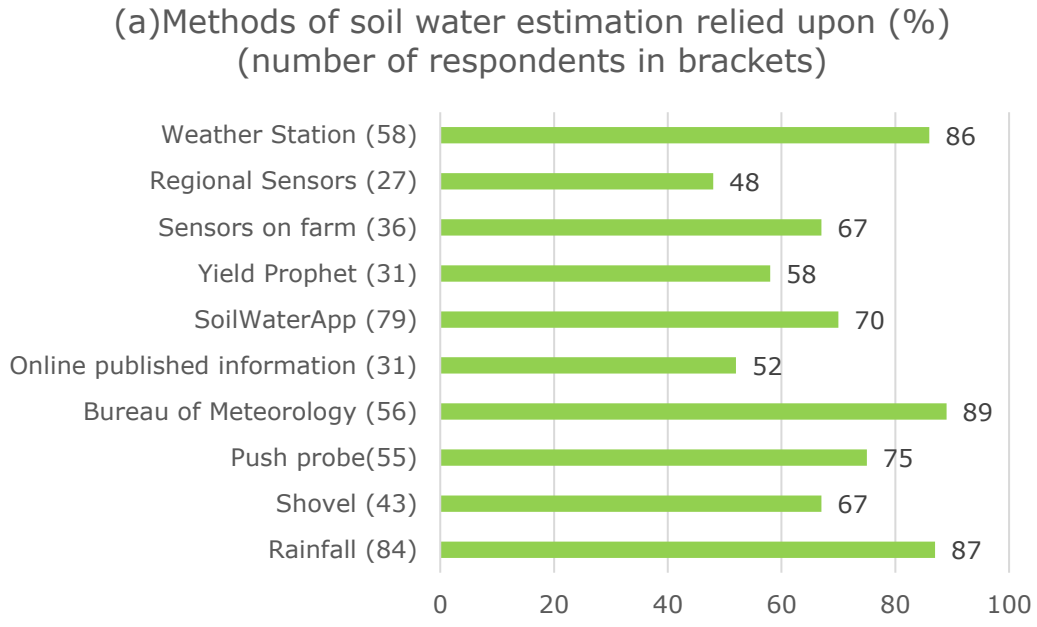
Many respondents identified the accuracy of soil sensor/probe readings compared with the estimations from SoilWaterApp. They identified the benefits of having access to the sensing equipment data. They also suggested that having access to sensor/probe readings allowed comparison and suggested that this data could be used for the initial soil water estimate required to commence the app modelling. Participants indicated the value in the app for providing economical estimations on a range of soil types and locations.

(SoilWaterApp data) supports the point source data – (probe data). (It has) greater spatial (relevance than sensor/probe data).

(In addition to using SoilWaterApp) I also dig around with a soil coring tube, lining up with probe data and where the moisture is. Extension Officer, VIC

The actual figure we put in last March or Feb – wasn't even the actual figure, it was what we thought it was from the amount of rain and how wet it was. It would have made that figure more accurate if I was to have an actual soil water reading from an electronic meter and that way when the models looking forward it has the most accurate starting point. I would use it parallel with soil moisture monitoring equipment. The more bang on you can get the starting soil moisture figure the more accurate it will be when you're trying to predict what it will look like at the end of the growing season. Graingrower VIC

Figure 3.5 indicates the methods of soil water estimation that respondents relied upon (a) and those methods of estimation respondents believe are suitable for their needs (b). Respondents mostly relied upon BOM (89%), rainfall (87%) and weather station data (86%), and to a slightly lesser extent push probes (75%), SoilWaterApp (70%), shovel (67%) and on-farm sensors (67%). Respondents believed that Regional Sensors (56%) and publishing this information on line (55%) may be most appropriate to their needs followed by on-farm sensors (47%), Yield Prophet (45%) and shovel (42%).



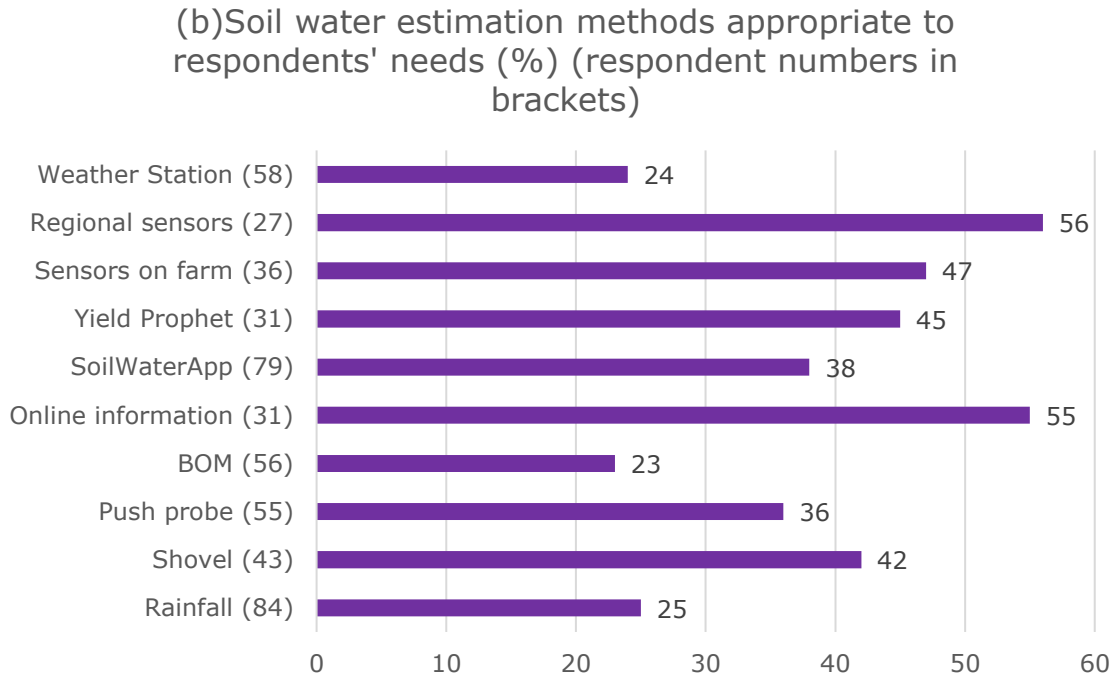


Figure 3.5 Current soil Water estimation methods (a) relied upon and those considered appropriate to their needs (b).

3.2.4 SoilWaterApp data use and management

Adviser users incorporated SoilWaterApp data in discussions, presentations and reports. Some users were using the app as a form of record keeping for rainfall and some were wanting to record and store app data for longer term. Some

agronomists took screen shots and sent to clients. Most respondents in the survey (54%) did not know how to save graphs (Section 5.1.7).

Almost half of respondents (46%) found the app useful in allowing recording and access to their own rainfall data. Few respondents discussed directly incorporating soil water estimates into yield calculators or budgets.

Reports? We have APSIM yield models for the fertiliser budgets in these trials. I use the figure and go into the yield model to work out yield potential.

I've weaned everybody off paper. I use a Farm record keeping app. I take a photo of the field specific to their farm, take a photo and attach to the app…. soil tests etc. get all recorded on the app as well.

3.3 Data on SoilWaterApp usage

3.3.1 Frequency of use

Participants reported using SoilWaterApp often to monitor soil water through the year. Almost half of respondents reported using the app more than 5 times per year (48%), 28% reported using the app 3-5 times per year and 22% reported using the app 1-2 times per year (Figure 3.6).

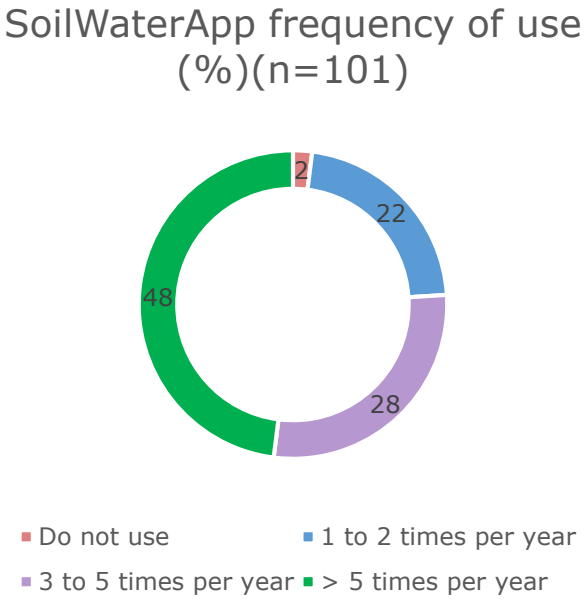


Figure 3.6 SoilWaterApp frequency of use

3.3.2 Number of sites

Most users had 1-3 sites set up (60%) and seven percent of users had 4-9 sites set up. Two percent (35 users) had set up over 10 sites (Figure 3.7). Some advisers set up sites in varying locations and on representative soil types, rather than setting up sites for every client. Thirty one percent (31%) of all registered users had not set up any sites.

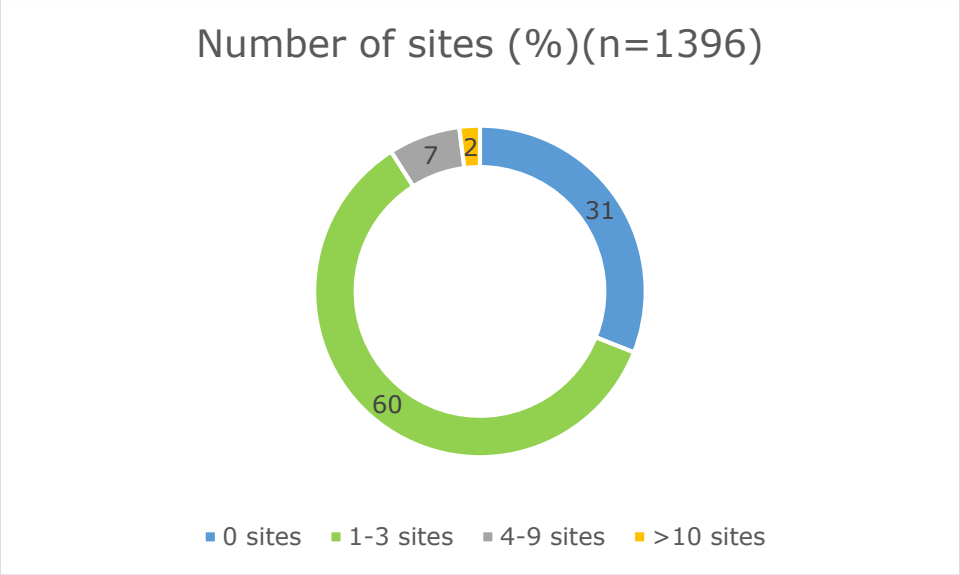


Figure 3.7 SoilWaterApp – number of sites established by registered users (n=1396)

3.3.3 Location of use

Respondents indicated they mostly use the SoilWaterApp in the office (71%). Thirty-seven percent indicated they use the app in the work vehicle (37%) and twenty two percent use the app in the paddock (22%) (Figure 3.8).

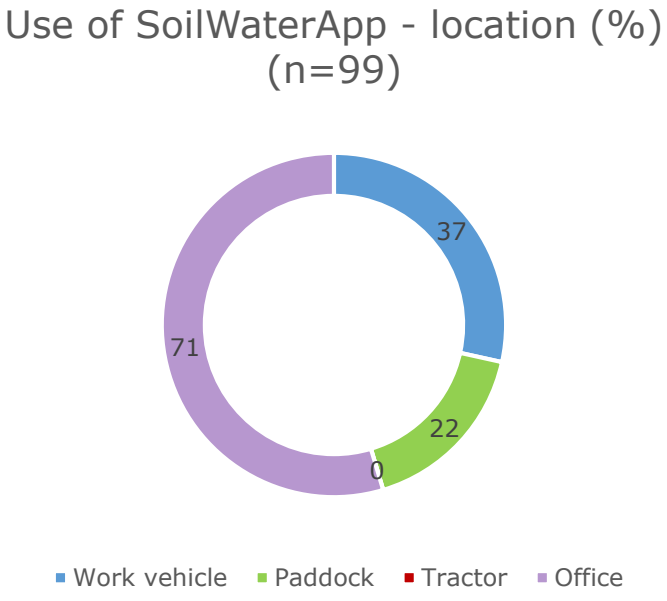
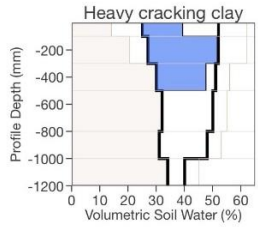
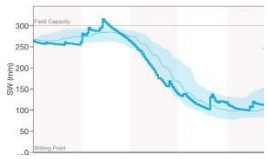
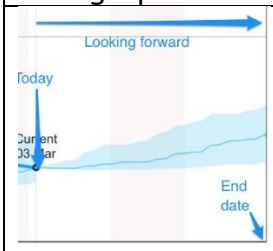


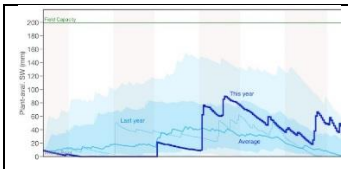
Figure 3.8 SoilWaterApp – location of use

3.4 Usefulness of SoilWaterApp data

Respondents indicated they found the numeric data on percentage of soil water and the line graph the most useful (65% and 63% respectively). Five percent of respondents indicated they did not understand the line graph or the projected soil water line graph (Table 3.2). Participant comments on this are listed.

Table 3.2 Respondents' ratings of the usefulness of SoilWaterApp outputs (%) (n=98)

	Of no use	Of some use	Useful	Very Useful	Don't Under-stand
 Numeric	0	7	26	65	1
 Water Balance Summary	0	19	42	34	3
 Volumetric graphic	0	17	26	53	2
 Line graph	0	7	23	63	5
 Projected soil water	1	9	31	50	5
	1	16	27	51	3

 Plumes showing spread of years					

Note – Data on the number of respondents with difficulty understanding graphs in the above table is low, however some survey comments highlighted poor understanding of graphs. It may be that although some users understand the graphs, they may find them only of small value in decision making (as the table above shows – 'of some use').

Graphs and terms could have better explanations on interpretation and using them for management decisions.

The output graphs took a bit of understanding for a while.

Yes battle with the graphs.

(Problems?) - Understanding the graph.

Understanding the green graph on the cover % graph, what is it showing?

PAW – think you need that – it tells you where the water is and where your water holding ability is with your soil. Where it is positioned. This is a critical thing to have that. Agronomists and farmers are more informed of the medium their working with – what its water holding ability is.

4 Application and outcomes

4.1 Example user cases

A selection of examples from SoilWaterApp users (interview and survey data) is presented in Appendix 11.2. The tool is contributing to (i) building knowledge about soil water and its storage and movement, (ii) ease of monitoring soil water, and (iii) on-farm decisions.

4.2 Outcomes and impacts

4.2.1 User outcomes

Participants in this study nominated the outcomes they had achieved by using SoilWaterApp to estimate and monitor soil water. Analysis of interview and survey data qualitative responses identified that use of SoilWaterApp was contributing to management, decision-making and advisory activities as outlined in the following sections.

4.2.2 Monitoring soil water and building knowledge

SoilWaterApp users reported on the relative ease of using the tool and visual presentation of the soil water storage data, allowing them to simply and remotely, better monitor changes.

Forty-seven percent of all respondents indicated that SoilWaterApp had enabled them to better monitor soil water (33% indicated 'somewhat' and 11% indicated 'a little'). Eight percent of respondents disagreed (Figure 4.1).

