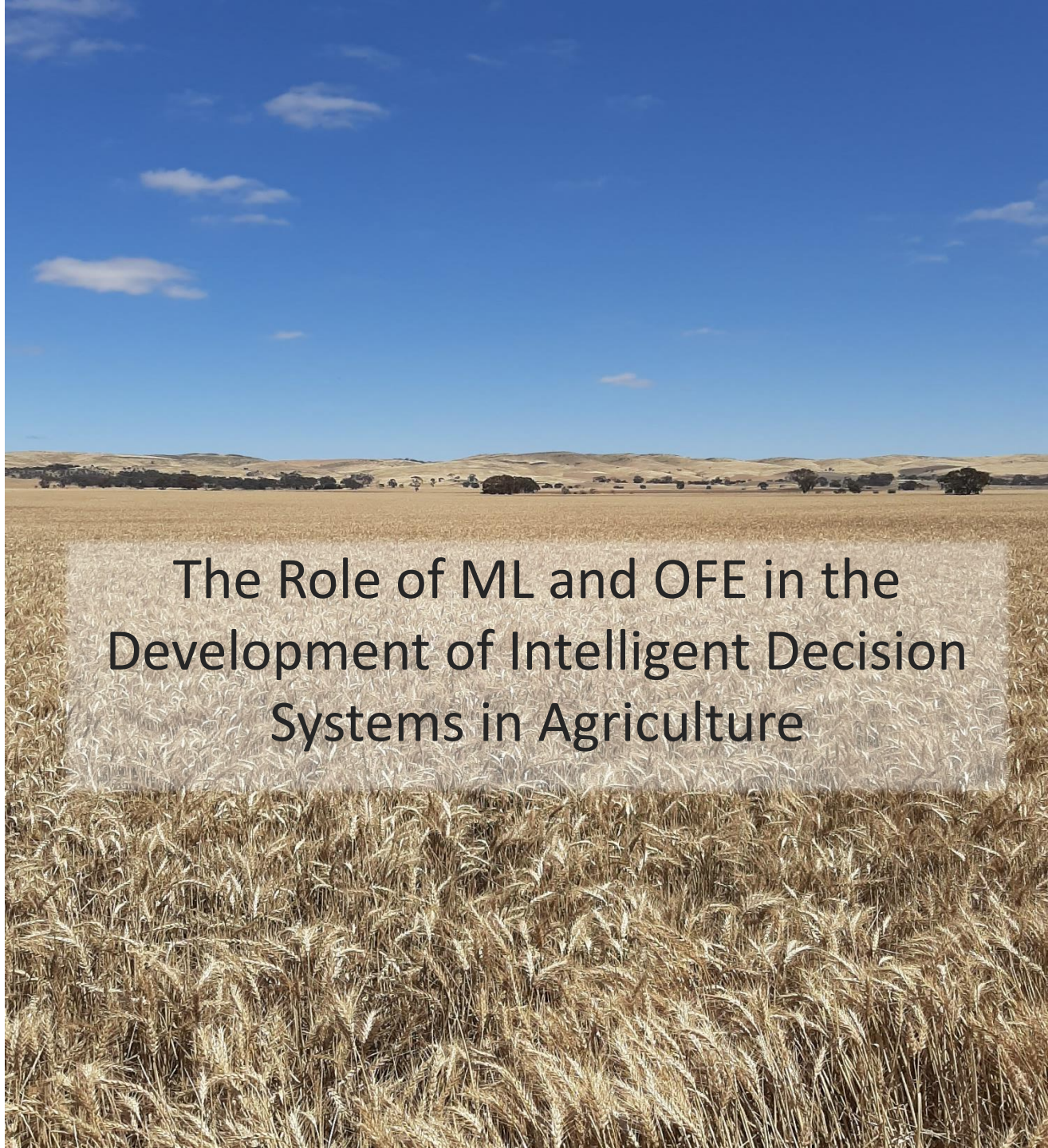
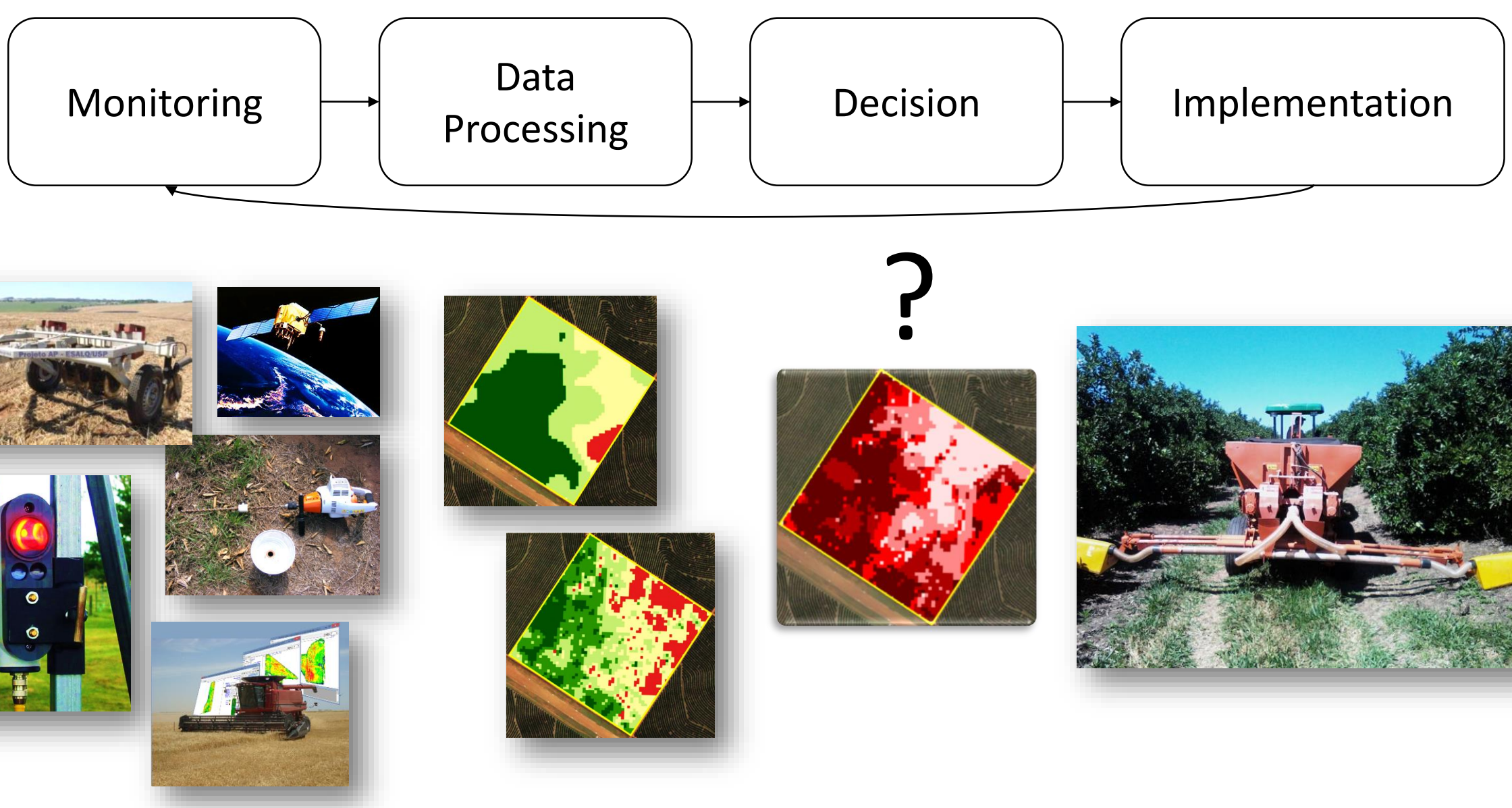
Data-Driven Decisions In Agriculture

Prof Dr André F Colaço

USP ESALQ




Monitoring
Data Processing
Decision
Implementation
?

