Farming Forecaster: integrating multiple sources of information for livestock producers

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Abstract
The rapid progress in digital agriculture is providing many new opportunities to measure, analyse and forecast key aspects of the farming system. Whilst these technologies generate vast amounts of data, a fundamental challenge lies in creating value for agribusiness via the integration, translation and communication of the data into insights for the target user. The Farming Forecaster (https://farmingforecaster.com.au/) web application targets key decision points for livestock producers by bringing together core elements of farm sensing and forecasting covering: weather, soil, pasture and feed budgeting issues. Built through a partnership between farming groups, state and federal government agencies, CSIRO and software developers, Farming Forecaster is providing the blueprint for a growing number of farming regions to capitalise on existing sensor networks, in conjunction with emerging simulation and analytic tools. We present an overview of the user engagement process, the data and analytics platform, its implementation as a web application and how the application is being used to uncover new insights for producers.

Keywords
Digital agriculture, pasture biomass, seasonal forecasting, feed budget, decision support

Introduction

The digitisation of agriculture has accelerated rapidly in the last decade, and critical to the proliferation of these digital technologies has involved combining sensors and analytics to inform operational and strategic decision-making. For livestock producers, there is an expanding network of soil water and weather sensors, remotely sensed imagery and predictive analytics to inform how they might manage their enterprise. However, despite greater access to data and information, the challenge of making sense of and realising value from these different types of technologies can lead to limited uptake and impact on the ground.

Farming Forecaster is a web application and data analytics portal (https://farmingforecaster.com.au/) for livestock producers based in southern NSW. It provides an integrated view on soil moisture, weather/climate and pasture and livestock conditions based on historic, current and forecast data. It has been co-developed in partnership with local farming groups (Monaro Farming Systems, Tablelands Farming Systems), South East Local Land Services (LLS) consultants, CSIRO and an agriculture software company (Square V).

Here we provide an overview of how the Farming Forecaster project incorporates several key domains in climate and pasture modelling, digital integration and user experience to provide an important resource for the livestock industry. We discuss how it may serve as an important blueprint for other farming regions and provide useful and timely access to new digital technologies.

Methods

The Farming Forecaster web application draws on pre-existing technologies and infrastructure that were developed in the region with South East LLS, consultants and CSIRO. Here, we provide a brief description of some key concepts and themes that informed the development process with particular focus on considerations around translating the complex biophysical datasets into actionable information for livestock producers. Some of the different components that were included in the

Farming Forecaster and how they might address a particular management question are shown in Table 1.

Table 1. Details of the different components of the Farming Forecaster and their relevance to on-farm decisions.

Management question	Timescale	Component in application*	Data and analytics	Farming Forecaster
How much soil water is available for pasture growth?	Current/past seasons	Probe details	Data feed from soil probes managed by LLS	Visualised as relative moisture content at different depths
How much rain has my area received?	Current/past seasons	Probe details	Data feed from sensors managed by LLS	Daily and monthly rainfall summaries
Will I get average pasture growth this season?	Seasonal (1-4 months)	Pasture details	Simulated pasture forecast from Pasture API (Thomas et al, 2019)	Four-month probabilistic forecast of green available herbage
How likely are cold conditions for lambs?	1-7 days	Weather forecast details	Sheep chill index computed from BoM weather forecast	Next 7-day sheep chill index

*See Figure 1A for different components of the application

Soil moisture and weather station network

The genesis of the Farming Forecaster application arose from an existing soil moisture network in the South Eastern LLS region established as a joint project between the LLS, Tablelands Farming Systems (TFS) and Monaro farming Systems groups in early 2016. To date, probe sites in this network have been chosen to cover a range of enterprise and environmental conditions. The probes consist of automated soil moisture capacitance probes, monitoring soil water content half hourly, to one metre depth. The sites also measure rainfall and soil temperature.

To aid interpretation and comparison across sites, soil moisture data are converted to percentage soil moisture using historical maximum soil moisture values. This allows producers to quickly understand the direction and magnitude of change in soil moisture at any given time relative to historical patterns.