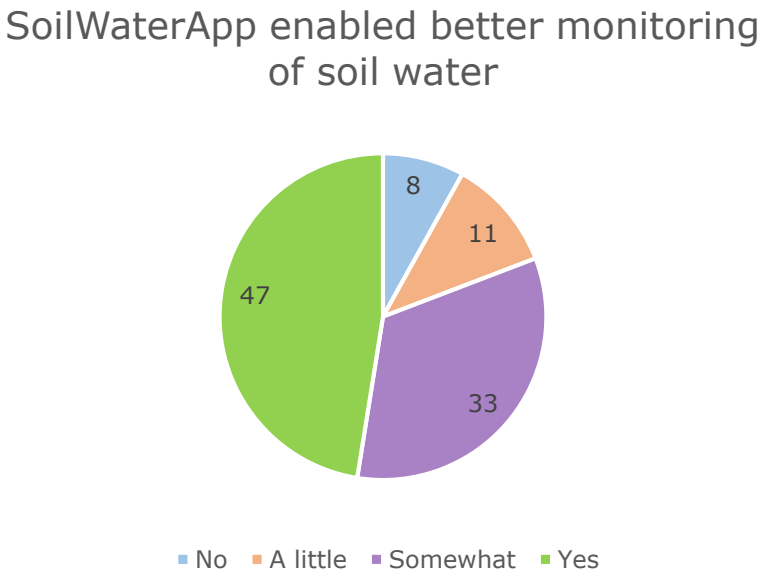


Figure 4.1 SoilWaterApp enabled better monitoring of soil water (%) (n=97)

App users reported improved knowledge and understanding about storing soil water.

The program understands fallow efficiency very well and has helped me understand more about filling a profile.

I have learnt a lot about the value of rainfall, how much we need to make a difference and how quickly moisture depletes.

Survey respondents believed that using the SoilWaterApp had improved their knowledge of soil water holding capacity and soil water changes. Forty three percent of respondents indicated 'yes' and 33% indicated 'somewhat'. Eighteen percent indicated 'a little' and 6% indicated 'no' (Figure 4.2).

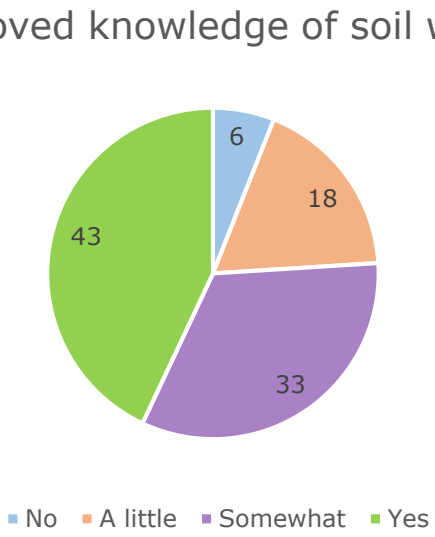


Figure 4.2 SoilWaterApp improved knowledge of soil water holding capacity and soil water changes (%) (n=97)

It's interesting when you look at some of the soil types, you can see the distribution of the water in the profile, which helps you understand why you can't push a probe in sometimes but you've actually stored water in the profile down below.

It's a good little demo tool with the growers sometimes.

Some growers have the app. This time of year it's really handy I will do a screen shot of a crop on their farm showing how much moisture they've got left so they understand. This year the crops have just about run out of water. So they know it's come in quickly. Agronomist, NSW

SoilWaterApp is helping our agronomists to understand how much the plant uses. Agronomist, WA

Many respondents to the survey indicated that SoilWaterApp had helped them learn about storing and maximising production from soil water (Figure 4.3).

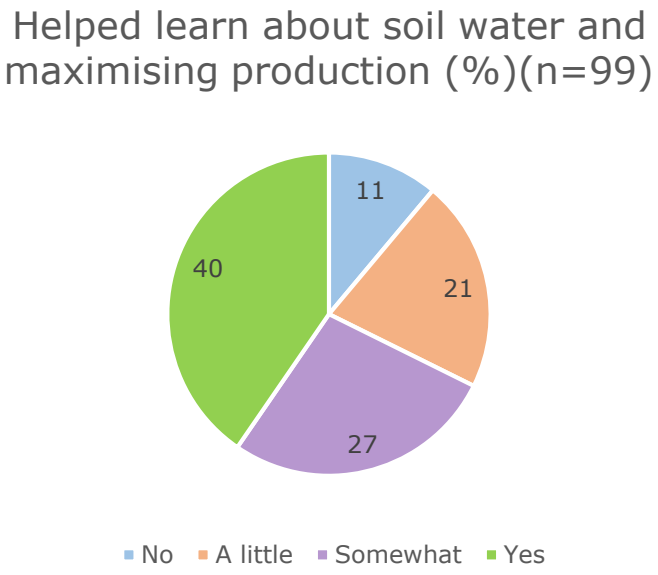


Figure 4.3 SoilWaterApp helped users learn about soil water and maximising production

4.2.3 Enhanced management practices

The following areas summarise some contributions to management practices from use of SoilWaterApp.

One third of respondents (33%) indicated that using SoilWaterApp had enhanced their planning (e.g. pre-crop), 25% indicated 'somewhat', 25% indicated 'a little' and 18% indicated 'no' (Figure 4.4).

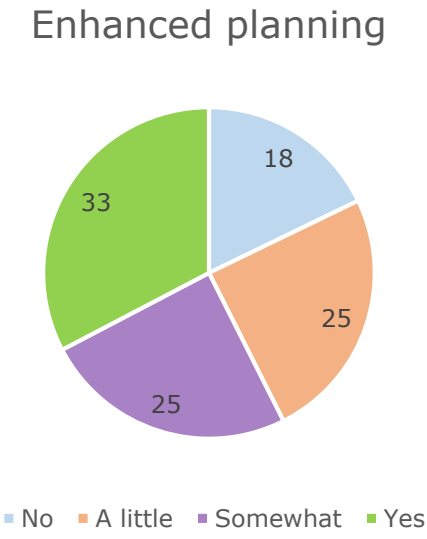


Figure 4.4 SoilWaterApp has enhanced pre-crop planning (%) (n=97)

SoilWaterApp was being used by some to estimate soil water and then to estimate crop yields and determine the type of finish to the season. Nineteen percent of respondents indicated that the app had enabled more reliable yield

estimates, 42% - 'somewhat'; 24% indicated – 'a little' and 14% indicated 'no' (Figure 4.5).

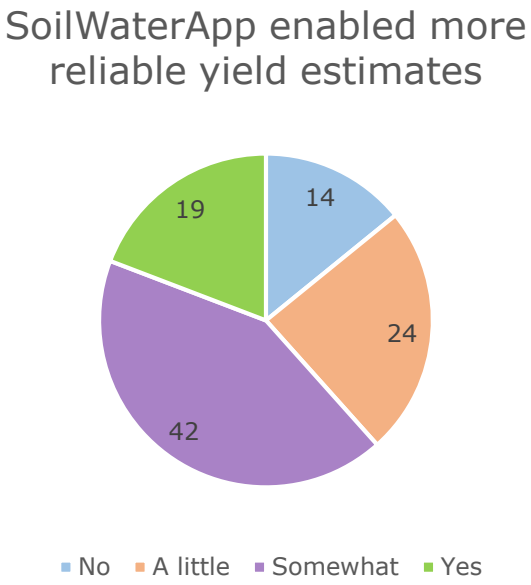


Figure 4.5 Estimating soil water using the SoilWaterApp enabled more reliable yield estimates (%) (n=98)

Forty two percent of respondents indicated that using the app had enhanced how they make decisions or provide advice (35% indicated – 'somewhat'); 15% indicated 'a little' and 7% indicated 'no' (Figure 4.6).

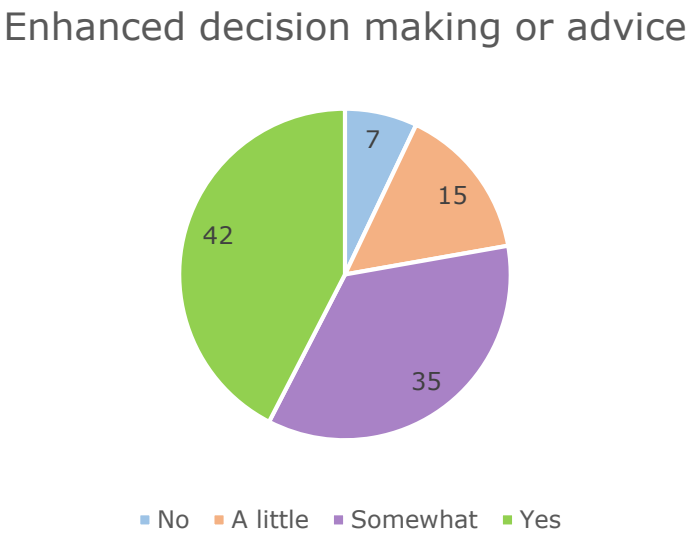


Figure 4.6 SoilWaterApp had enhanced how respondents make decisions or provide advice (%) (n=97)

The app has definitely helped with discussions with my father – about the timing of operations, when should we sow, what should we sow. It has helped with

discussions about the % (soil water) also with my father, being able to quantify, it has helped with discussions and planning'. Graingrower, NSW

'Client said I don't know if I will go ahead with seeding – I brought it up on the app and showed him this is where you are sitting, it was still April, starting to go dry. I was able to show he was well above the average and that he didn't need a lot of winter rain on top - that all he had to do was get the crop out of the ground. When he could see where he was in relation to average seasons, it gave him confidence'. Adviser, WA

SoilWaterApp is next best guess approach (beyond probes). We can monitor effects of thunderstorms in the late part of summer on our base soil moisture and leading into our sowing decisions and how that can influence our crop choices. Also what our nutrition is like. What our target yields might be, planning nutrition around that. Graingrower, WA

4.2.4 Communication and engagement

Participants in the study were using SoilWaterApp data in their communications, especially between advisers and farmers. Thirty three percent of respondents to the survey indicated they share SoilWaterApp data with others (10% - 'somewhat' and 23% - 'a little') (Figure 4.7).

SoilWaterApp use was contributing to enhancing adviser learning and the ability of advisers to communicate with their clients for improving understanding and decision making. Researchers and extension officers were using SoilWaterApp data in their presentations and in group activities.

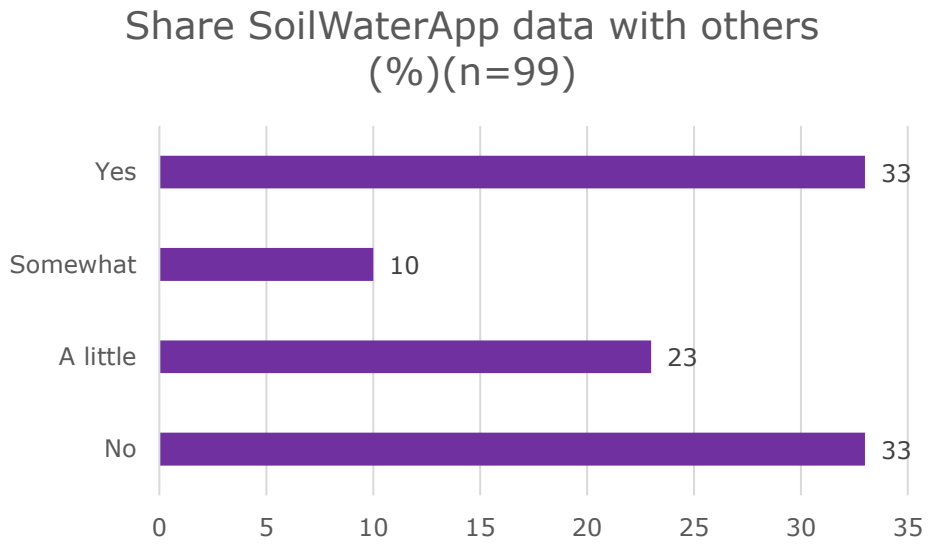


Figure 4.7 Respondents' sharing SoilWaterApp data with others

We've had some great discussions with growers about it and I think they think there is more moisture than there really is, than what the app is telling us. I

probably think the app is closest to the moisture levels than what the growers think. It is another piece of information I can put to them and say this is what their soil moisture is and they say it can't be, we've just had 100 mm of rain. We've had discussions out of it and made trials to change plant populations to reflect a little bit more conservative approach. Agronomist, QLD

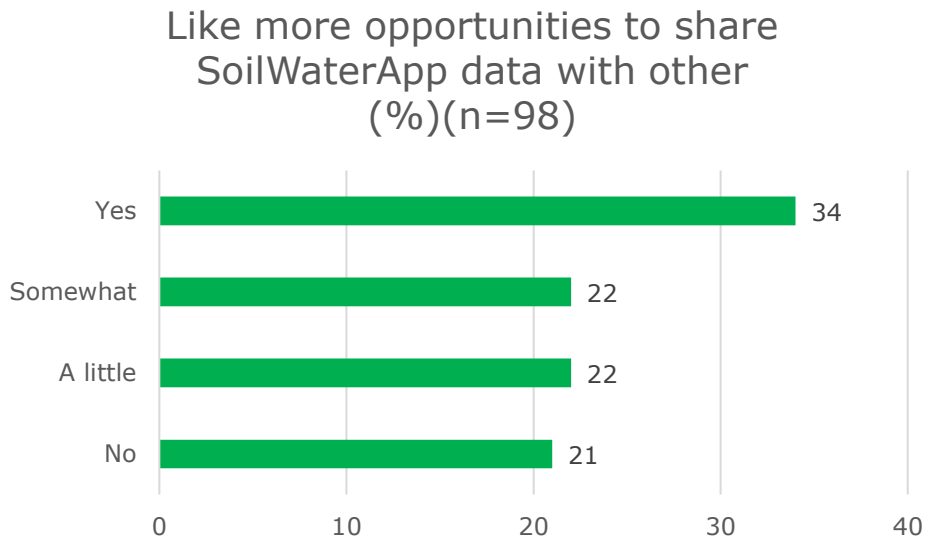
We discuss with growers what we're seeing in certain paddocks to find better moisture holding for longer. X% of barley stubble compared with Y% stubble cover. Having that discussion and trying to use that information to better plan cropping practices. The mm figure enhances the conversation. It helps you work out how much rainfall you'll need to join the profile up. It helps you explain why one paddock went 5 t and the next one went 3 t, there might have been some moisture left in the paddock. Helps to explain why each paddock performed differently. Agronomist, NSW

I've used screenshots in meetings, I might put a typical paddock up with 30% stubble and pluck rainfall data from Moree site BOM and show how it's progressed over summer. We do winter crop meetings in April. I do a screen shot and print out on our notes and that'll be a topic of discussion, how much moisture we've stored in the fallow, helping discussions with the growers about crop types, when to plant. Adviser, NSW

Enhances credibility

Yes I think so – the confidence. Because it is an intensive trial site there is much measured, there is expectation that I know at any point in time soil water and I'm doing exhaustive gravimetric soil testing to monitor. When I say I'm using SoilWaterApp, everyone seems to nod and say Ok – he's using something acceptable. If I was asked what I am using (to measure soil water) and I said just nothing specific, the credibility would be much reduced. Researcher, QLD

Over one third of respondents to the survey indicated they would like more opportunities to share and discuss soil water estimates (Figure 4.7).



Starasts, A. (2018) *Evaluation of the SoilWater app.* Report for the Australian Government's National Landcare Program. University of Southern Queensland.

Figure 4.8 Respondents who wish to share and discuss SoilWaterApp data

4.3 Other impacts

Overall benefits from using SoilWaterApp are summarised in terms of the water use, production and risks.

Twenty nine percent of respondents believed that the app had enabled more efficient use of soil water in production, 33% believed 'somewhat'; 22% indicated 'a little' and 16% believed the app had not improved water use efficiency (Figure 4.9).

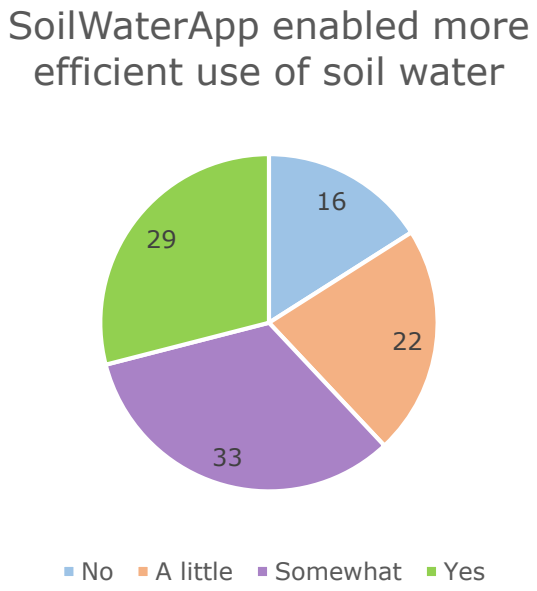


Figure 4.9 SoilWaterApp had contributed to enabling more efficient use of soil water

Maximise production

Eighty-five percent of survey respondents believed that SoilWaterApp had contributed to maximising production. Twenty five percent agreed, thirty five percent agreed 'somewhat', and twenty five per cent believed 'a little'. Fifteen percent did not believe the app had contributed to maximising production (Figure 4.10).