Challenge – complex decision with simplistic agronomic rules

How much fertiliser to apply?

Demand = **Supply**

Yield Potential

Soil

Other sources

available in the system

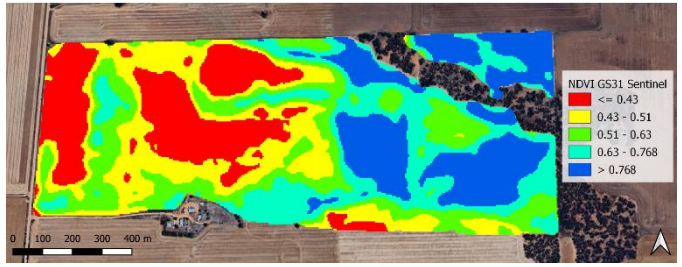
+

Fertiliser

efficiency

Fertiliser management in Precision Agriculture

Satellite imagery (NDVI)



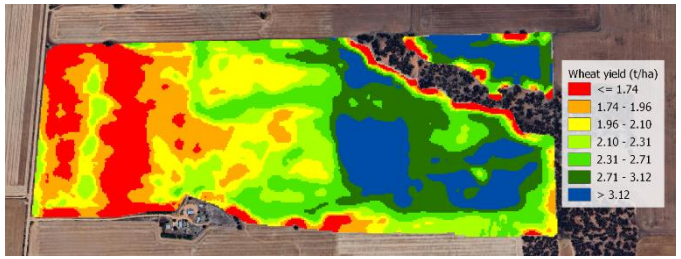
Demand = **Supply**

Yield Potential

Available in the systems

+

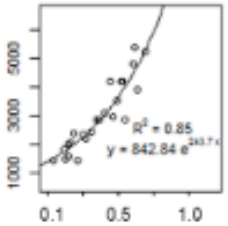
Fertiliser

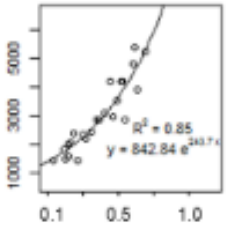


Yield monitoring

Soil moisture sensors / weather stations

Precision/Digital Agriculture and decision systems





Mechanistic Knowledge

Crop Biomass

Plant nutrient status

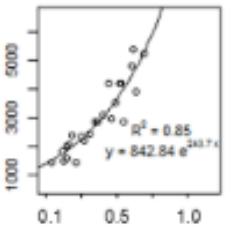
Plant available water

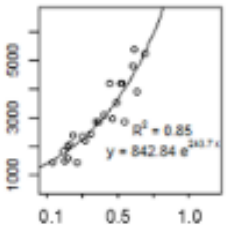
Yield potential

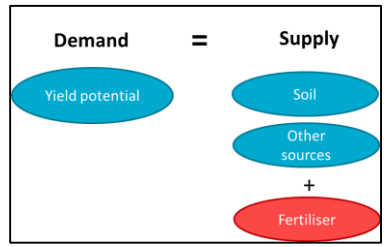
Soil fertility

etc…

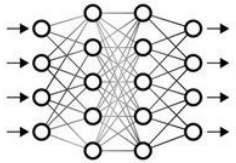
Decision support systems







Intelligent Agriculture (?)



Mechanistic Knowledge

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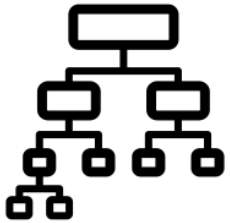
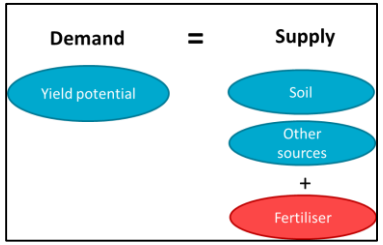
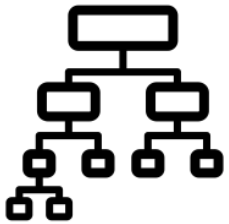
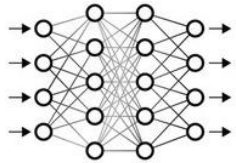


Decision support systems







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How will the next-generation of sensor-based decision systems look in the context of intelligent agriculture? A case-study

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Crop reflectance sensors
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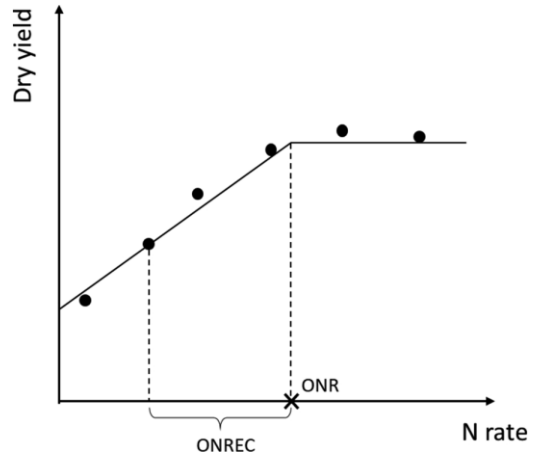
Nitrogen

ABSTRACT

The development of cost-effective, digitally based decision support systems is a key challenge in the optimization of farm management. Yet, the majority of sensor-based decision tools which support fertiliser management have relied on simplistic mechanistic frameworks normally informed by a single sensor. This study used a 20-year nitrogen (N) experiment on winter wheat (*Triticum aestivum* L.) to test a range of approaches for N decision support systems, including commercial sensor-based options and a novel, multivariate, data-driven approach. The latter was based on a non-mechanistic framework in which various digital variables were trained directly against optimum N application rates using machine learning. It was hypothesized that such a method would enhance our ability to handle system complexity, resulting in higher accuracy for the decision, as compared to current farm management or to available sensor-based options, both of which are normally underpinned by mechanistic methods. Results showed that the proposed approach was able to predict the optimal N rate with an RMSE of 16.5 kg N ha^{-1} ($R^2 = 0.79$). This method was also the only one that was statistically superior ($p < 0.05$) to the control scenario (the application of the historical average optimal N rate; RMSE =38.0 kg N ha^{-1}). This proposed approach used a multivariate digital input including a spectral vegetation index (normalized difference vegetation index, NDVI), weather and soil moisture data and information from on-farm experimentation (the in-situ N response using a 'N-rich' strip) to guide the decision. When similar data input and modelling techniques were used to predict yield potential to then derive an N recommendation through a mechanistic decision framework – a nutrient mass balance – the recommendation error (RMSE) increased to 26.0 kg N ha^{-1} ($R^2 = 0.51$). In summary, by forcing the input data through the mechanistic framework, the decision error increased. This study challenges the ideas that farm decisions should follow pre-established agronomic mechanistic frameworks and that digital technologies must necessarily be used to estimate specific crop and soil attributes so as to enable deployment of current decision systems at scale and site-specifically.