Weather and climate information

Current and future weather (7-day forecast) and climate (3-month rainfall forecast) conditions are provided on the application using Bureau of Meteorology forecasts (ADFD and ACCESS-S1 products) delivered via application programming interfaces (APIs). Additional analytics were performed on the forecast data to make it more useful including: a sheep chill index for the 7-day forecast (Moore et al. 1997), and a tercile-based rainfall forecast and confidence value for the seasonal climate forecast data feeds (Mitchell and Brown 2019).

Automating pasture forecasting

The probe sites also represent locations where pasture modelling had been used to inform the seasonal outlooks for producers in the respective farming groups. Previously, pasture forecasts had been produced for two key times of the year (early autumn and early spring) by manually setting up and running the pasture-livestock simulation model GrassGro™ (Moore et al. 1997). The Farming Forecaster ingests data from an improved pasture forecasting system developed by CSIRO (Thomas et

al. 2019) that embeds the GrassGro™ model in an automated workflow platform so that nowcasts (real-time conditions) and forecasts (1-4 months) can be run as regularly as needed.

Creating value through understanding user requirements

Integrating the different data and analytical components described above involved bringing together the expertise of advisers and extension specialists as well as user experience professionals. User experience research undertaken in the initial design of the application, was done to ensure that the application was fit for purpose and would align with how farmers make decisions and understand the information presented. The research involved kitchen table or farm office interviews of seven different farmers across the Tablelands and Monaro regions, with a variety of farm sizes, ages, levels of on-farm experience, and levels and methods of education. They were conducted using a contextual inquiry approach focused on: understanding the farmer's key decision points, the tools used to inform these decisions, and their experience with and understanding of the types of information that the project was seeking to present to them.