Reduce risks in production

Most respondents (86%) believed that SoilWaterApp had contributed to reducing risks in production (to varying extents) (28% agreed, 38% somewhat agreed and 20% agreed a little) (Figure 4.11).

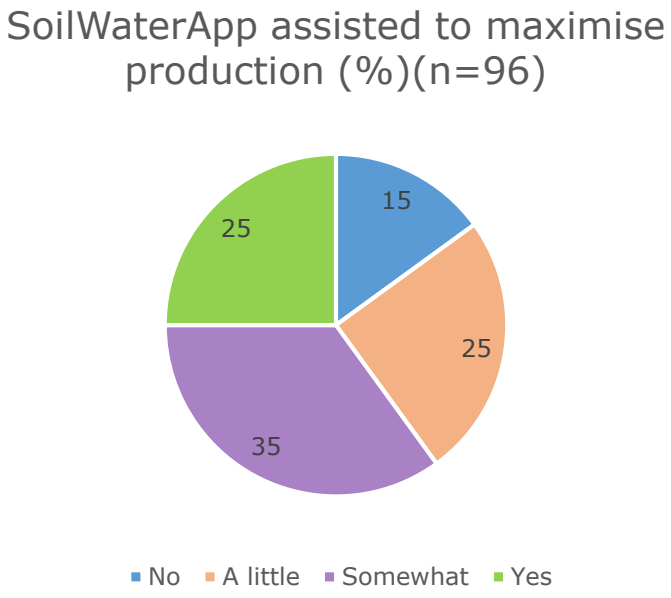


Figure 4.10 SoilWaterApp has helped maximise production (%)(n=96)

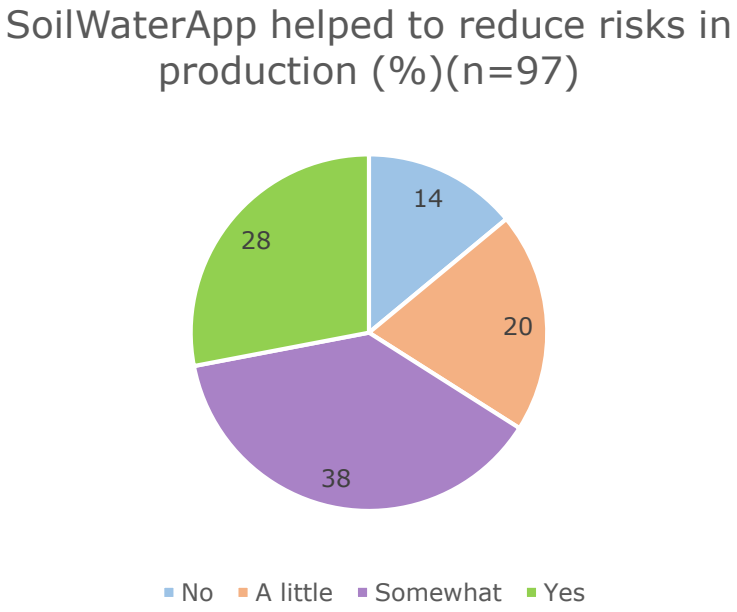


Figure 4.11 SoilWaterApp helped reduce risks in production

5 Usability

5.1 Usability

Overall data on usability of SoilWaterApp indicates mostly good ratings especially in terms of installing the app and using the app data in decisions.

However many users had some difficulties choosing appropriate soil types and there were common difficulties entering passwords.

5.1.1 Install SoilWaterApp

Most respondents found installing SoilWaterApp easy (85%) or somewhat easy (8%); six percent had some difficulties and one percent (1 respondent) found it difficult (Table 5.1).

Table 5.1 Ease of installing and using SoilWaterApp (%) (n=100)

	Difficult	Somewhat difficult	Somewhat easy	Easy	Don't know	
Install SoilWaterApp						
All	1	6	8	85	0	n=100
Use SoilWaterApp						
All	1	8	33	57	1	n=98

5.1.2 Ease of use

Many respondents found using the app easy (57%) or somewhat easy (33%); eight percent found it somewhat difficult and one percent (1 respondent) found it difficult (Table 5.1). Ease of use statistics on this app may be lower than what might be anticipated by developers. Box 5.1 provides a summary of these statistics.

Box 5.1 Summary of usability statistics – SoilWaterApp

- Most respondents (93%) were able to install and use the app; 7% found it difficult or somewhat difficult to install the app.
- Fifty-seven percent of respondents found the app easy to use; 33% found it 'somewhat easy'.
- Forty-one percent (41%) found it easy to input rainfall; 37% found it 'somewhat easy' and 19% had difficulties inputting rainfall.
- Thirty-three percent found it easy to choose and input soil type and paddock history (33%) and 38% found it somewhat easy. Twenty eight percent of respondents (28%) had difficulties choosing and inputting soil type and paddock history.
- Seventy-five percent (75%) found it easy or somewhat easy to use SoilWaterApp data in their decisions, 13% of respondents had some difficulties using SoilWaterApp data in their decisions (12% did not know).
- Fifty-four percent (54%) did not know about saving or transferring SoilWaterApp data.
- Forty-eight percent (48%) used the app more than five times per year.
- Sixty-two percent (62%) had not used the Help sections.

Survey data on inputting rainfall, soil type and initial soil water estimates is presented in Table 5.2.

Table 5.2 Input and use SoilWaterApp data – ease or difficulty (%)

	Difficult	Some what Difficult	Some what Easy	Easy	Don't Know
Choose and input rainfall data					
All (n=98)	2	17	37	41	3
Choose soil type and paddock history					
All (n=100)	8	20	38	33	1
Use soil water estimates in decisions					
All (n=100)	3	10	33	42	12

5.1.3 Input and use rainfall data

Forty one percent of respondents found it 'easy' to input rainfall data and 37% found it 'somewhat easy' (Table 5.2). Seventeen percent found 'some difficulty' and 2% found 'difficulties'. Nineteen percent of respondents finding difficulties inputting rainfall data indicates that this is a limitation in use of this app.

When entering rainfall, it actually takes off rather than adding it on the rainfall. Agronomist, NSW

I bring in weather station and then override with the actual.

Patchy rain can make it difficult using weather station data. Agronomist, WA

The biggest challenge I've had is the need to continually update the rainfall record accurately if you want it accurate. I would love to be able to download my rainfall data as csv or excel file. I was given a Bluetooth rain gauge. We've been meaning to deploy it a few times and haven't. That should enable us to do that (?) But we are just duplicating. We've already got a rain gauge at that site. Researcher, QLD

I'd like to get a couple of growers who keep rainfall records to enter in.. the way I've done it is the information is driven by me and presented to the growers. One or two might be interested in putting in their own data. Everyone has plenty to do, do they really need another job. Don't think you'll get growers to enter their own. Agronomist, QLD

5.1.4 Choose relevant soil and paddock history

Thirty-three percent of survey respondents found it 'easy' to choose and input a soil type and paddock history and 38% of respondents found it 'somewhat easy'. Twenty percent of respondents had 'some difficulties' and 8% had 'difficulty' choosing soil types and paddock history (Table 5.2). Twenty-eight percent of respondents finding difficulties choosing soil types and inputting this data also indicates significant a significant limitation with this function.

Soil types

I would expect that soil type to be in a system like that – when we use the Soilwater Express (APSIM – can help you develop a profile for Yield Prophet – to establish PAW – there's been a lot of effort put in to characterising soils) – you would think it's a sandy loam. Once we got the data back from the soil cores – we took the particle size analysis…As far as my expertise goes I could choose (an appropriate soil type from SoilWater Express) (to a level I was happy with).

There's only 10 or 12 WA soils in here. Graingrower, WA

(The problem is) identifying the right soil type, I was using one soil type on another place and it was telling me I had a bucket of water which I didn't.

Picking soil type plays a major role and lots of our soils are sodic and that doesn't take into account sometimes the infiltration rate. I play around with the soil types and try and pick the right one that shows me what I think I'm seeing. Agronomist, NSW

My agronomist, spent I think 2 days in Brisbane 2 weeks ago and they really hadn't come to a consensus on how to do it – to work out how to calibrate the soil. I'm not a scientist, so probably poorly describing it. Graingrower, NSW/QLD

Crop and fallow options

Crop choices are a bit restrictive at times here – we need oats for hay, lentils, field peas, lupins, potatoes for seed and carrot for seed. Agronomist, VIC

5.1.5 Use soil water estimates in decisions

Forty-two percent (42%) and 33% of respondents found it 'easy' and 'somewhat easy' respectively to use SoilWaterApp estimates in their business decisions. Ten percent suggested there was 'some difficulty' and 3% had 'difficulties'.

5.1.6 Move between paddocks

Forty-eight percent of respondents (48%) found it 'easy' and 29% found it 'somewhat easy' to move between paddocks in the app. Eight percent (8%) found 'some difficulties' and 4% found this 'difficult'.

5.1.7 Save graphs and transfer data

Most respondents (54%) did not know about saving graphs or transferring data. Twenty-seven percent (27%) indicated it was 'easy' or 'somewhat easy' (10% and 17% respectively). Twelve percent found 'some difficulty' and 7% found it 'difficult'.

5.1.8 View on iPhone, iPad

Most respondents (66%) found it 'easy' to view the app on iPhone or iPad, 19% found it 'somewhat easy'. Five percent had 'some difficulty' and 2% had 'difficulty'.

5.1.9 Connect to the internet

Most respondents (58% - 'easy' and 26% - 'somewhat easy') found it easy to go online using the app. Eleven percent (9% - 'some difficulty' and 2% - 'difficult) had some difficulties.

5.2 User issues and limitations of the app

Problems identified by participants in this evaluation are summarised in the following section. The major problem areas identified by participants in using SoilWaterApp were:

- the inability to enter, change or request passwords or for it to accept passwords,
- choosing soil types in the initial setup,
- understanding graphs (for some) and
- the inability to extend the cropping period.

A sample of user comments for all issues listed are presented in Appendix 11.3.

5.2.1 Password, accounts and phone update problems

Passwords

Many users recounted issues in logging on. For some the app would not accept their original password and they had to reset the password each time. For some this was continually unsuccessful. For others, when prompted to enter a password, a blackened area appeared on the screen. Others did not get an automated email to reset their password. These difficulties were very disconcerting and quite a number of these users had given up trying to log in. See Appendix 11.3 for a sample of user comments.

Rollover accounts

One participant identified a problem having moved employers and could not access previous clients' data through a new email address.

Phone and app updates

Numerous other participants indicated difficulties when they replaced their mobile phones or when they updated their device – in continuing to access the app with their previous password.

5.2.2 Setting up SoilWaterApp

Difficulties setting up the app (especially choosing soils and initial soil moisture estimates) were the largest limitation to its use. Participants commented that the app data is only as good as the initial choices and many had difficulties with these. In addition, choosing stubble percentage or crop were limiting for some

and a source of error therefore in estimates. They indicated that significant time was required to successfully understand the app and select inputs.

5.2.3 Choosing soil types

There are limitations in the range of soil types in the app – in meeting users' expectations in choosing their soil type. A sample of comments are presented in Appendix 11.3. Users were expecting to choose a fairly exacting soil type which matches texture, soil water storage, rooting depth and provides a soil water estimate in line with their own estimations.

It is suggested that many users lack sufficient knowledge of soil types to choose an appropriate one. Agronomists who have knowledge of soil types were adjusting soil type choices and cover in order to find a soil type that estimated soil water similar to what they had measured (gravimetric measurements, push probes or estimated by other means). The need to undertake such non-standard adjustments may be unnecessary with a wider range of soil types available in the app.

5.2.4 Initial soil water estimate

Users had difficulties inputting an initial soil water estimate and choosing a timing for this. A number of researchers had the luxury of using gravimetric soil moisture data to set up each crop and then use the app through the growing season. It was suggested that where fixed probes are set up as part of industry or public projects, that the data could be published online – which would be of assistance for nearby properties setting up the app. Some guidance for users on initial soil water estimates may be beneficial. (See Appendix 11.3 for user comments).

5.2.5 Fallow and crop inputs - timing and sequential crops/seasons

Some users had difficulty choosing fallow, crop and pasture inputs that could lead to useful soil water estimates for them. There were difficulties establishing fallow periods, and capturing rainfall data during fallow. Users wanted to continue using their soil water estimate site ongoing (beyond 2-3 crop/fallow seasons), to follow on with and monitor future crops.

5.2.6 Concerns regarding accuracy

Some users had some concerns regarding the accuracy of SoilWaterApp estimates which affected their ability to rely on the data (e.g. lower crop water use than predicted in the app and higher soil moisture storage in fallows than estimated by the app). As indicated previously, some adjusted soil type and cover in an attempt to provide more accurate estimates. It was also alluded to that there were differences across properties in the factors affecting infiltration (variations in soils, slope and rainfall intensities) which were not taken into account by the app.

Some participants identified that rainfall in nearby weather stations is not the same as in individual paddocks and that this was a limitation for them in relying on SoilWaterApp's estimations, along with rainfall variability and the difficulties predicting this.

A small number of users recounted difficulties obtaining useful estimates from the app in very dry conditions and when soils were cracked. See comments in Appendix 11.3.

5.2.7 Choosing sites and inputting rainfall

Participants indicated they wished to connect to weather stations beyond the BOM sites – including local farmer sites and DAFWA sites. They also indicated that local weather station rainfall data differed to individual property rainfall data. There were difficulties entering and maintaining rainfall data in the app and for some setting up and using blue tooth rain gauges. One participant had difficulty adding sites. Agronomists suggested that many growers would not have the time to enter their own rainfall or set up the app.

5.2.8 Other input, data and screen issues

Participants indicated other minor errors along with the fact (for some) that fonts were too small for them to successfully use the app on iPhone.

5.2.9 Sharing and reviewing SoilWaterApp data

Some participants indicated that they could not go back in time to review data at a previous point. Also some reported difficulties sharing reports. One participant indicated the app provided rainfall on incorrect dates which made it difficult to use the data in a report.

5.2.10 More information and help

Some users reported wanting additional information especially on choosing soils and entering inputs and on understanding graphs. Some were unsure of or unaware of some of the app's features (including help).

5.3 Suggestions

Users made the following suggestions in relation to improvements and future developments of the app.

Indicate rainfall on graphs

Would be nice if the rainfall could be indicated on the graph as well as a bar?

Estimate yields

A grower at Farmlink open day at Temora on 1 Sept 2017 requested predicted yield at today's date line for 40% average and 60 percentile climate scenarios and another yield estimate for the crop finish date, using these climate regimes. I know this is about soil moisture but if we are predicting biomass in the bottom graph can we also project yield?

Forecast rainfall

Add future rainfall forecasts to the decision support.

Additional weather stations

Linking to DAFWA weather stations would allow more accuracy of data for consultants.

Communicate with users

Wouldn't take much. Technical emails or something like that, if anything is updated, let us know, any features added. Email or Youtube channel with instructions. There'd be parts of it I don't know about….

Access to probe data

I think it would be really good if we had some soil moisture monitoring equipment giving those actual readings. I think the model would be more accurate if it could look forward with today's soil water figure rather than the one we put in two months ago, with reference points along the way (i.e. an actual probe reading).

Training

It was suggested that a self-paced tutorial could be available online or a webinar to help users learn how to best use the app.

Store and show soil water data over time

Really good. I'm a grower. If you could have a database of each of your paddocks with soil water over time, you start to build up a really good database of what's happening. That'd be really good to have on the desk top to refer back to.