20-year N plot experiment in Oklahoma – USA

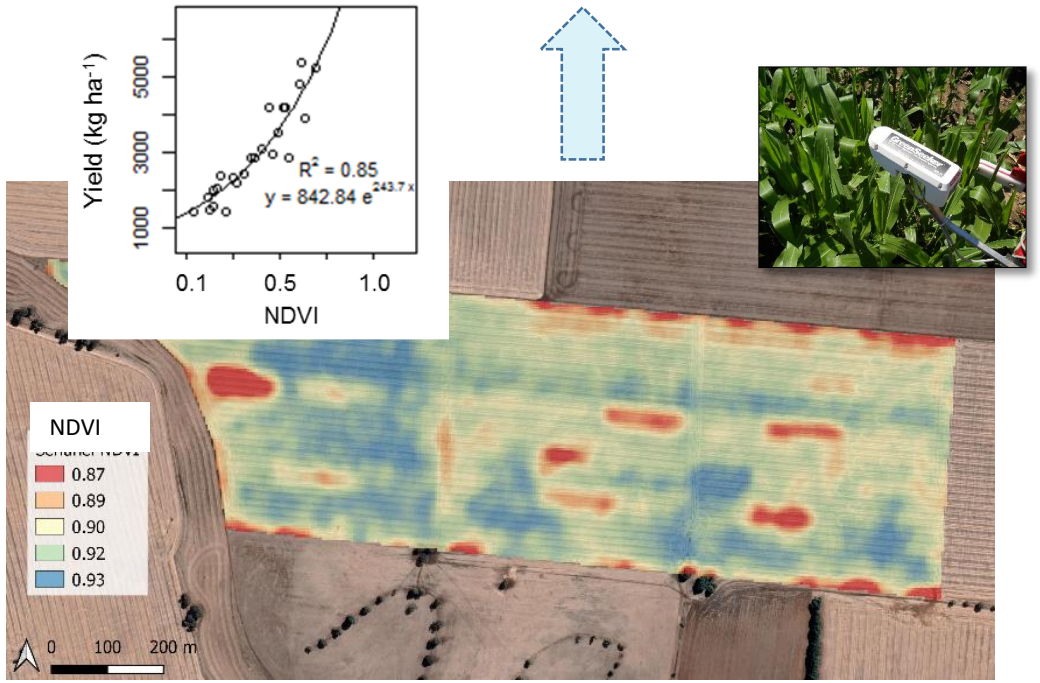


NDVI, soil moisture, weather data, etc...

Nutrient Balance

Demand = **Supply**

Yield potential



Soil

Other sources

available in the system

+

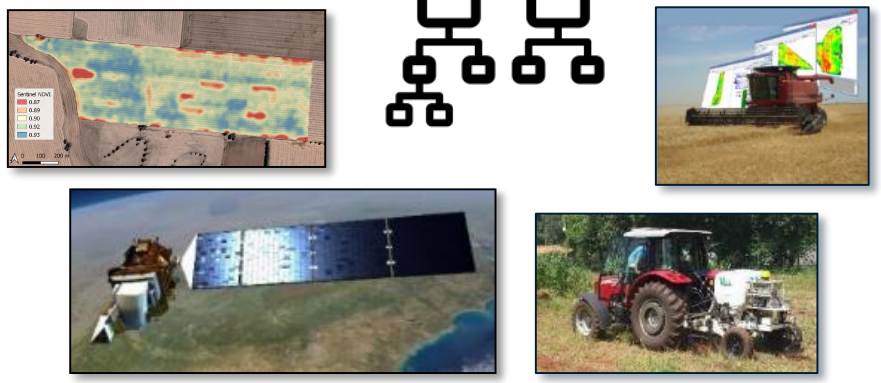
fertiliser

efficiency

Nutrient Balance +ML

Demand = **Supply**

Yield potential



Soil

Other sources

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\+

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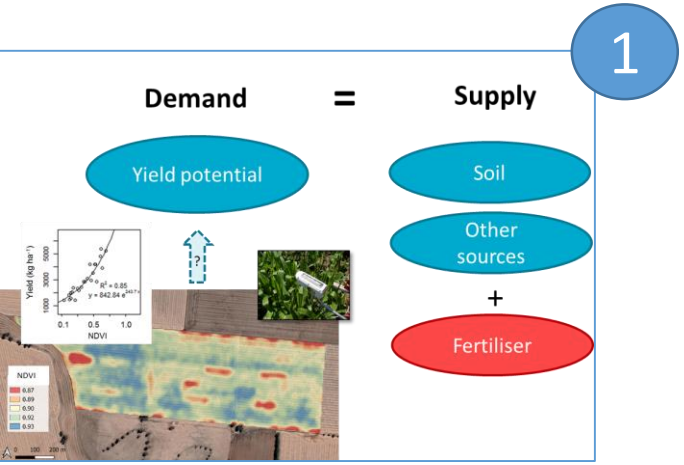
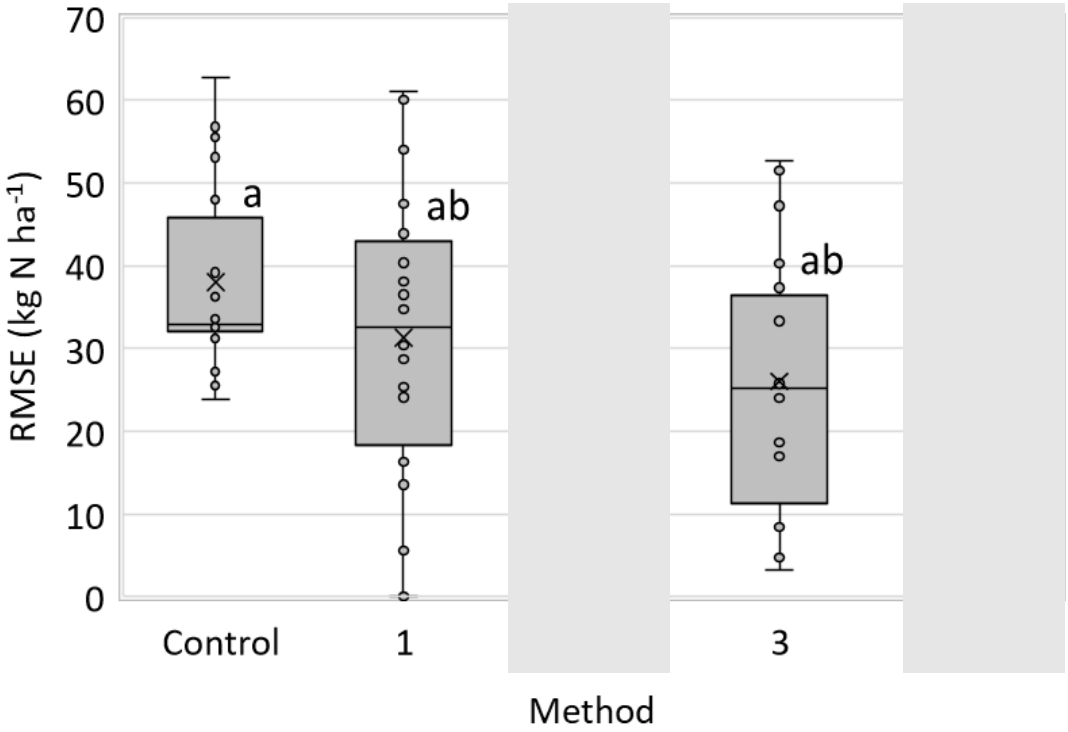
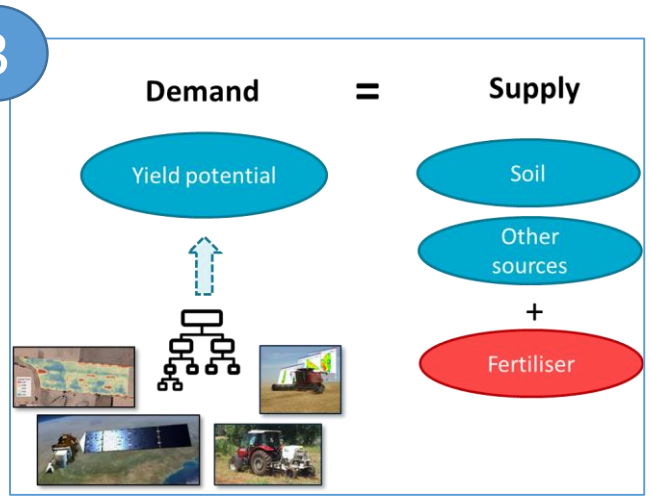
efficiency