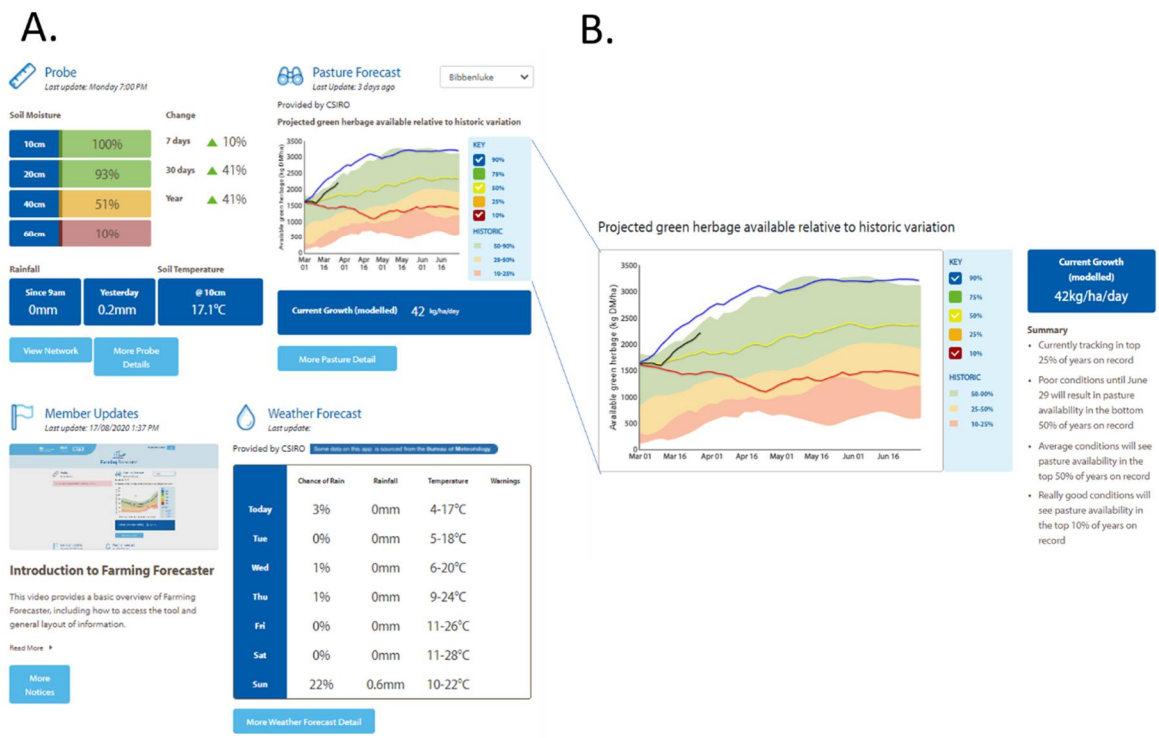
Results and Discussion

The design and implementation of the Farming Forecaster brought together key findings of the user experience research and existing experience of extension specialists and researchers (Figure 1 A). Launched in April 2020, the site has received positive feedback from producers and as of March 2021 has had over 30,000 visitors with the bulk of page visits going to the soil moisture probe and pasture forecast pages.

A key finding of the research was that producers in the regions sampled have a specific way of thinking about seasonal decisions in relation to the "average season". This means that producers have a specific template for an "average season", with expected levels of rainfall and pasture availability at specific times of year. This perspective meant that any forecast information needed to be presented in terms of a potential departure from this average condition. To present information that directly related to the user's mental decision-making model, we chose to show historical information in graphs as background shading of different colours – green for the top 50% of seasons ("above average"), yellow for the 25% just "below average" and red for the really poor bottom 25% of seasons (Figure 1 B). Overlaying the current status of pasture biomass against this backdrop of historical patterns allows farmers to quickly judge whether the current conditions are above or below average relative to the historical record and helps them quickly make decisions matching the scientific data to their existing way of thinking. This template for decision-making also informed the design of the soil moisture graphics that use a simple traffic light appearance and tracks changes in soil moisture from recent history as well as longer term changes in moisture (Figure 1 A).

Another challenge in designing the application was presenting complex graphs on pasture biomass and other variables that had previously been presented and interpreted by consultants at their seasonal outlook presentations (see https://www.monarofarmingsystems.com.au/wp-content/uploads/2019/09/MFS-Seasonal-Outlook-Sept-2019.pdf). The user experience research indicated that these weren't readily understandable by the potential end user of the site. Producers who had some experience in reading these graphs relied on rules of thumb gleaned from the seasonal outlooks to make sense of the graphs. This drove us to include a "summary" section next to the chart which aims to interpret the graph for the farmer in the same way that the professional agronomist would at in-person meetings (Figure 1 B). In this way, farmers who are new to the system can still take as much advantage of the available data as farmers who have been looking at these graphs for many years. The grazing consultants also continue to play an important role in offering tailored information for specific decisions during the critical autumn and spring periods.

Figure 1 A) Example of the Farming Forecaster "home" screen with information visible for the key components of the application. B) Example of a probabilistic forecast of pasture biomass (green available herbage) displayed in terms of the departure from "average" conditions. A text summary is also provided to aid interpretation.



The integration of the historic, real-time and forecast information on soil moisture, rainfall to date, and pasture growth rates provides relative measures of productivity for a representative enterprise at pre-defined locations. These sites act as 'sentinel' locations for producers to monitor and understand their own farm conditions. The project has invested considerable efforts in providing guidance for producers to translate the activity at different probe sites for what they can expect under their own farming system. It provides local benchmark for gauging factors such as feed on offer and provides confidence for making strategic decisions around stocking and supplementary feed purchases.

Conclusions

The Farming Forecaster has been designed using existing and emerging technologies in soil moisture monitoring and pasture forecast systems in conjunction with user experience considerations that incorporate producer's needs for accessible and timely information for decision making. Ultimately applications such as this build confidence for producers to plan and take action in response to a solid evidence base around their enterprise. The Farming Forecaster contains many re-usable components that provides the blueprint for other regions interested in harnessing digital technologies that can inform pasture and livestock management.

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