Add more crops and years to graphs

Have that graph over 2-3 years, you could probably extend it over 5 years time, have a rolling graph.

Allow more crops to be added to the app beyond 2 crops – so can continually roll over and estimate soil water. Currently have to start a new site for the third crop.

Key for choosing soil types

Key to choosing soil types could be helpful

Inputs – crop/pasture species

Participants suggested that a wider range of crop and pasture options in the app would allow more accuracy in their estimates.

5.4 Recommendations for developers

5.4.1 Current SoilWaterApp (for developers)

Password input errors – Ensure users can easily see input screens for passwords and no errors occur at this stage.

Ensure rainfall input screen and function has no errors – that data is not removed or moved and that the function to upload rainfall files (.csv or other) is working.

Promote and further develop where necessary information on inputting rainfall and soils data. Consider further information to help with understanding graphs and to understand how dry conditions affect soil available water.

Provide general guidance on choice of soil type explaining either that soil type does not have to match exactly (and outline some examples of how to adapt soil type depth and texture) OR provide wider range of soils and mapping assistance for choosing soil type. Also provide some additional guidance on estimating initial soil water stored.

Consider iOS mobile device updates and possible interference with app functionality.

5.4.2 Future SoilWaterApp development

Site data rollover and compatibility – Currently each analysis is virtually lost after two seasons as users have to set up a new site to continue to a third season. Provision of the output in report and in spreadsheet format would allow it to be incorporated into other calculators and decision tools as well as maintained in a historical database for each site. Consider enabling the app **to rollover to further seasons** and crops (beyond two).

Regional support base – To facilitate adoption and use of the app it is suggested that key organisations who have a vested interest (grower groups, agribusiness, government) encourage and support relevant staff (e.g. agricultural extension or development, agribusiness advisory) to provide relevant, regional seasonal updates from the app through media or in presentations. Such staff could take on the role of key user in that location, providing examples and some support in using the app. In some areas, this is already happening (e.g. in farmer groups) and is facilitating education and understanding to a wider community.

Consider **adding wider range of crops** to the app AND the ability to indicate if the **crop was suffering stress or the crop or fallow was invaded with weeds.**

Consider the possibility to link the app to **publicly funded weather (e.g. DAFWA) and soil probe sensor networks** to enable access for users to the best available weather and soil data for their location.

Real time, Real place data – Whilst SoilWaterApp provides a cost-effective and efficient means of estimating soil water storage, users in this study seeking more site-specific storage data would have their needs met through soil water sensor probes.

6 User analytics

This report incorporates data and analytical capacity incorporated into SoilWaterApp which are collected automatically each time a user accesses the app. It provides a rich picture of spatial and temporal use of the app.

6.1 Spatial distribution

6.1.1 Users and sessions

At the time of report finalisation, there were 1434 registered users of SoilWaterApp, seven of which occurred in the past 7 days. Figure 6.1 shows the geographic spread of the 2300 sites registered by users.

Figure 6.1 Distribution of registered users' primary site of SoilWaterApp July 2018 number of sites = 2300.

Users are undertaking calculations in the app based largely on sites throughout the eastern, western and southern grain production areas. There are only a few users outside of this grain belt – across northern or central Australia. Users and sessions are classified by state in Figure 6.2. Over 40 percent of the users and the sessions are located in New South Wales, followed by Queensland (sessions) and Queensland and Victoria (users). Note that only 3% of all sessions originate from Western Australia.

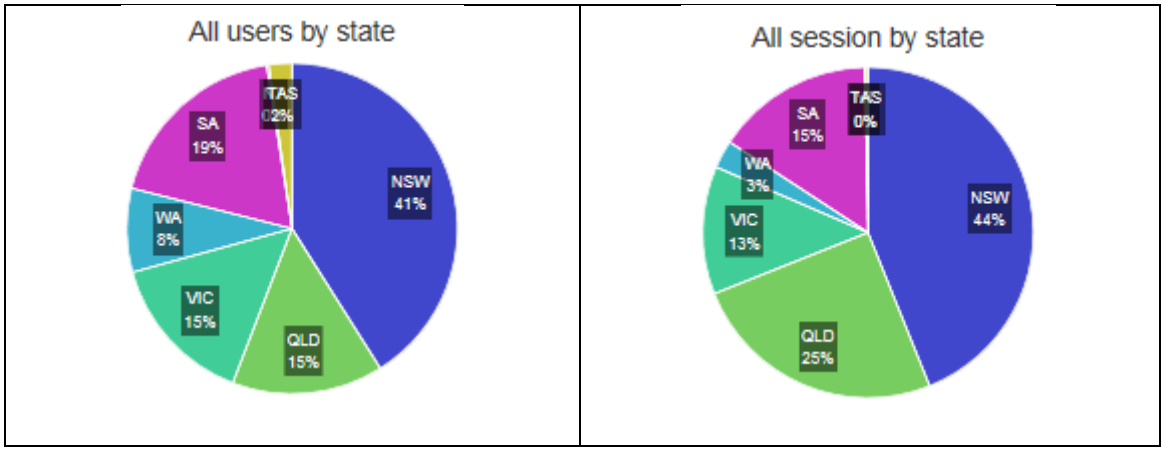


Figure 6.2 SoilWaterApp users and sessions classified by state, July 2018

Survey data and app analytics provided limited information on users' roles and organisations. Figure 6.3 depicts an approximate breakup of users based on email address and nominated organisation. Other / Unclear registered users may be mostly farmers, but could include some agribusiness, government and project staff and some students.

Survey respondents included mostly SoilWaterApp users involved in grain production (farmers and advisers), but also extension staff (dairy, sugar cane), researchers, farmers and advisers involved in sheep and wool, beef, pastures and silage, olive growers and tropical fruit growers (see Figure 2.1).

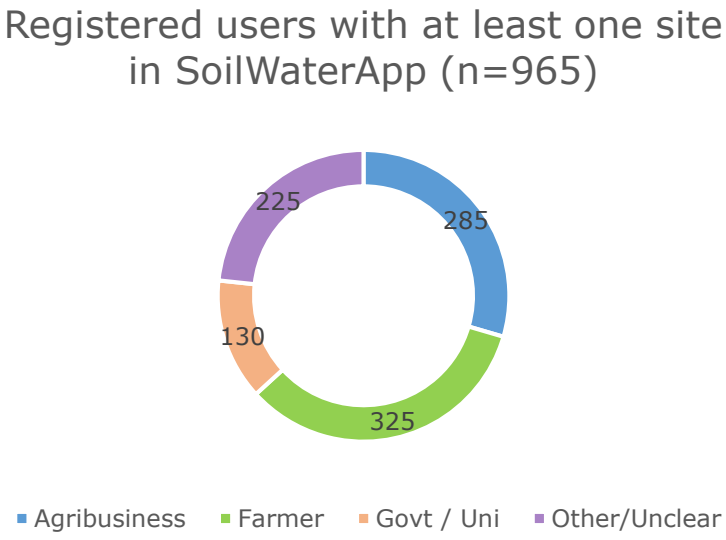


Figure 6.3 Approximate breakup of SoilWaterApp users with at least one site set up (based on email addresses) (n=965) ('Other/Unclear' users also incorporate Farmers)

The range of crops and activities for which SoilWaterApp is used is listed in Table 6.1. In addition to broadacre grain crops, the app is being used for hay, pasture and silage production. Respondents from horticulture and mining revegetation were investigating and testing the app.

Table 6.1 Crops for which survey respondents were using SoilWaterApp to monitor soil water

Wheat, Barley	Lentils	Safflower	Dragon Fruit
Oats, Triticale	Field peas	Chickpea	Olives
Canola	Faba beans	Sorghum	Hemp
Dryland cotton	Lupins, Linseed	Mungbean	Sugarcane
Millet	Revegetation practices	Maize	Aerobic Rice
Soybean	Vetch	Sunflower	Lucerne
Hay (oats, triticale)	Pasture	Maize silage	Ryegrass

6.1.2 Sites

Figure 6.4 shows the new sites added in the past 30 days, indicating that information about the app and its value is spreading.

Sites added last 30 days (n=207) (georeferenced by climate station)

Figure 6.4 New sites added in SoilWaterApp over last 30 days (n=207)

Most users had set up 1-2 sites (Figure 6.5) with 124 users establishing 3-5 sites and 47 users establishing 6-10 sites and 35 users establishing greater than

10 sites. The large number of multi-site users indicates the strong commercial use of the app among advisers.

There are 279 users who registered the app and have not set up a site. This could indicate a lag in analytics, one-off users or it may indicate the extent of some of the barriers identified in this study (including time limitations in understanding and trusting the app, difficulties choosing soil types, or inability to re-log in due to the password issues).

There are 609 registered users who have set up only one site. This is 44% of all registered users and includes agronomists, farmers and other agricultural operators. The fact that such a large percentage of users have only set up one site with one soil type suggests the app is being used as a guide only rather than for detailed monitoring across soil types. Many operators in agriculture are working with more than one type of soil (different paddocks, different sites, different clients) and it might be expected that dedicated users of the app may have set up more than one soil type for monitoring soil water storage.

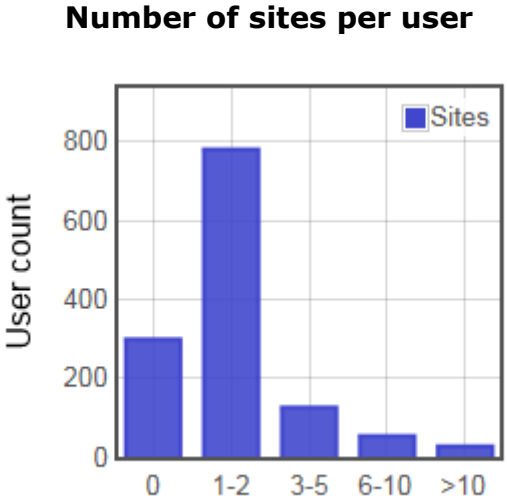
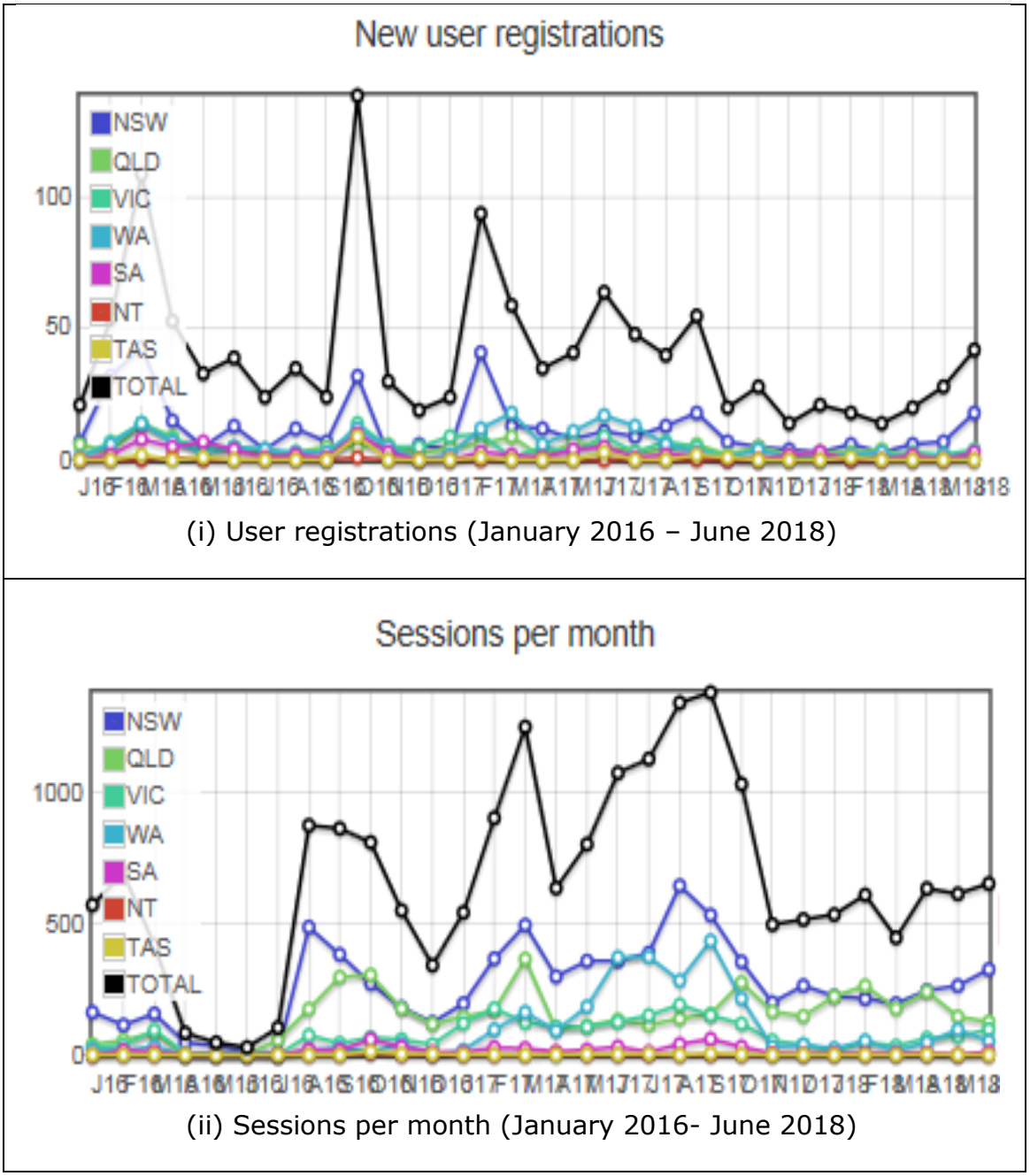


Figure 6.5 SoilWaterApp - number of sites (n=1434 users, n=2280 sites)

6.2 Growth in user and session numbers

New user registrations show a seasonality of use, especially in autumn, winter and spring (Figure 6.6 (i)). A 'session' represents a visit to the app for a minimum of 30 seconds and is a measure of how often the app is being used. The number of sessions per month over the period from January 2016 to June 2018 is shown in Figure 6.6 (ii).



(i) User registrations (January 2016 – June 2018)

(ii) Sessions per month (January 2016- June 2018)

Figure 6.6 SoilWaterApp user registrations (i) and Sessions per month (ii) January 2016 – June 2018

6.3 Connection, device and use of SoilWaterApp

Users are connecting online to use SoilWaterApp on mobile connections (50%) and on WiFi (47%), they are mostly using iPhones (64%) and iPads (36%) (Figure 6.7). App analytic data suggests that users are using the app throughout the day and evening, with slightly higher use in the morning (Figure 6.7).

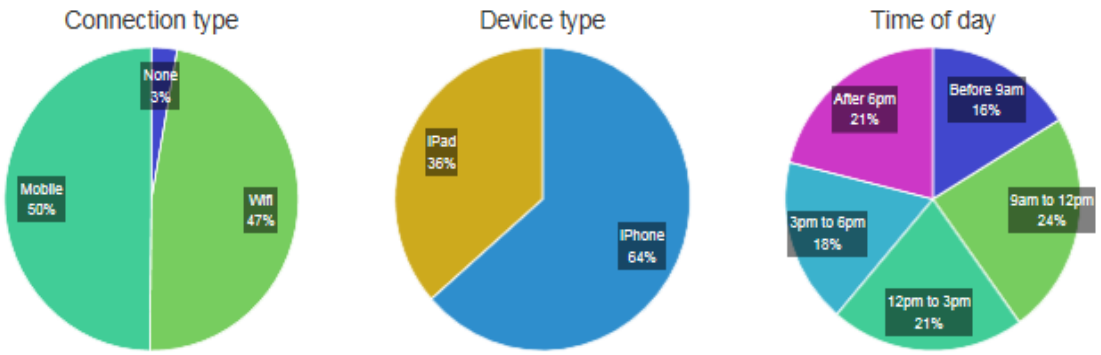


Figure 6.7 SoilWaterApp usage – connections, device and time of day (n=20139)

6.4 Frequency of use of SoilWaterApp

Figure 6.8 shows that almost half of survey respondents (48%) used SoilWaterApp more than 5 times per year. Twenty two percent used the app only 1-2 times per year and 2% of respondents did not use the app.