N recommendation error for sensor-based N decision methods

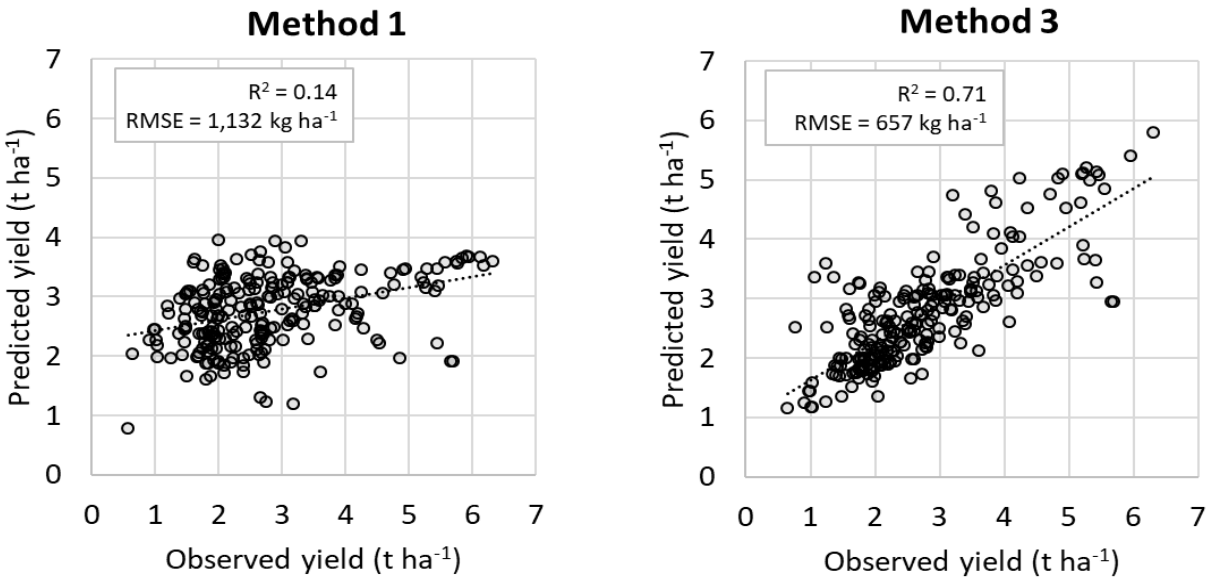


Tukey test results with different letters indicating significant difference ($p<0.05$); each boxplot represents the error variation across years.



Should we focus on yield prediction?

