NCEA

Technological Innovations

an Australian view

Steven R Raine

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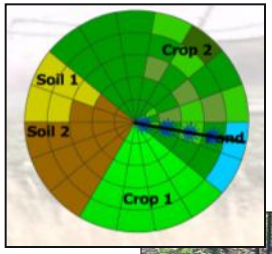

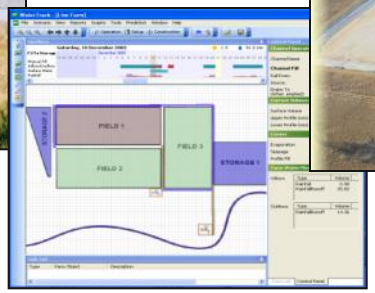

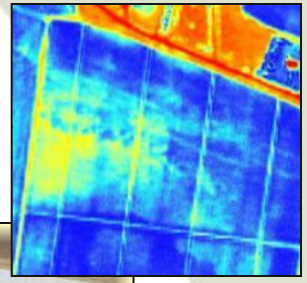

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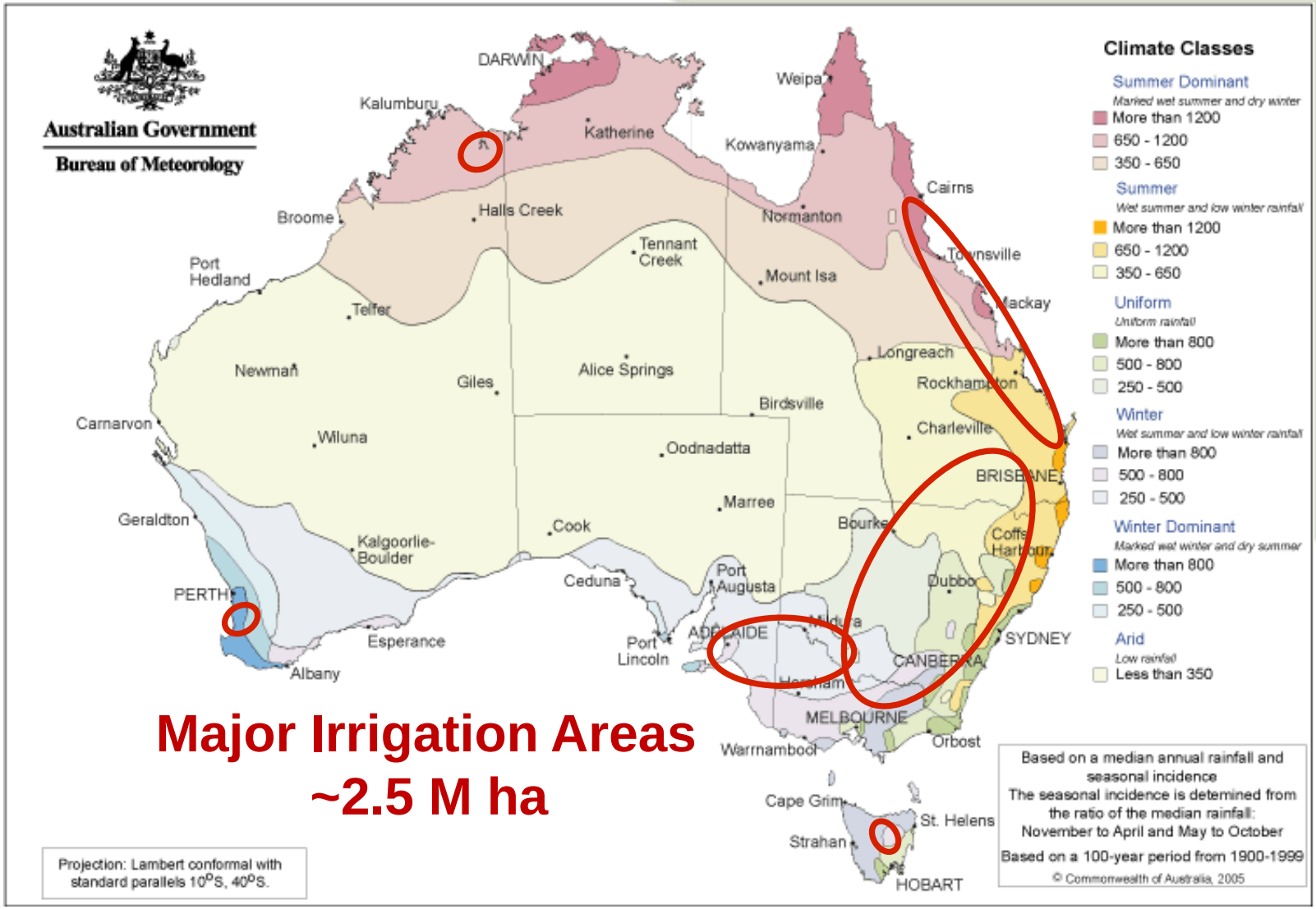
Outline