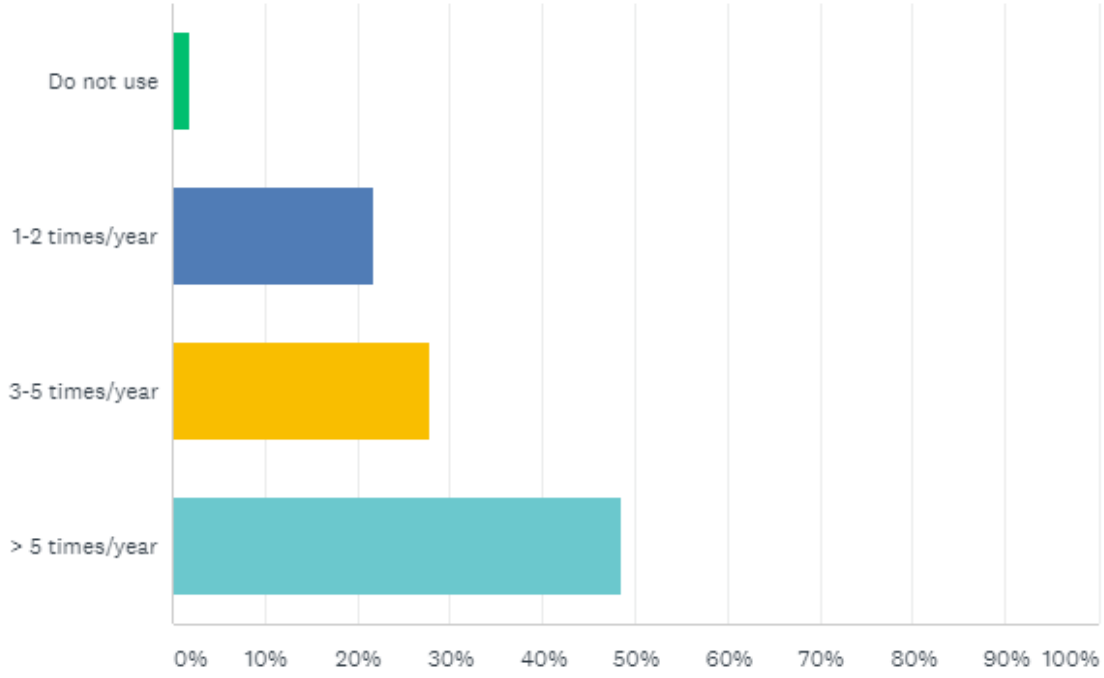


Figure 6.8 Respondents' frequency of use of SoilWaterApp (per year) (%)(n=101).

7 Information, education and awareness

Consideration was given to how users became aware of SoilWaterApp, their needs for information and support in adopting the app, and in considering and applying SoilWaterApp data.

7.1 Awareness of SoilWaterApp

Survey respondents first heard of SoilWaterApp largely through a seminar or presentation (34%), colleagues (25%) or articles (26%) (Figure 7.1).

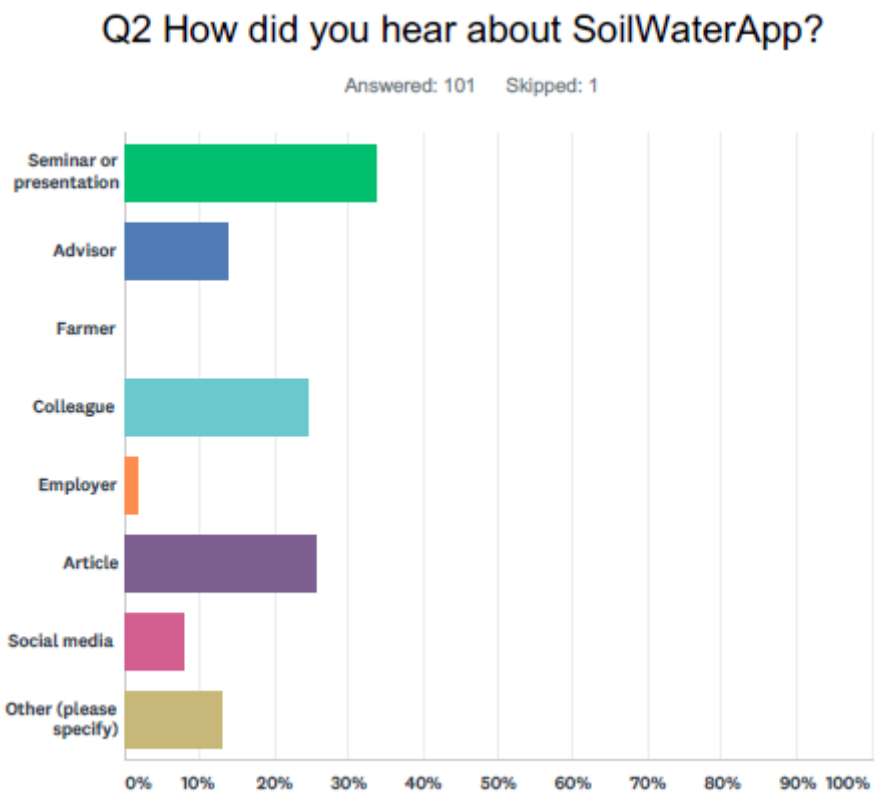


Figure 7.1 How SoilWaterApp survey respondents became aware of the app (%) n=101

7.2 Accessing SoilWaterApp information

Most respondents (46% agreed and 38% somewhat agreed) believed there was sufficient information available to start using SoilWaterApp. Nine percent only slightly agreed and seven percent of respondents disagreed (Figure 7.2).

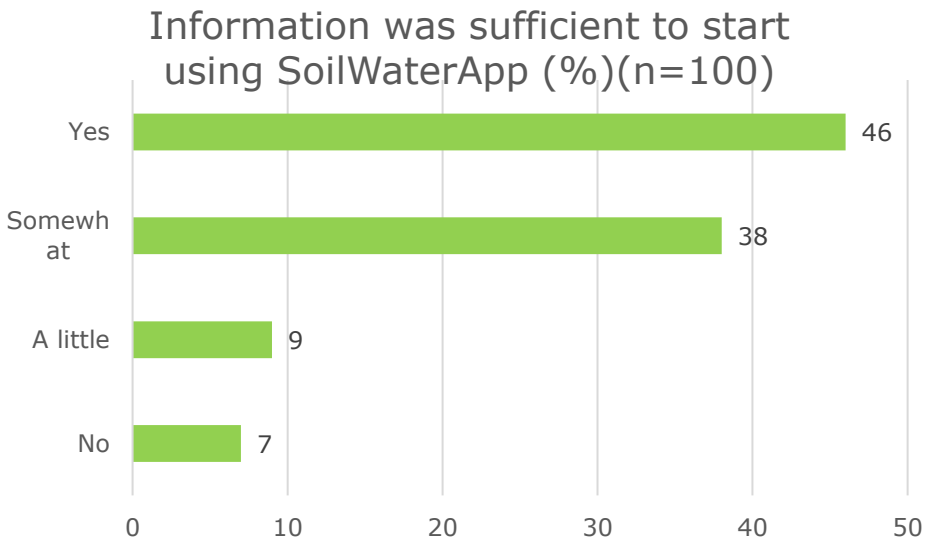


Figure 7.2 Respondents belief that available information was sufficient to start using SoilWaterApp

Help and Library information

Most survey respondents had not used the Help information (62%) or the Library of supporting information available on the website (66%). Thirty two percent found the Help section useful and 30% found the Library of supporting information useful. Six percent of respondents did not find the Help section useful and four percent did not find the library of information useful (Figure 7.3).

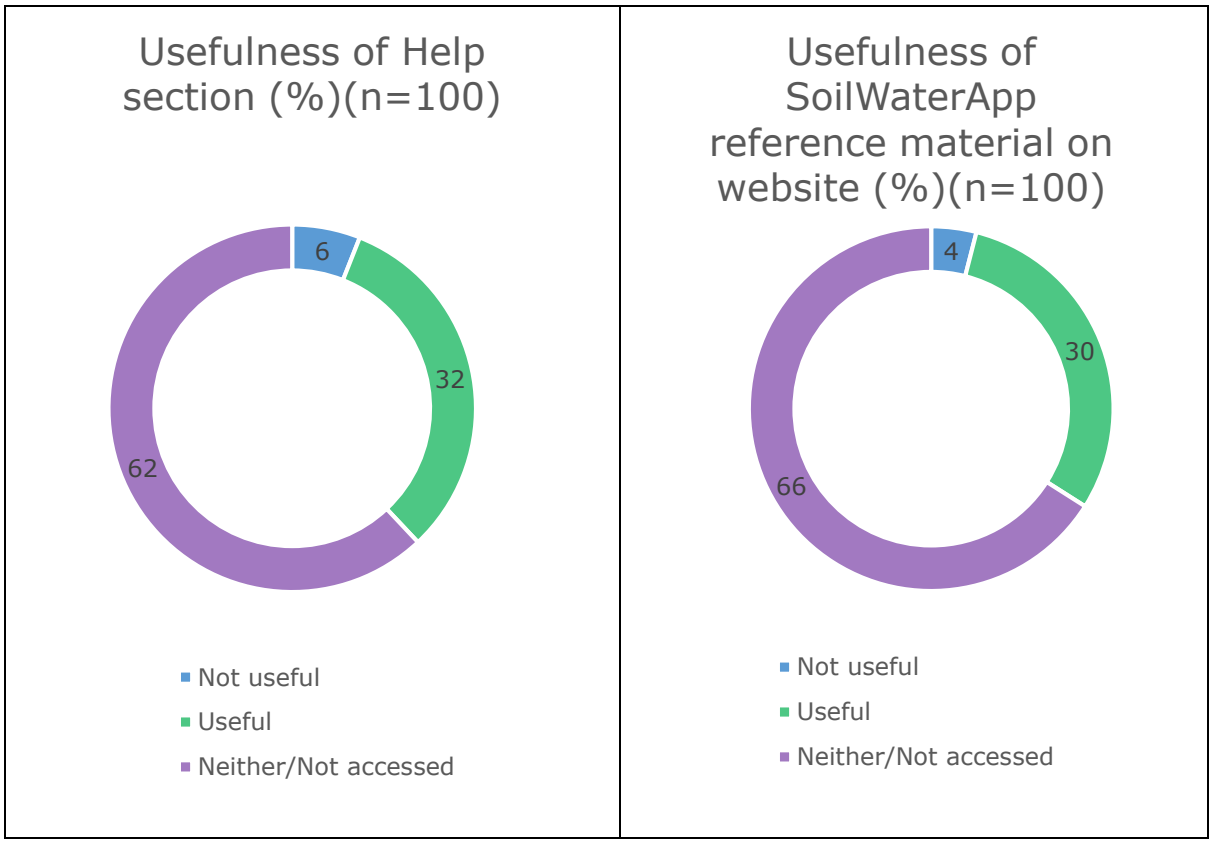


Figure 7.3 Usefulness of Help and Library files (SoilWaterApp)

7.3 Value from using SoilWaterApp

Only 11% of respondents believed they were getting the most value from the app. Forty four percent (44%) indicated they somewhat believed this and 22% indicated only a little. Twenty two percent (22%) of respondents indicated outright that they were not gaining the most value they could from the app (Figure 7.4).

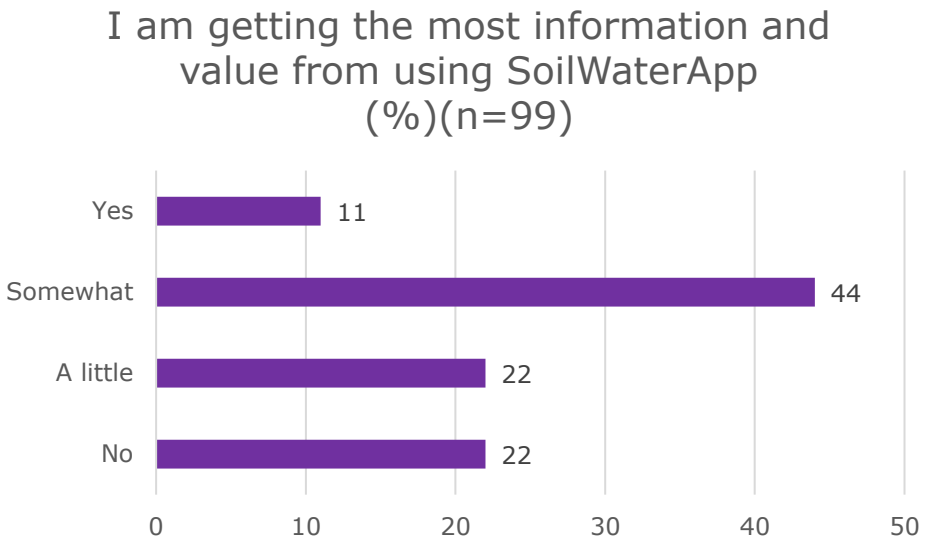


Figure 7.4 Respondents' belief they were gaining most value from SoilWaterApp

7.4 Sharing SoilWaterApp information

One third of respondents (33%) indicated they share SoilWaterApp information with others (and an additional 10% indicated somewhat). One third (33%) indicated they did not share the information (Figure 4.7)

Over one third (34%) of respondents indicated they would like more opportunities to share and discuss SoilWaterApp information (an additional 22% somewhat agreed with this) (Figure 4.8).

8 Discussion

8.1 A monitoring, decision and learning tool

The SoilWaterApp is playing a significant role in facilitating Australian broad acre users to understand, store and manage soil water. It is enabling farmers, land managers and advisers to consider not only rainfall but the systemic processes surrounding soil water storage and understand their importance in contributing to agricultural production. The visual and quantitative basis of the app's estimations along with the input (soil, fallow and crop data) adjustments are a basis for learning, decision making and discussion among users.

Simply put, users are learning about how to store water in their soils, how farming activities and seasonal conditions are contributing to storing water, and how stored water produces yields. The app is highlighting the importance of soil in the 'Rain to Grain' process.

The app is being used to guide planting decisions and the identification of planting triggers, and to guide nitrogen fertiliser and other in-crop input decisions. It is being used to assist in disease management decisions and residual herbicide management, and is contributing to yield forecasting in broad acre farming.

For advisers, the app has enabled remote monitoring of soil water storage; it is used as a visual tool as a basis for discussion, reporting and education with growers about crop water use and soil water storage.

The app is used by broadacre researchers across Australia to plan experiments, identify planting time, choose crops, estimate water use efficiency and to understand water movement and storage in soils. It is also used in scheduling irrigation in research trials.

SoilWaterApp is being used by some advisers and growers to schedule irrigation within both broad acre and horticultural industries.

The app is also being used within the pastoral industry to help with grazing animal management by helping to predict pasture growth, and therefore animal intake and growth rates. In addition, the app has been used to support training and learning – about soil water storage, crop water use and fallow efficiency within agribusiness firms, farming businesses and agricultural colleges.

8.1.1 Extent of use within grains industry

It is estimated that up to 4% of Australian grain growers may have registered and set up sites in SoilWaterApp. Data on Australian consultant and adviser numbers is unavailable, however up to 500 advisers have now registered and set up sites in the app.

This level of adoption, is commendable considering that following initial promotion (at GRDC updates or through Groundcover magazine) all support was

provided by the developers with no additional industry or local organisational support.

8.1.2 Outcomes and value on investment

Use of the app has led to improvements in relation to monitoring and managing soil water and reducing risks. Survey responses indicate that almost half of these users (47%) believed the app had helped to better monitor soil water, 43% believed the app had increased their knowledge about storing soil water and its losses, and similarly had enhanced their decision making (42%). Almost 30% believed use of the app had led to more efficient use of soil water and also had led to decreasing risks of production. These achievements also are commendable indicating application and real value within the grains industry. They indicate how easily the app can be integrated with current on-farm advisory and decision processes.