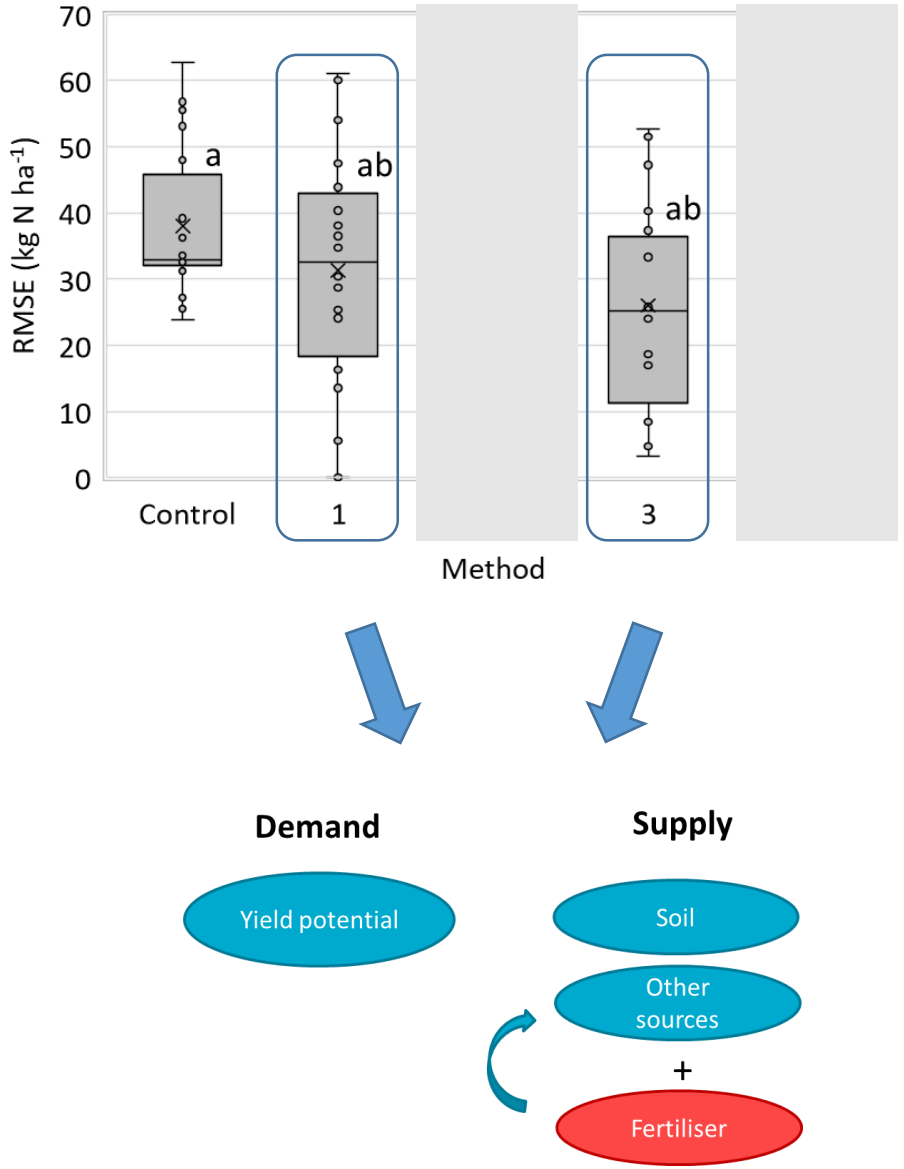
Yield prediction results



NDVI as the predictor variable and simple regression

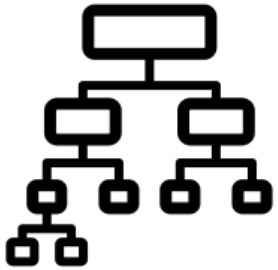
Multiple variables and Random Forest

N recommendation error

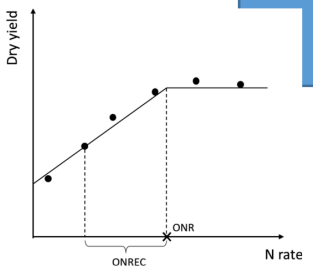


Data-Driven Decision Support

Training



Observed optimal fertiliser rate



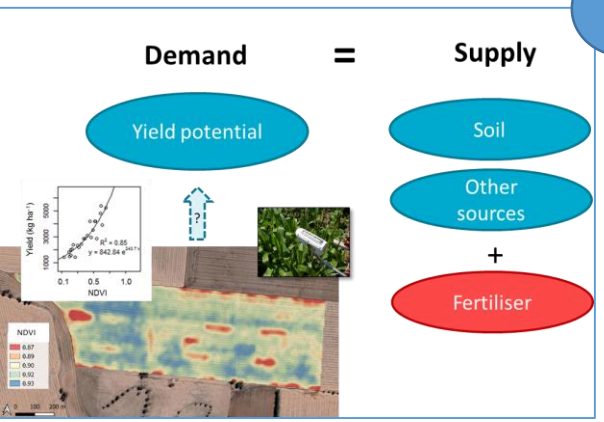
Field conditions

Application

Field conditions

Predicted optimal fertiliser rate

1



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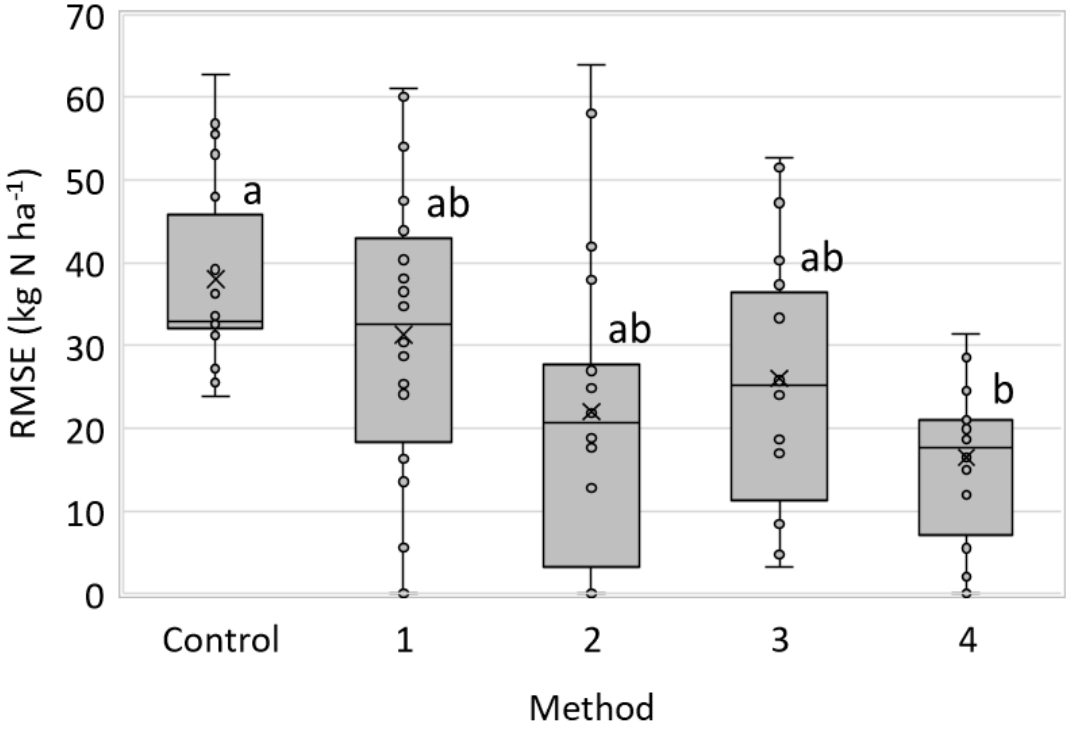

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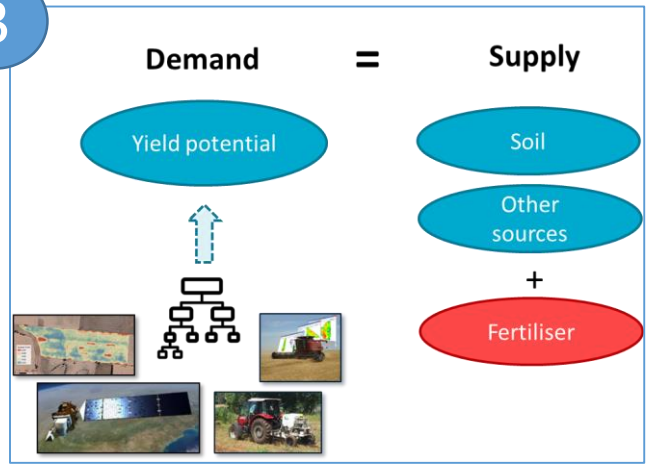
3



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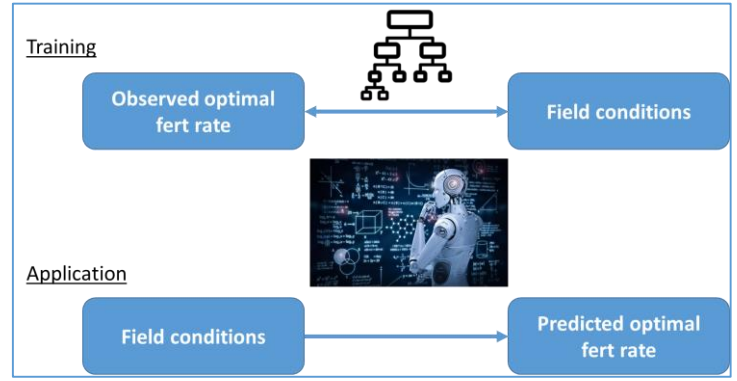
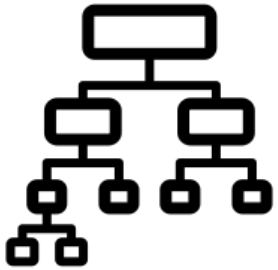


Data-Driven Decision Support

<u>Training</u>

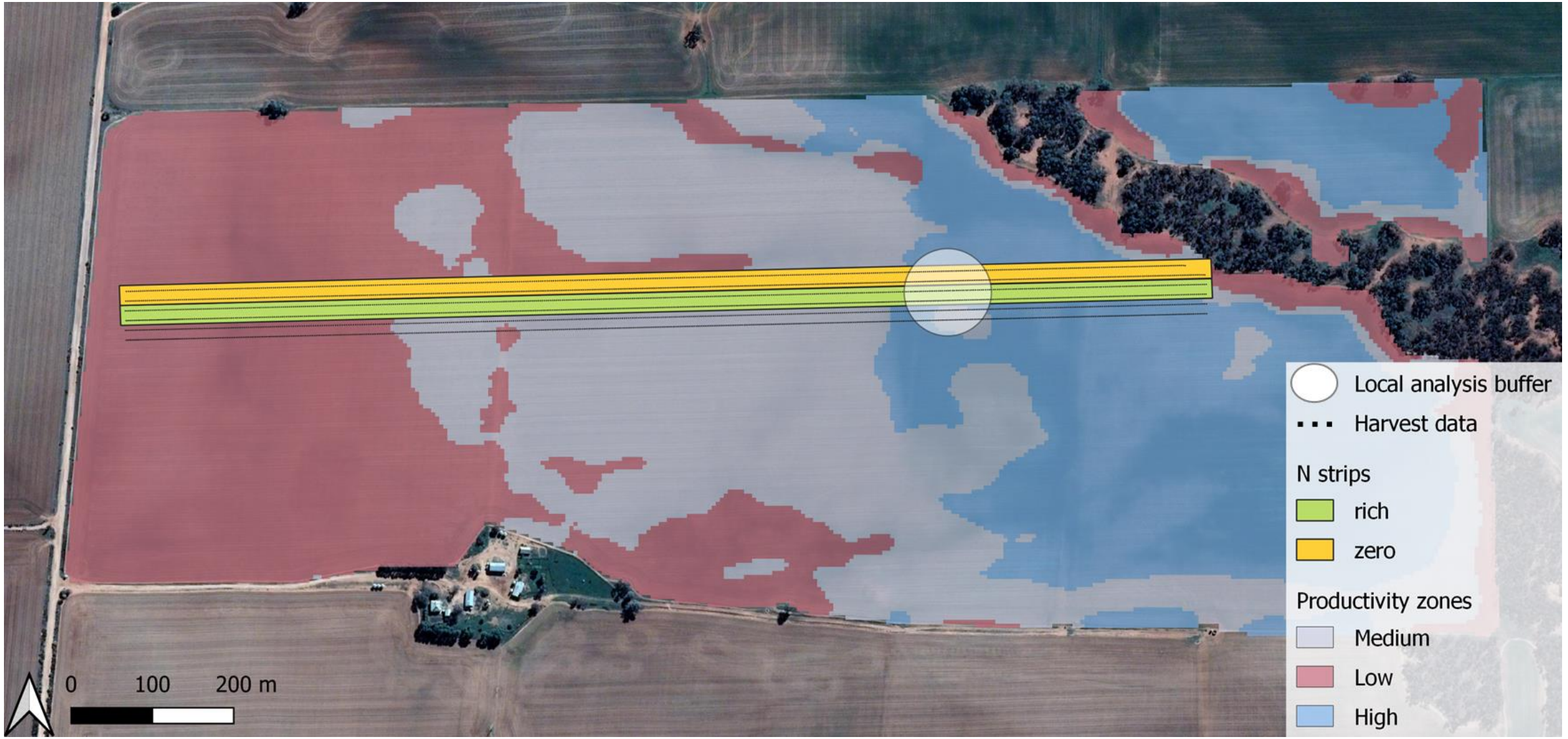


Observed optimal fertiliser rate ⟷ **Field conditions**

<u>Application</u>

Field conditions → **Predicted optimal fertiliser rate**

On-Farm Experimentation (OFE)