Adoption of SoilWaterApp (a free download) is extremely economic compared with the cost of installing a weather station with soil water sensors (estimated at AUD$2-10 000), and Freebairn et al. (2018) identify successful comparisons between app estimates with current sensor technology. It is considered that investment in developing SoilWaterApp is being offset throughout Australian agriculture through more efficient input economies, and more timely management and planning. The app has facilitated increased cropping through enhanced confidence to take advantage of opportunity cropping and higher risk cropping scenarios.

8.2 Set up and accuracy

The fact that significant percentages of users have found value from using this app indicates that many have managed to establish functioning and useful sites despite the fact that some users found SoilWaterApp somewhat difficult to set up and obtain reliable data.

Difficulties setting up the app (especially choosing soils and initial soil moisture estimates) were the largest limitation to its use. Participants commented that the app data is only as good as the initial data inputs (rainfall, soils, cover, fallow, crop and initial soil water estimate) and many had difficulties choosing and entering these. It was through adjusting these inputs (trial and error) that some were able to produce more trustworthy estimates. Most agronomists went through quite a process of this adjustment and it was suggested that few farmers would go to the extent of making these adjustments.

It is in the representation of the relationship between these inputs that makes the SoilWaterApp model so useful as a learning tool through the cropping season and fallow. The value of this app may not be necessarily in its accuracy but rather as a guide and discussion and demonstration tool showing soil water changes through fallow and cropping phases.

8.3 Barriers to use

Limited awareness of the app may be the initial barrier to its use. This occurred among farming community, agribusinesses and agricultural organisations. Users of the app were largely individuals who had seen a presentation about the app or heard of the app from a colleague or article and put in the effort to evaluate and become familiar with using the app. There appears very little local or industry based initiatives to support or resource individual users in commencing to use the app. Participants in this study indicated good support was provided by the developers when they had problems but many with problems or who did not understand (e.g. graphs) had not sought help and some had abandoned the app.

The fact that most users had not sought out user information and help files is a barrier to adoption of this app – information on choosing inputs (especially soil types), entering data (e.g. rainfall) and information on reading graphical output are mostly what users were requiring. It is suggested that online training, the provision of examples of use (e.g. case studies), and contact with others to discuss how to use the app would facilitate many in using the app.

The following section discusses other limitations to successful use of the app.

8.4 Limitations to successful use of the app

Many users recounted issues in logging on. For some the app would not accept their original password and they had to reset the password each time, and for some this was continually unsuccessful. Some reported blank screens when prompted to enter passwords. Users also reported errors downloading rainfall data for individual sites. These difficulties were very disconcerting and quite a number of these users had given up trying to log in.

An obvious limitation to obtaining useful estimates from the app is the quality of the initial soil water estimate and this is an area where users had some concerns. One limitation noted by avid users was the inability to provide ongoing soil water estimates for a site – beyond 2 consecutive crops. Some users also indicated that local weather station rainfall was sometimes quite different to a particular paddock's rainfall. Discrepancies also between field conditions and app estimates occurred for some especially in dry conditions.

8.5 Information and training

The uncertainty of choice of soil and inputs, and difficulties using Bluetooth or inputting rainfall means that using this app can be complex. Better support and promotion of Help and information may be necessary to assist users in choosing appropriate soil types.

Most users (two thirds of survey user respondents) had not used the Help screens and in fact, many did not know they existed. In addition, although a wealth of information has been provided on the SoilWaterApp website in various presentations and handouts, most users had not sought out this information.

Although user registrations are rising, it is suggested that to build a larger community of users (or a community of users who obtain better value from using from the app) and to make the set up process easier, that basic and advanced user information and help files be promoted to users and further developed if necessary. This could especially be useful for potential farmer users. In addition, it could be further promoted to users that they could contact app support or a nominated local support person for assistance. Regional sessions could also be held annually.

8.6 Maintenance and support

Maintenance and support for this app is important. There are sometimes errors especially with passwords and logging in, in inputting rainfall or in linking with Bluetooth data. Users must always have somewhere to go for assistance, otherwise it appears they may give up on the app.

Respondents in the survey were very happy with the support received from the developers. The future of maintenance and support for apps developed through funded projects though is unclear. A future plan for funding maintenance and support for this app is therefore necessary.

8.7 Communication with users

Similarly, maintaining communication channels with users will help grow a community of informed and skilled users who gain better value from using the app. Over one third of users indicated they would like opportunities to discuss using SoilWaterApp. Extension initiatives through individual industries or local organisations could provide opportunities which may support individual users in applying and gaining the most value from the app.

8.8 Strengths, Limitations, Opportunities and Risks

Strengths

- Portability
- Graphical output
- Learning and discussion tool
- Efficient method of estimating soil water at local and remote sites
- Soil water estimates were found to be reliable by users (once sites were successfully established) compared with push probe and sensor data. (In addition Freebairn et al. (2018) identify successful comparisons between app estimates with current sensor technology)

Limitations

- Necessity of logging on and associated errors
- Difficulty estimating initial soil water
- Difficulty choosing appropriate soil types
- Limited suite of inputs (crops and crop condition)
- Unable to monitor more than one fallow–crop-fallow sequence

- Some limitations adding on-farm rainfall data (which would make the app's output more relevant than local weather station data).

Opportunities

- Extend the app to monitor beyond 2 seasons and provide data in format to archive (spreadsheet or database)
- Promote the user information and help sections to users. Explore the possibility of providing further information on understanding graphs.
- Widen range of crops and ability to input crop status (e.g. stressed)
- Provide some regional support and promotion
- Publish the app online (world wide web)

Risks

- Insufficient future support and help for users with problems (which may occur with disjointed project funding) may encourage users to abandon the app.
- Lack of development will result in the app losing currency and innovation

9 Conclusion

SoilWaterApp is increasingly and successfully used across the grains industry by farmers and advisers to monitor soil water and inform decision making about planting, crop inputs and irrigation. There are 1434 registered users of the app Australia wide, seven of which occurred in the past 7 days. These users have set up 2300 sites.

The app is making contributions to decision making, management and reducing risks in grain production through Australia in terms of maximising fallow efficiencies and in-crop water use efficiencies. The app is also being used by some pastoralists in grazing animal and drought management, and by broadacre researchers and educators.

Barriers to adoption include lack of awareness, poor use of information about the app and how to use the app, lack of obvious organisational or regional support, and lack of examples of use. Notwithstanding these, use of the app is continuing to grow and users are reporting significant benefits.

There is little doubt that SoilWaterApp is making a significant contribution. That over 40% of survey user respondents believed the app had improved monitoring, knowledge and decision making is evidence of this. It indicates the potential for enhancing knowledge and decision making that this app provides.

This evaluation has identified some of the successes from the adoption and application of SoilWaterApp, especially in decision making in order to maximise productivity, especially in variable and drier environments, and in improving understanding and learning about fallow efficiencies and soil water storage.

10 References

Allen, I. E., & Seaman, C. A. (2007). Likert scales and data analyses. *Quality progress*, *40*(7), 64.

Bennett, C. (1975). Up the hierarchy. *Journal of Extension* [On-line], 13(2). Available at: http://www.joe.org/joe/1975march/75-2-a1.pdf

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology*, *13*(1), 3-21.

Corbin, J., Strauss, A., & Strauss, A. L. (2014). *Basics of qualitative research*. Sage.

Douthwaite, B., Alvarez, S., Thiele, G., & Mackay, R. (2008). Participatory Impact Pathways Analysis: A practical method for project planning and evaluation. Available at https://cgspace.cgiar.org/bitstream/handle/10568/70093/ILAC_Brief17_PIPA.pdf?sequence=1&isAllowed=y Accessed 30/5/18.

Freebairn, D.M., Ghahramani, A., Robinson, J.B. and McClymont, D.J. (2018) *A tool for monitoring soil water using modelling, on-farm data and mobile technology, 104,* 55-63.

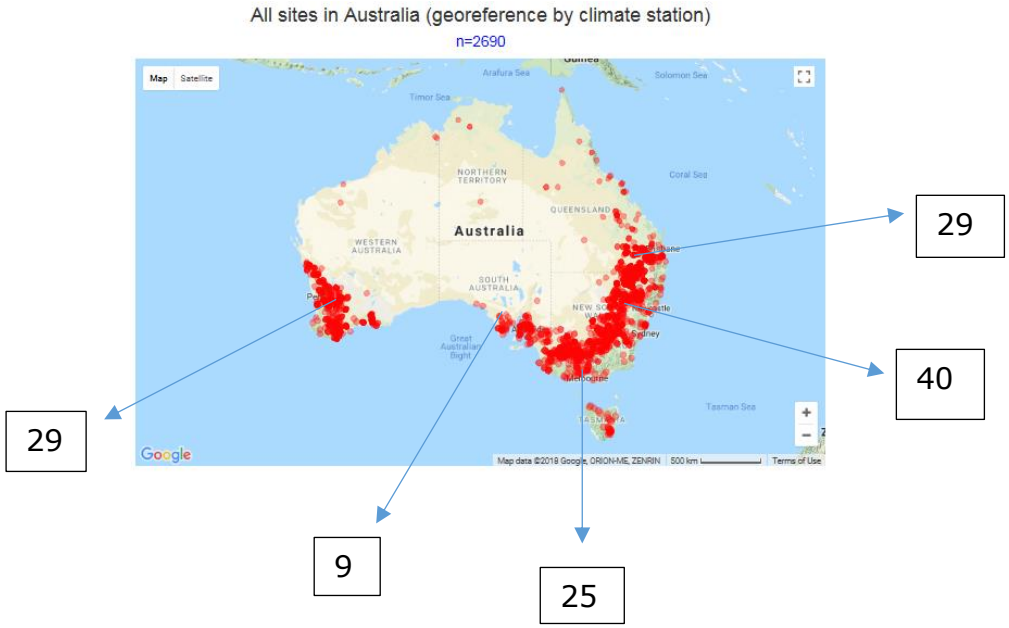
Leith, P., & Vanclay, F. (2017). Placing science for natural resource management and climate variability: lessons from narratives of risk, place and identity. *Sociologia Ruralis*, *57*(2), 155-170.

Likert, Rensis (1932) 'A Technique for the Measurement of Attitudes', Archives of Psychology, 1932, Vol. 140, No. 55.
Penfield, T., Baker, M. J., Scoble, R., & Wykes, M. C. (2014). Assessment, evaluations, and definitions of research impact: A review. *Research Evaluation*, *23*(1), 21-32.

Radhakrishna, R., & Bowen, C. F. (2010). Viewing Bennett's hierarchy from a different lens: Implications for Extension program evaluation. *Journal of Extension*, *48*(6).

11 Appendix

11.1 SoilWaterApp evaluation participants



11.2 Case-based examples from SoilWaterApp users

Agronomist, NSW

So on growers' farms, I'll have a rain gauge on farm which I check myself or use the rainfall the grower gives me. I'll have the paddocks close by set up in the app – whether fallow or in crop. I'll just track the soil water change over time – ongoing for those paddocks. I track and compare what I'm seeing in the app comparing it with the push probe. I can put that data in and match it up to see how it compares, out of curiosity.

I am using it like a rainfall gauge for those areas, to see how it tracks over time and with the stubble cover - seeing how it influences fallow efficiencies. It helps, slowly following it through to yield (helps you learn). You can slowly build up a rough map of how the whole picture comes together. I am trying to link rainfall and fallow efficiency, (to get a better) understanding of the soils and how they wet up.

Picking soil type plays a major role and lots of our soils are sodic and that doesn't take into account sometimes the infiltration rate. I play around with the soil types and try and pick the right ones that show me what I think I'm seeing.

I discuss with growers what we're seeing in certain paddocks to find better (ways of) moisture holding for longer. (Talking about different levels of stubble cover). Having that discussion and trying to use that information to better plan cropping practices.

I use (the SoilWaterApp's) mm figure – it is better because the push probe is only a rough guess, I can't tell how full it is, most soils are different, different amount of pushing; some are soft and you can push even when they are dry, some clays are rock hard.
The mm figure enhances the conversation. Helps you work out how much rainfall you'll need to join the profile up. Help you explain why one paddock went 5 t and next one went 3 t, there might have been some moisture left in the paddock.

Grower, NSW
This grower manages 14 different properties covering 7 different areas, 3-4 different soil types, and over 12 000 ha of wheat, chickpeas, cotton, sorghum, sunflower.
'I was at a GRDC day and they showed it to us and did a talk and introduced it. I downloaded it straight away, for all the different properties and different locations of where it reads from, just to measure the bucket of the soil profile. How each paddock is filling up.
(The properties) are obviously spread out, it is just easier to just jump on there and see how they're doing. It's a bit of a guide obviously…and it's on your phone. I use the push probe whenever I am in the paddock…I am not 100% accurate with the rainfall we are getting. I just use the nearest weather station rainfall, it'd be too much work if I went and added 20 different rain gauge data. It's a bit of an easy guide to look at. That's about it really. It is terrible currently, it says my bucket is 8%'.
The app has definitely helped with discussions with my father – about the timing of operations, when should we sow, what should we sow. It has helped with discussions about the % (soil water) also with my father, being able to quantify, it has helped with discussions and planning'.

Consultant, QLD
This participant is a consultant working with around 15 growers in Queensland.
'I've used it a bit leading up to this season, I've had a couple of farms change hands. I've looked at the app and seen 40% moisture profile and x amount water in the dam, so we know we've not going to have enough moisture to get 10 bales unless we stretch our plant stand out a bit.
The app has helped new growers get a feel for the percentage of water. It is a really quick way to sit down and get a feel for a field on a farm, based on the closest soil type and the closest weather.
I've used the app under a pivot and a lateral irrigator to get the grower to self-schedule irrigation. It's been pretty handy, especially as we have some challenging soil types, where the probe is saying we need to irrigate and the grower is saying not, and the app is saying we do.
Where we've had two pieces of information telling us we do need water, we've gone with that. People who have no scheduling tools, using overhead irrigation – it can be a general guide and is pretty handy for that. We've got to trust the technology, that it is a little better than gut feel.
The app has meant definite improvements in knowledge and skill and knowing that we need to trust our information a bit better. Many growers don't have moisture meters in their paddocks, they should be using the app to give them

a bit more information rather than "we irrigated this time last year". It would be the first step in getting better with scheduling'.

Researcher, QLD

I am a Farming Systems researcher. I use the app largely for making decisions about planting experiments and management of my farming systems project and decision making. We have 8-10 paddocks. (Soil water is crucial to our experiment as we are investigating WUE). We want rules about amount of soil water needed before we plant crops. Different crops have different soil water requirements. I use the SoilWaterApp as one of my prediction tools to decide when we are planting, what crops we might plant. Monitoring where we think the soil water status is right now, in crop.

Also we use the app for fertiliser decisions…We use measured and app soil water estimates as guidelines for yield potential on which we base our nutrient budget. We are using gravimetric soil moisture sampling and SoilWaterApp. Then we also use EM38 to some degree as another triangulation on that data set. We probably do use SoilWaterApp before we use EM38. I do prediction based on a rule of thumb for how much water we might have accumulated, then use SoilWaterApp, then if we have EM38 data to correspond, I will use all three together. If all concur, we know where we are. We are trying to be as precise as possible.

Before SoilWaterApp we would have used APSIM. We know SoilWaterApp isn't as precise as APSIM but it's easier to use.

The biggest challenge I've had is the need to continually update the rainfall record accurately if you want it accurate. I would love to be able to download my rainfall data as csv or excel file. I was given a Bluetooth rain gauge. We've been meaning to deploy it a few times and haven't. That should enable us to do that (?) But we are just duplicating. We've already got a rain gauge at that site.

Adviser, VIC

Works with farmers to identify options and costs and potential returns. He uses the app to evaluate risks associated with decisions - regarding foliar fertiliser, nitrogen fertiliser, and e.g. whether it's worth spraying chickpeas. He doesn't use the app for planting decisions – dry sown, use a spade to decide how deep to sow. The app confirms this. He inputs probe data in the app.

He uses the app to illustrate to farmers what the moisture levels are – to plan to stress Lucerne to bring on seed set. He uses the app to help schedule irrigation in Lucerne and seed crops. Total area 4-5000 ha Lucerne.