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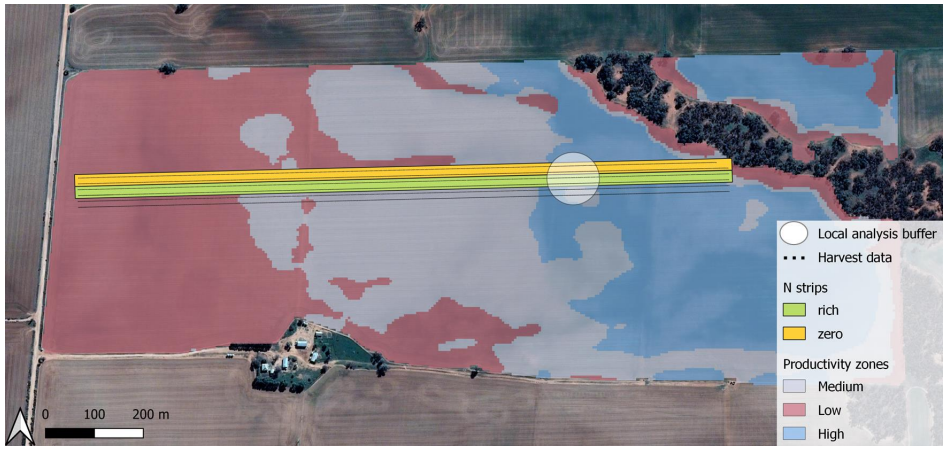
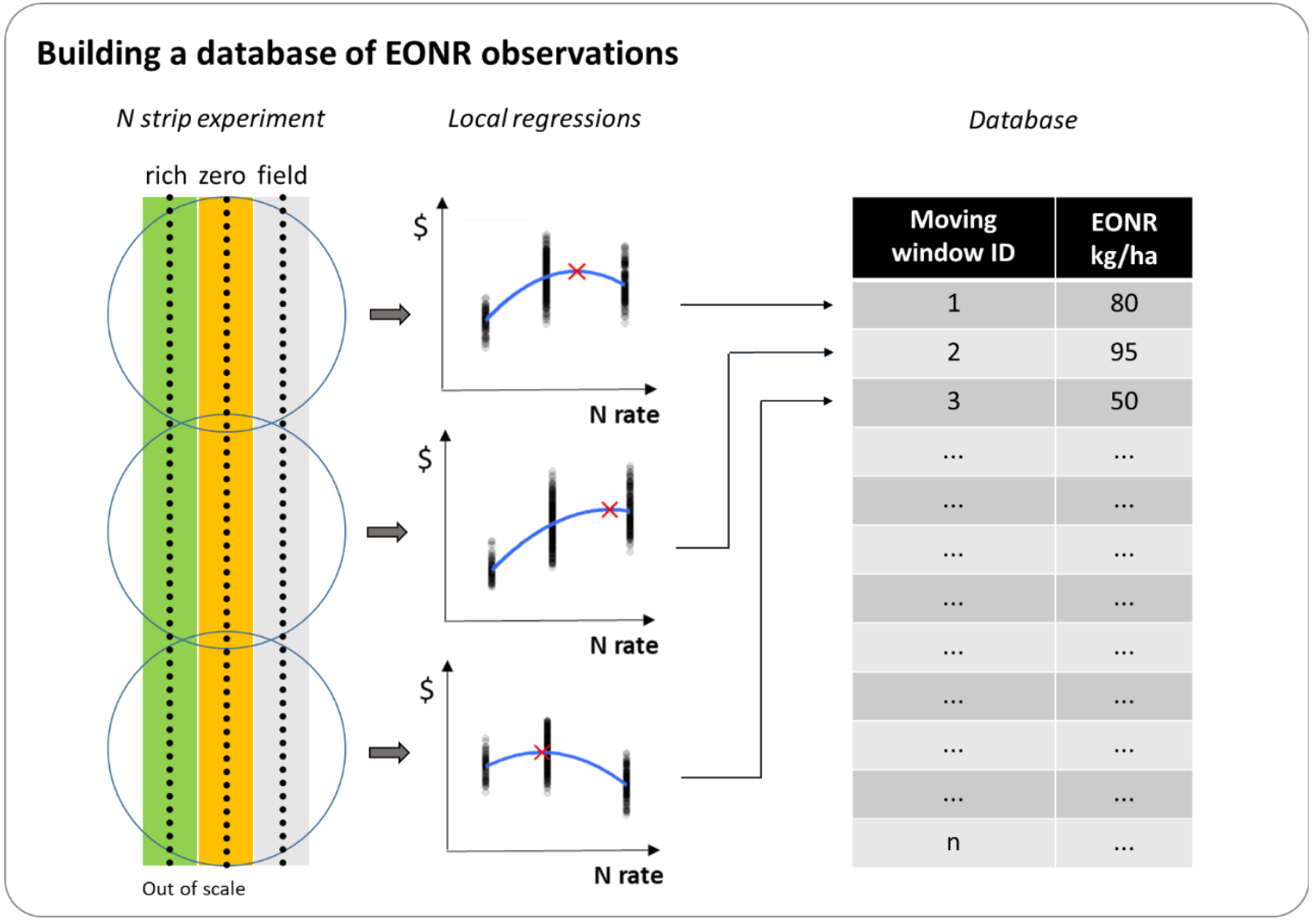
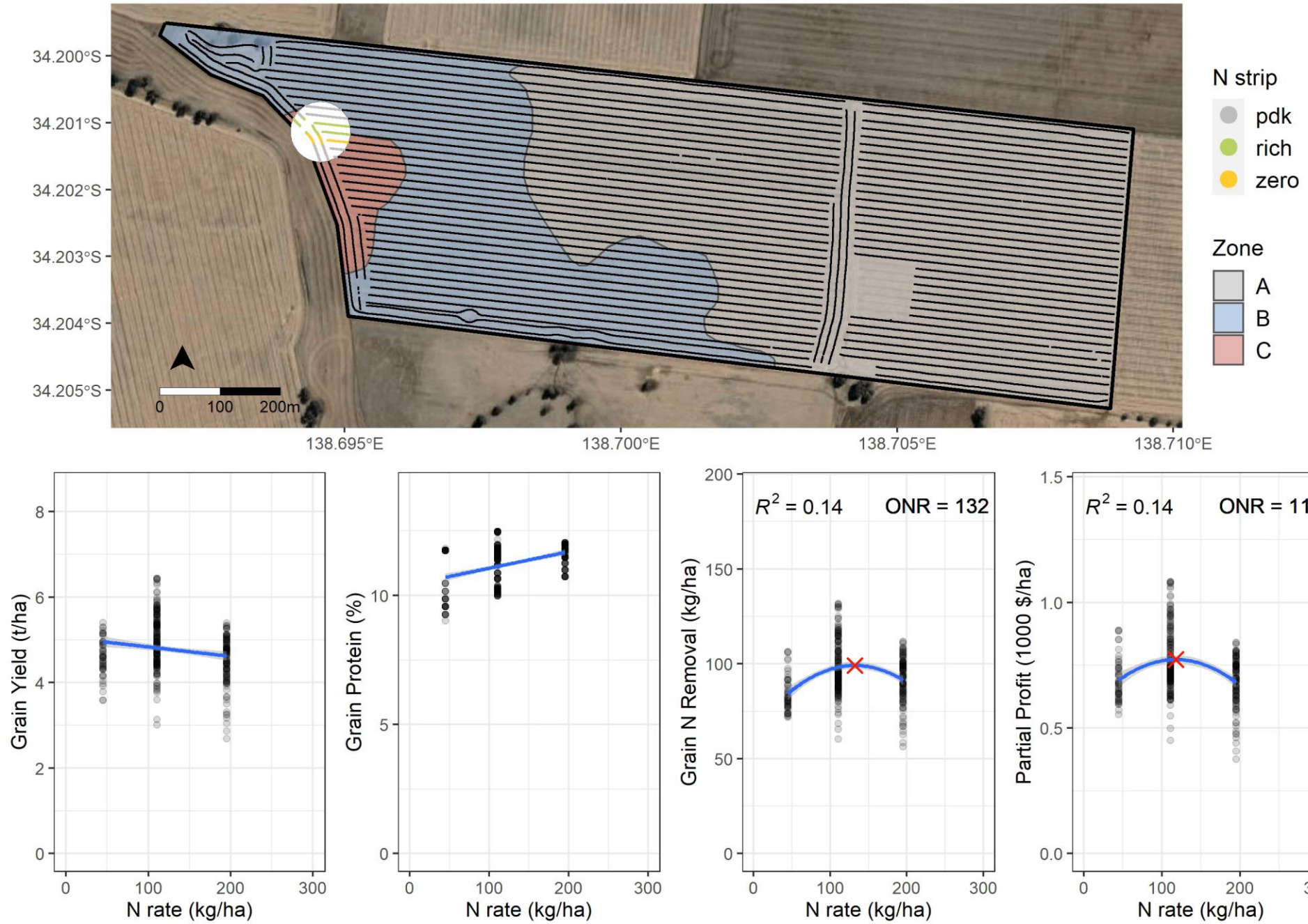
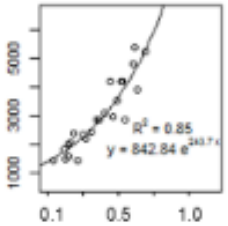
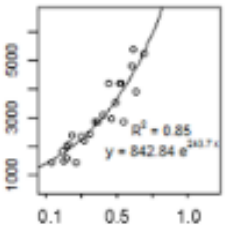





34.200°S
34.201°S
34.202°S
34.203°S
34.204°S
34.205°S
0
100
200m
138.695°E
138.700°E
138.705°E
138.710°E
N strip
pdk
rich
zero
Zone
A
B
C
Grain Yield (t/ha)
N rate (kg/ha)
Grain Protein (%)
N rate (kg/ha)
Grain N Removal (kg/ha)
R^2 = 0.14
ONR = 132
N rate (kg/ha)
Partial Profit (1000 $/ha)
R^2 = 0.14
ONR = 118
N rate (kg/ha)

Rethinking the paradigm of decision support systems in Precision Ag





Mechanistic Knowledge

Crop Biomass

Plant nutrient status

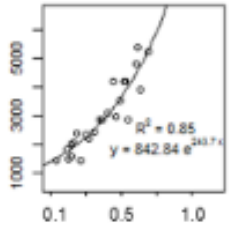
Plant available water

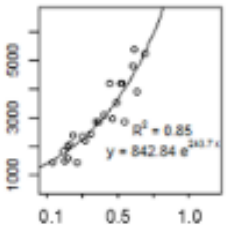
Yield potential

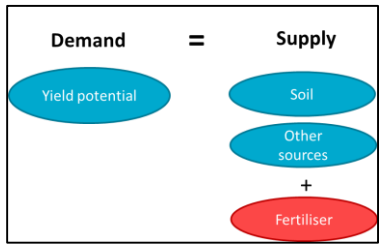
Soil fertility

etc…

Decision support systems





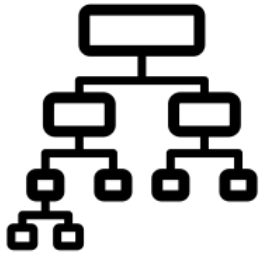


Rethinking the paradigm of decision support systems in Precision Ag

Digital data input

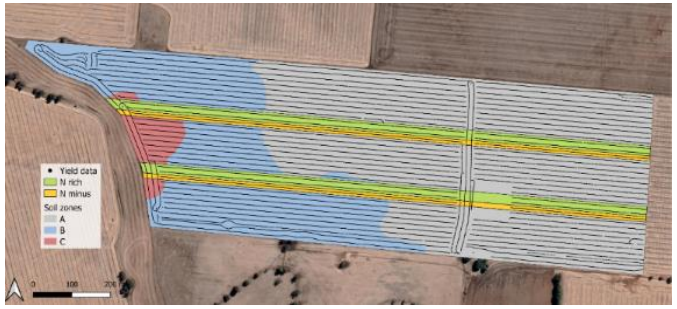
+

ML model



Optimal decision

OFE



Future Farm Project

Precision Agriculture
https://doi.org/10.1007/s11119-023-10102-z

Check for updates

Digital strategies for nitrogen management in grain production systems: lessons from multi-method assessment using on-farm experimentation

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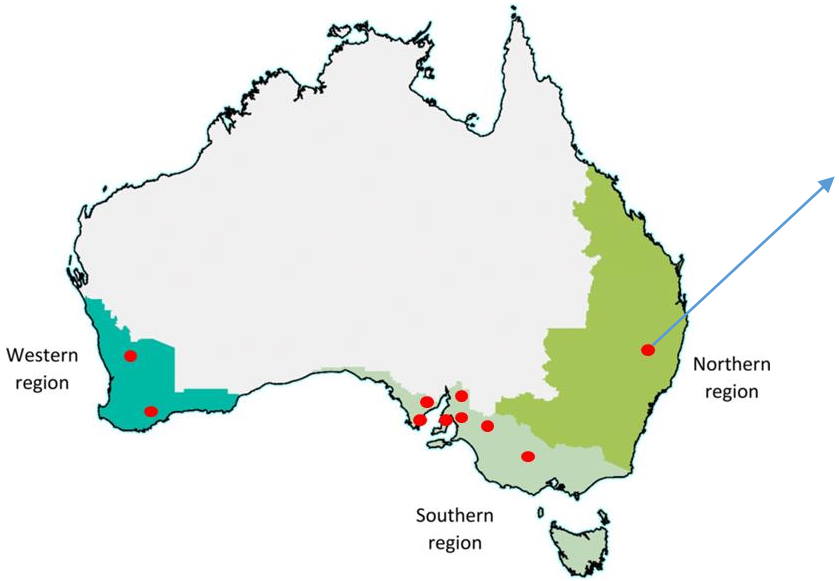
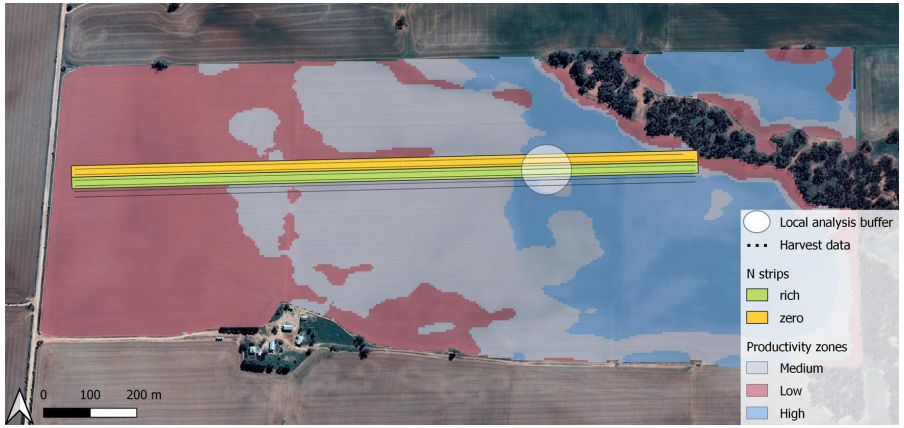
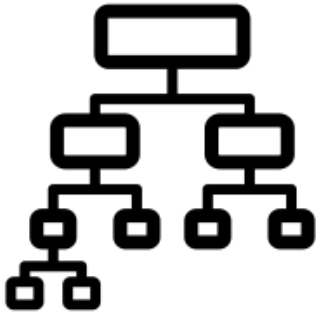
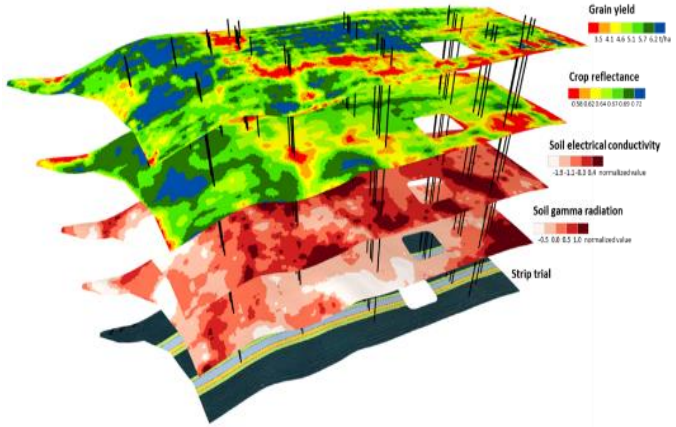
CSIRO · The University of Sydney · QUT Queensland University of Technology · Agriculture Victoria · University of Southern Queensland · GRDC Grains Research & Development Corporation









Thank you

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