App helps explain 'why' – the graphic is useful because farmers like to see data and make their own decisions. He sends the output to farmers to justify some of his advice.

Suggests a key to choosing soil types could be helpful, and that crop choices are bit restrictive at times here – he needs oats for hay, lentils, field peas, lupins, potatoes for seed and carrot for seed.

Extension Officer, WA

I went out to the paddock with another researcher. He put it up for us and someone from the grower group as well. They were really keen to have some new technology on the growers' property and to have something that we could

share with other growers, but we struggled to share the site between us on the day. I had originally set the site up but nobody else could use the BlueTooth Raingauge. Because it's the grower's property and he needed to access the data more than me, we set it up on his phone. And so he was able to download data from the BlueTooth Raingauge and then we tried to share the site….I still haven't been able to login to the app when I've tried to reset the password a couple of times. I can't even use the app anymore.
I tried it again today – I've tried doing it , then when I get to the page that's what I got…Every now and then if you watch it long enough it will come up with a bit that you can type onto and then it disappears again.

Fruit grower, QLD
Tried to use the app to better understand how rainfall and irrigation move in the soil and to make decisions about irrigating. They heard about the app on social media. The producer was not sure what inputs were required into the app and was unsure about the accuracy of the app soil moisture estimates. The grower had difficulties with many of the functions and indicates they don't understand a number of the graphs. They had not used the help section.

Grain grower, WA
'In May I said (to a climatologist colleague) I'm half way through seeding – and he said what are you doing that for – and I said I have a friend who has the SoilWaterApp and I've got a fair bit of water in the soil from 3 rainfall events in February.
I would have been much more coy to plant without the SoilWaterApp data. The outcome that my friend got for me was interesting – it was encouraging for me to plant some crops with very little moisture – we had a most crazy year in 2017.
Another friend said you only need 6 mm of rain and you'll get it up…I trusted the SoilWaterApp's estimate. I knew there'd be some fuzziness because of slope, intensity, no till, livestock and texture of soil'.
Despite no significant rain until August, this grower managed to harvest an entire crop, some germinated on the initial planting and most was late germinated.
'I would like more tools to complement (the app). My head goes close to working that out as well. What I actually need is data – to show me where it has and has not rained and where the water has run to'.

Researcher, QLD
I use it for one trial site, I enter my own rainfall. I created my own chart there which was quite simple.
It saves me doing gravimetric measurements and soil probe. I have done soil probes and a few random cores to see what the app suggests is there in terms of soil water and checked the push probe. I am reasonably comfortable to use the app as the site is a fair distance.
I use the app to monitor soil water and have done some scenario analysis e.g. What should I plant next. It is interesting to see what the app says. I model some soil water outcomes if I was to double crop. I check out what the model says, and what does my gut feel say.

Turnaround time is harvest one day, plant the next. I wasn't able to do gravimetric measurements. I'm trying to get the app to cater for that.

Agronomist, NSW
It's interesting when you look at some of the soil types, you can see the distribution of the water in the profile, which helps you understand why you can't push a probe in sometimes but you've actually stored water in the profile down below. It's a good little demo tool with the growers sometimes.

Some growers have the app. This time of year it's really handy I will do a screen shot of a crop on their farm showing how much moisture they've got left. So they understand. This year the crops have just about run out of water. So they know it's come in quickly.
I question the figures, there's a lot of variability, the figures you get with soil water are never necessarily the same as what we're seeing in the paddock.

The hardest figure to put in there is the starting soil water, what the crop has left behind. It has such a big influence on the numbers…you can't guess with a push probe because at the stage of crop maturity you can't push a moisture probe in.

So that's the biggest variable in it all. Maybe it needs to combine two seasons even, so instead of putting in one seasonal snapshot, say this year we're looking at chickpeas, the wheat last year, guessing say 50% moisture left in the profile. If you could somehow map last year's wheat crop, what it used, you'd have the end point and then start with that end point with your chickpea crop.

Grain grower, VIC
I think I got it late 2015 or early 2016 and started using it because I wanted to know how much moisture my crops were pulling out and how much moisture was there at certain times so I could make decisions for more fertiliser and what not – just another tool.
We've got a soil moisture probe in a neighbours paddock – it's handy, so local and it's in a soil type similar to what we have in most of our paddocks. Last year when I was keeping up to date with the SoilWaterApp it was very similar to what the actual probe was doing.
So I found that interesting – even though I'm not sure whether I've got the right soil type entered in.

Adviser, WA
This adviser deals with 36 growers each of whom farm in the order of 7-10 000 ha. He has set the app up for different areas – to represent a few key growers in different locations and soil types.
(Working with a client) *'who said I don't know if I will go ahead with seeding – I brought it up on the app and showed him this is where you are sitting, it was still April, starting to go dry. I was able to show he was well above the average and that he didn't need a lot of winter rain on top - that all he had to do was get the crop out of the ground. When he could see where he was in relation to average seasons, it gave him confidence'.* (The season turned out well).

He also uses SoilWaterApp in accordance with another app – N broadacre – he uses SoilWaterApp to see what decile they are at and then estimates yield (relative to average yield) and then plug data into N Broadacre (which has soil test results in it) and this indicates what amount N is recommended.

Grain grower, WA

SoilWaterApp is a next best guess approach (beyond probes). We can monitor effects of thunderstorms in the late part of summer on our base soil moisture and leading into our sowing decisions and how that can influence our crop choices. Also what our nutrition is like. What our target yields might be, planning nutrition around that.

During the growing season, I probably set my sights on how well we're going to finish and try to tailor some inputs around that. I try to model, looking forward what likelihood what yield levels we might be expecting and try to match nitrogen decisions during the growing season to that.

We knew we had a lot of moisture after last summer, we couldn't get on the paddocks to sow, it was interesting to use the app with that situation and see how it drew down the moisture during the season. From what I've seen it's pretty well bang on with what I've seen through the season and what the app has been talking about.

Extension Officer, WA

We were encouraged to use it in our project because we were new recruits, only been around for a year or so and haven't done that stuff before. We got a blue tooth raingauge. Chose a location. We went and installed it. We also have paddocks we've been monitoring for a few years.

We were using it to work with the growers, what they were planning. They might look at a particular date to see what soil moisture it was predicting. We individually talk to growers. We're learning, so its not advice. We have certain paddocks we monitor. This is what its predicted and you are going to seed on this date and if you get average rainfall, this is when you'll run out (of moisture).

I don't think my growers have picked it up. We've shown our growers how to use it (not step by step). They were not massively interested. I set up sites and tried to share them so it was all done and they could just look at them. I sent an email. But there was no feedback.

We were anticipating we could email the Farmer a link. We couldn't so we reset it up on his phone and he tried to share back to us and it didn't work.

Grain grower, WA

The previous year this grower had used the app – *'I've got a few rain gauges around the property and they're quite different. Putting the rainfall in from the gauges was interesting for me. It got to the point where I had the app going and each time I go and check the rain gauges I'd open the app and put the rainfall in'.*

'I updated the app and it asked me to register and now it keeps failing every time I try to get in. I'm sure I registered the first time. I can't even get in to the app'.

'I've not really played enough with it to get much value out of it. I am interested – because we do get variable rainfall across the property.'

This grower suggests having a case study – a couple of articles – of people who are using it and what they're doing with it '*might inspire us to want to use it more or show us benefits we haven't discovered or whatever'.*

11.3 User issues - comments

Password, accounts and phone update problems

Passwords

Changing the password was the only (problem) to date.

Unable to log-in to website to download data (tried to reset password several times, but never received email).

Yes, the web based app doesn't work for me. When I tried resetting password, no email comes to me to re set it.

My password wouldn't work and then I did the reset password (when DMF was here, he was in this room – he said all the emails go to him but it didn't even send an email to him) I never got that sorted so I never had that experience with downloading the data – that was what I was trying to do, but I could never do this.

I have not looked at it for quite a while (since unsuccessfully trying to reset password). Extension Officer WA

Got to the point where I had the app going and each time I go and check the rain gauges I'd open the app and put the rainfall in. Then I updated the app and it asked me to register and now it keeps failing every time I try to get it. I'm sure I registered the first time. I can't even get in to the app. Grain grower, WA

Also I tried to log in to computer to download data from that blue tooth gauge but I couldn't get into my login or reset so I've not had experience with doing that either…

Rollover accounts

Couldn't flick between old account (with old employer) and new account (with new employer) to get the data. Old data from previous employer not available. Can't log in under another name.

Phone and app updates

Be aware if our devices are going to want to update, the app needs to be compatible with updates.

I updated the app and it asked me to register and now it keeps failing every time I try to get in. I'm sure I registered the first time. I can't even get in to the app.

Setting up SoilWaterApp

Time needed to understand the app and select inputs

I need to spend further time on the app - particularly on inputting our specific rainfall records but also on specifying the soil type to align with the criteria on the app.

Yes unclear on what input was required.

Inputting data can be problematic and needed trial and error to get the configuration right.
A useful tool but requires some effort in set up to obtain useful relevant data

Box 11.1 Additional user comments on choosing soil types (see also Sections 3.2.2 and 5.1.4)

Getting my soil type correct was the most challenging part of using the app
Other issue is the soil type selection, most growers don't have the confidence to pick one but they can play with alternatives to get a feel for the influence of different soils.
Identifying the right soil type, I was using one soil type on another place and it was telling me I had a bucket of water which I didn't.
Picking soil type plays a major role (in successful use of the app) and lots of our soils are sodic and that doesn't take into account sometimes the infiltration rate. I play around with the soil types and try and pick the right one that shows me what I think I'm seeing. Agronomist, NSW
My agronomist, they spent I think 2 days in Brisbane 2 weeks ago and they really hadn't come to a consensus on how to do it – to work out how to calibrate the soil. I'm not a scientist, so probably poorly describing it. Grain grower, QLD
Unrealistic rooting depth used.
I feel there is a gap in knowledge of soil properties and their spatial variability where we have challenging soil/landscape relationships. Researcher, NSW
Not sure whether I have all the appropriate soil types with PAWC's for my region. Probably not too bad though.
As with Yield Prophet it will only be as good as the soil type description. There may be an option to have more soil types included in the database.
I did look at the soil types. A lot more work has been done on Eastern Australian soils types than western soil types. Hard to get one that you think might match.

I would expect that soil type to be in a system like that – when we use the Soilwater Express we develop a profile – to establish PAW – there's been a lot of effort put in to characterising soils – you would think it's a sandy loam. Extension Officer, WA
WA soil types they've got in here, are only about 10 or 12 (I have clay at depth, red soil). Grain grower, WA
When wanting to restrict the root growth, it would be easier if it could be restricted in terms of depth. Restricting them by % doesn't really work, there were results that didn't make sense. Or have the option of reducing the soil depth.
I question the figures, there's a lot of variability, the figures you get with SoilWaterApp are never necessarily the same as what we're seeing in the paddock. Agronomist, NSW

Initial soil water estimate

Estimating initial soil water is probably the hardest. Without a probe it's purely a guess.

Still not sure about the Start time and initial soil moisture and how this influences results.

Get the data from the local probe site because that's all public data – there's no reason why it couldn't go into the app as well. I can guess it but it'd be handy to have it right in the app, side by side. You've got all your local post office rainfall why wouldn't this data be able to go in the app. Grain grower, VIC

If setting up individual crops it's easy to say where do I start it at?...At the moment I don't have that reference check.

I'll set my initial scenario based on soil samples I've done. I'll have a bit of a feel, might not measure it, I'll see where it's wet to. That's the initial starting conditions, especially if it's been dry. If it's wet you know it's full. Agronomist, VIC

Fallow and crop inputs - timing and sequential crops/seasons

Good for annual crops. Not sure that I get fallow correct. Tried it on pasture, not so successful.

Users wanted to continue using their soil water estimate site ongoing, to follow on with and monitor future crops.

Have wanted to be able to "rollover" sites/paddocks from year to year rather than having to set the paddock up again in the new year.

I can apply a start date, but can only add one crop in, I can't add sequential crops….That is the problem. Agronomists, NSW

I set up scenarios, at the start of 2016, we'd come off a chemical fallow scenario, looking through that season we could grow a wheat crop through to the end of the year and then fallow through summer and then coming into a barley crop this year. At the start of the year, because I'd planted two crops back to back, I could only set it up with a wheat crop sowing date; and then I couldn't roll over the scenario into the next year. I think I had to copy – basically set up a new scenario with the same conditions. Agronomist, VIC

(I'd set up a 4 month fallow), then the other day, this fallow was still occurring (after the 4 months ended) and I was trying to do the calculation. It was missing a rainfall event in April (a big event). I had to reset it. The 4 month fallow was locked in, prior to whenever you were doing the data run. I put in 30% moisture in end March – but it was still saying 30% in end May. (Had to pick up the April rain somehow). Extension Officer, VIC

Inputs – crop/pasture species

Gave a better idea of possible moisture profiles but limited by the options available, particularly relating to pasture species and composition.

I am attempting to set up a crop which is not specified in the app (grazed perennial pasture) on very light soils (often less than 10mm PAW).

Some extra crop types would be handy. Chickpeas are the only grain legume able to be selected.

Addition of more crops, - lentils, durum.

Crop choices are a bit restrictive at times here – we need oats for hay, lentils, field peas, lupins, potatoes for seed and carrot for seed. Agronomist, VIC

Winter crops and chickpeas are pretty good – just peas and lentils may not align well with the crop models.

11.3.1 Concerns regarding accuracy

It gives a rough guide only. The inputs have to be correct, one false assumption and the output can be misleading. it did give advance notice of fields which would be ready for planting in the following season and a rough guide on a 1/2 or full profile.
I question the figures, there's a lot of variability, the figures you get with soil water are never necessarily the same as what we're seeing in the paddock. Agronomist, NSW

Projected soil water line graph didn't seem to have much accuracy to real conditions.

Weather station rainfall not relevant

Sometimes local weather station is a little bit too far (away). It is a very good indication of what it is trying to do in a general sense. Agronomist, QLD

Patchy rain can make it difficult using weather station data. Agronomist, VIC

Variations and factors on property

The farm is not homogenous, got some hilly and heavy and light soils and I don't think the speed of the rainfall was known exactly – intensity of rainfall, speed, texture, soil cover and the length of time the soil has been in no tillage – all affect the infiltration rate. Grain grower, WA

Extent of adjustments

Many participants, especially agronomists indicated the adjustments they had made to soil type and cover in order for the app to predict soil water levels more in line with expectations.

It's more about calibrating me, my expectations. The other thing I discovered doing the gravimetrics was that doing the cover right (on SoilWaterApp) makes a big difference.

I fiddled around enough that I can manipulate the cover to get it to what I think it should be. I've had a few times when it was close to my trigger and I've pushed the cover up and down and looked at the range of possibilities and just from there decided whether I was confident with that one and whether it should be more or less and go back and reassess the cover if necessary to see what differences that would have made.

These are not too useful as yet because I have not been able to modify the parameters to closely follow crop and soil of interest. I can see that they will be very useful as indicated for the included crops and soils.

Turn around time is harvest one day, plant the next. I wasn't able to do gravimetric measurements. I was trying to get the app to cater for that, I had to extend the maturity of the previous mungbean crop or start with zero water and muck around a little bit. Researcher, QLD

No it doesn't match very often with what's in the field which is interesting….I use a weather station rainfall and when it tries to predict what the profile would be its not always right. We're doing some work on that. That particular field we've had trouble with. .. my agronomists are spending a lot of time on it to get its right. – the soils. Graingrower, NSW

Predictions

Our rainfall is so variable I put little faith in any rainfall predictions more than a few days out.

Limitations in terms of crop water use, evaporation estimates.

Cracks and dry layers

Some cracking clays fill from the bottom from summer storms then switch to top fill with dry bands remaining.

Had one situation when it said we were close and I went out and had a look and it had actually all run down the cracks the top was still dry and the water was all in the profile. I think it is something we've got to accept and know to check.

Fallow and crop water use discrepancies

Evaporation rates seem high. After summer rainfall, the soil had much more moisture left than was modelled. In-crop water use seems less than modelled.

It is worrying that you cannot input the general condition of the crop to make the estimates of transpiration more accurate.

Being able to have an imperfect fallow from summer rainfall would be great. i.e. allow for self-sown canola/cereals to grow for a period post rainfall events.

I do think it needs some more testing in terms of its predictions of soil water extraction.

We are running research projects on canola vs wheat and chickpeas. They are running gravimetric readings vs neutron probes on 5 sites. They are showing that SoilWaterApp is giving good indication of available water to crops….BUT it is not working this year…..This season (2017) we are finding it is too dry to use the water…(the crop's) extraction ability is limited (in this dry). We know that water in the top 30-40cm is a hell of a lot easier for the crop to use. Agronomist, NSW

Choosing sites and inputting rainfall

Connecting to Local Weather Station Networks

DAFWA local rainfall gauges were not able to be added due to some error.

My main problem has been getting DAFWA rainfall data into SWApp reliably, (it) doesn't always connect, so (I) have to have two sites for the same location, one DAFWA and one PPD.

Had problems linking to local weather stations.

Rainfall data not locally represented

Occasionally local rainfall is different to weather station, cannot change without inputting whole rainfall data.

The spread of BOM gauges is thin in my part of the world and failed to capture a lot of storm activity.

Difficulty inputting and storing rainfall data

Initially had some issues with rainfall chart not staying as inputted and some values disappearing.

I find the rainfall input a bit clunky - it would be good to be able to upload an excel spreadsheet file with the rainfall data in it.

Yes. Downloading weather information wasn't ever successful.

I find all these apps painful as none share a common data structure & you have to re enter/set up or re enter rainfall figures.

A few minor glitches where the software was subtracting the rainfall rather than adding but generally no major problems.

When entering rainfall, it actually takes off rather than adding it to the rainfall.

There were issues with functionality. One site worked fine and one when I clicked on it to enter, it would say updating data and never got out of that loop and would crash. So I deleted the site, started it again and it did it all again. I couldn't use it with that grower because I couldn't get it to work.

Unable to access one site. It says loading data and then shuts down the app each time I try to use it.
Disappointed that I cannot see wireless raingauge data that other people download, have to travel past and download myself.

Growers – no time to set up or enter rainfall

I'd like to get a couple of growers who keep rainfall records to enter it in…the way I've done it, the information is driven by me and presented to the growers. One or two might be interested in putting in their own data. Everyone has plenty to do, do they really need another job. Don't think you'll get growers to enter own.

10% of my growers have the app. Whether they use the app…

I don't think my growers have picked it up. We've showed our growers how to use it (not step by step). They were not massively interested. I set up sites and tried to share them so it was all done and they could just look at them. We sent an email. But there was no feedback.

Difficulties connecting to Bluetooth gauge

Blue tooth rainfall slow to respond when first set up.

Still trying to get it to blue tooth and connect into. I couldn't even get flashing lights. I can't even connect it in. Since David came I can't get it to talk to it. (David got it to talk on the phone).

Other input, data and screen issues

The date wheel sticks when it stops rolling and so needs to be closed and reopened to get to the date desired.

Table on water balance sometimes does not add up and does not correlate with runoff on non-wetting soils, which are most of ours.

Fonts

I find the font although it might look stylish, impractical. It is too fine and too small. I don't want something that is hard to read.

On an iphone all the fonts are too small in the information sections. Now go outside and the screen might as well be blank. I'm not a fan of the black screen with white writing and not having defined a button to press more clearly. For me, what I want is big writing that is crystal clear and sharp, contrasts well and easy to read.

Sharing and reviewing SoilWaterApp data

Reviewing outputs

Few times I've gone into a graph and seen that point there was pretty close to my trigger – I wonder why I didn't plant – and you can't actually go back to there and see what it was. If the trigger was 50 and it was 40 you can't pick the difference on the scale.

Reporting and sharing sites

The only issue is with sharing the data between different users.

Where we installed the rain gauge, we were anticipating we could email the farmer a link. We couldn't so we reset it up on his phone and he tried to share back to us and it didn't work.

I've lost my ability to share reports. My emails (are now) not set up for my account.

For some reason the days have got mixed – it's a day ahead of itself. I downloaded the weather data (it says we're going to have 68 mm tomorrow!)….I couldn't put the report together (and use it) – had to wait until the next day to have the calculations from the app.

More information and help

A self-paced tutorial would be a helpful addition to both the SoilWaterApp and Climate to allow a casual user to use the wider capabilities of both apps more fully.

Graphs and terms could have better explanations on interpretation and using them for management decisions.

The output graphs took a bit of understanding for a while.

Understanding the green graph on the cover % graph, what is it showing?

Perhaps more training needed for more depth in information gathered.

Lucky to have David at the seminar, who fired it up and ran through a few things with me. I have not explored or moved on much from that. If other training or updates are at a seminar that I'm at, I may move on further. It took a bit of time to input local rainfall, and was limited by the crop choice available.

Wasn't sure about the graphs till I saw the '?' button which explained what I was looking at.

The graphs need better explanations of what they represent and how they should be interpreted.

Have looked through most of the help material. Initially I thought it was a bit too generic, but now I think the level of detail is well-tailored. It took me a while to find how to import local rainfall records, but I think that may have been just my lack of familiarity with the app.

Users are unsure or unaware of features

Didn't know you could add own rainfall or use your own paddocks – am I on an old version?

Struggling with putting in my rainfall – a great feature if I can work it out though.

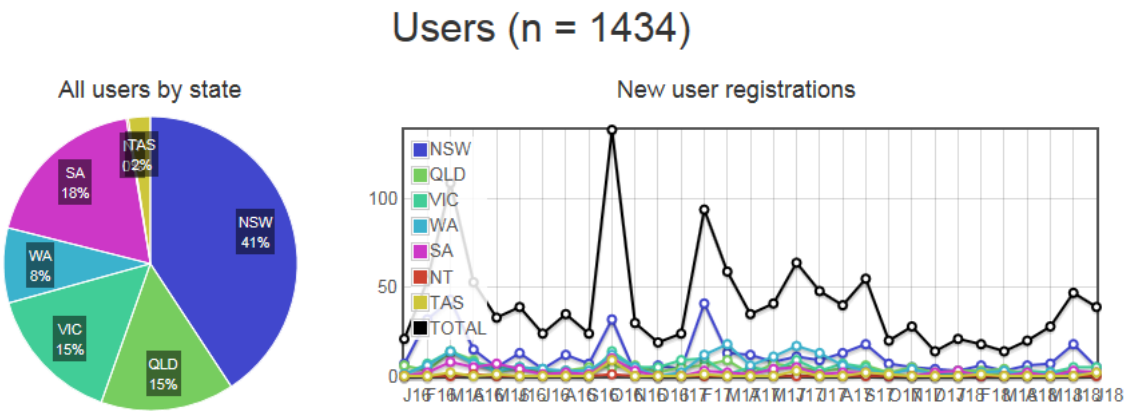
Wasn't aware the other functions existed, sound useful, I'll need to explore.

Where is help, library. Could not access rainfall data.

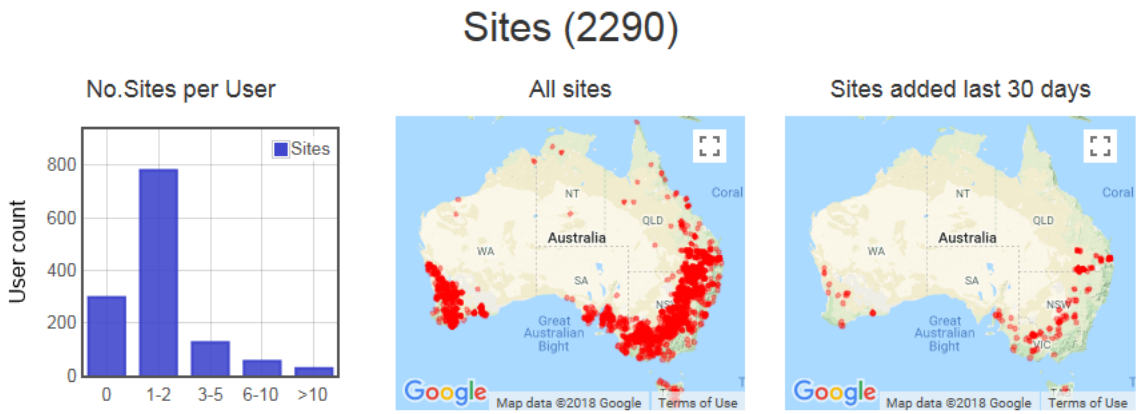
I haven't found the water balance table (as shown in the survey images). I use IrriSAT to do a similar thing.

11.4 Analytics available to administrators of SoilWaterApp

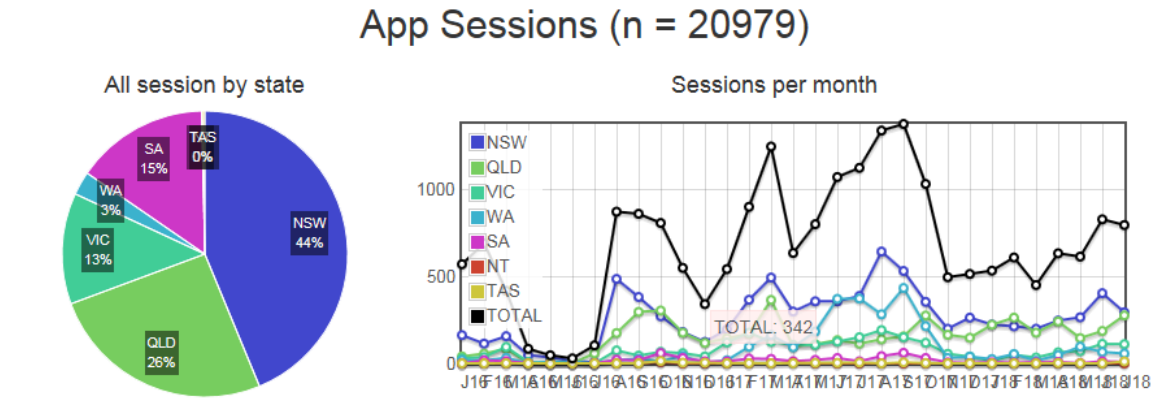
11.4.1 User data



11.4.2 Site data



11.4.3 Sessions



11.4.4 Registered users (example data)

All registered users

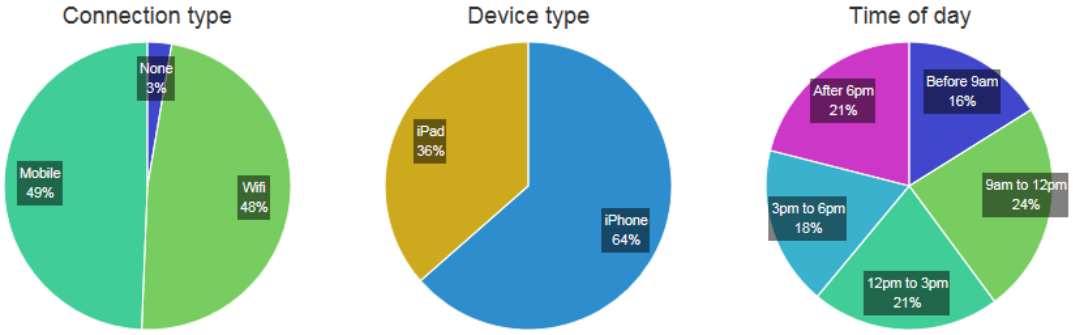
Register a new user

Show 10 entries

Search: Starasts

Name	Organisation	Location	Sites Count	Register Date (AEST)	Last Access Date (AEST)
Starasts, Ann (ann.starasts@usq.edu.au)	USQ	Toowoomba	3	-	09/07/2018 04:10 PM

11.4.5 Connection and device



11.5 Notes taken from first time users of SoilWaterApp

(A compilation of notes taken from first time users incorporating errors and mistakes found in the app and suggestions)

End User Agreement – must have clicked at the start – cannot see this on the app at home page anymore.

I don't want my data on the server – can I still use the app? (Is that disable analytics collection?)

I pressed to enter my email into the Login section and cannot see – I had to enter it blind as it was a black screen. There was nowhere to enter the password.

Pull to resync data (Slide down)??

Configure Starting SW(%) (not sure where I saw this but needed a close bracket)

Advanced Enable Veg profile modification ? – Do you need some information about this?

I tried to send my feedback – my email to you is from my Apple store login email (private) which I did not use to create my Soil Water app login!! (but I had to use to download the app from App store). This is not acceptable.

Medium and Thin lines on graphs are very similar. Had complaints in survey.

Where is the 'info' button? Many people do not see the 'i'

Does amount of soil water (mm) equate with potential crop yield or potential N requirement – where do we get this information from? Hopefully there is some information or guidance on this in the video.

Don't understand the volumetric graph

Tried forget password page, no emails came to either address (my App store or my login address)

What does 'tap table toggle outputs' mean??

In Settings for fallow/crop/cover – the graphic WB has no labels or numbers – Is it meant to tell us anything? What are dates? Toggle and get a blank graph.

What are the 3 little dots in the centre of the page? Ok – after months of looking at this app found there are three screens that correlate with the 3 dots. What are the 3 screens? Same paddock, dates, soil, fallow/crop – why the different PAW, runoff and fallow efficiency? Where is the app getting these different figures from?

Enter new push probe data on ipad. Keyboard pops up and cannot see entry screen/box.

What does Swipe to redo or Swipe to undo mean? What are we doing when we swipe? This is confusing for new users. I think a lot of users don't know about swiping or they too would be confused at finding 3 simulations on the screen. However the option to compare the different scenarios of starting soil water, cover, crop etc is great.

Went to the library link on the website and the Youtube video on setting up SoilWater app 'is unavailable'.

Why when you type in push probe at 160 why does it show 30mm?

What advice should we get when the probe dot is way off the estimated graph?

Information – i

Water balance

– 'irrigatios'

Statement at bottom 'As such the average line and plume provide a good estimate *(maybe just 'an estimate')* of likely *(maybe – 'average')* conditions and variability'

Soil Water profile

Graph is poor quality with no labels to help explain.

Need more words and point to the lines you mean. What are the dark lines around the blue? Maybe explain an air-dry limit? Maybe explain drainable porosity?

Soil Water and cover

'stabdard'

Not sure the average farmer even knows the meaning of 'plume'. Difficult to find the meaning when searched.

The wording and labels around the '60,90%' of years in relation to the plume is confusing. Is it that you choose in Settings if you want the app to show shadings for 60% OR 90% of years or both??? Or is it that the lower line is 60% of years and the upper line is the 90%? May be confusing for some not familiar with plumes and it is VERY small print on the ipad. Perhaps explanation of plumes is provided in the Youtube video.

Soil water views

'chages'

Initial soil water

'In many cases we will not know the exact soil type and PAWC, so an approximate estimate of PAW is sufficient. It does not need to be exact. (suggested text change).

Simulate until

'basedr'

Cover-soil water time series

This link is repeated

Planting date

'default'

Maturity date

'default'

Configure Local Rainfall – so I went in and found all this USQ Raingauge set up ????? Is this an example?

The information section for 'Rainfall chart' and 'Check for data' say the same thing

Edit rainfall

Important note: spelling errors – 'release' 'if – should be of', 'entry'.

Calibration Factor

'manufactures'

Last updated

Is blank.

Reset sensor

'eventually'

Irrigation type

These 'rules' provide (not provides)

I am reading about BlueTooth sensor – is this a fixed probe? I haven't heard of a BlueTooth sensor. Do people all over Australia use the USQ NCEA Bluetooth loggers????

I set up my own rainfall data file (on the computer) and tried to upload it. There was no information about what file format to put it in in order to upload it. I tried .xls and .doc – the website would not accept those formats. So I set it up as .txt and uploaded it – the screen went to a summary of my sites but under the Rainfall column there were no entries. When I clicked on 'Upload my own rainfall data' button on the new screen it went back to the original screen (from where I had seemingly uploaded it). I entered on the computer but haven't found any evidence of my rainfall on the app.