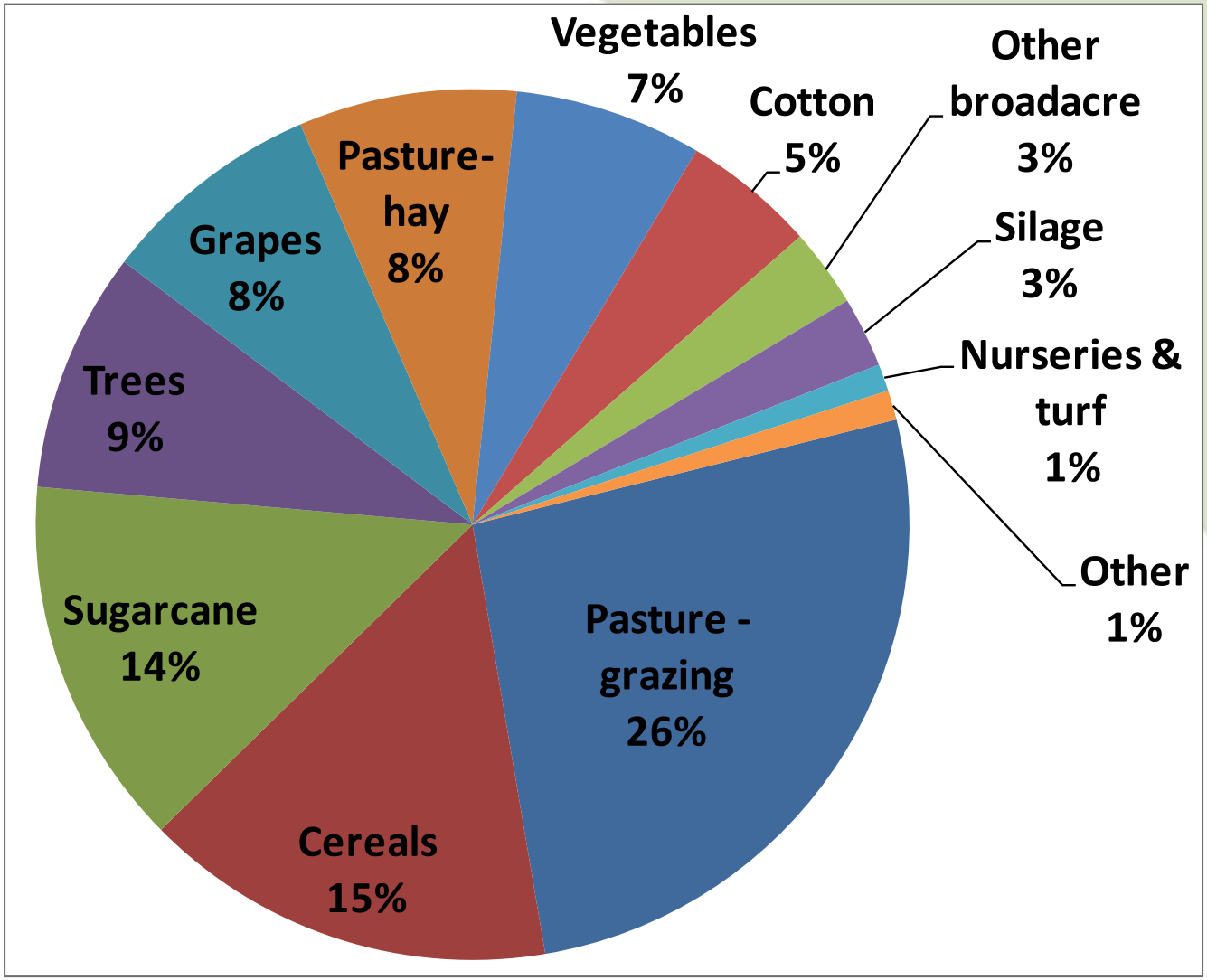
- Australian Context
- Drivers for Change
- Technological Responses
- Prescription & Adaptive Control
- Conclusions

Seasonal Rainfall Zones

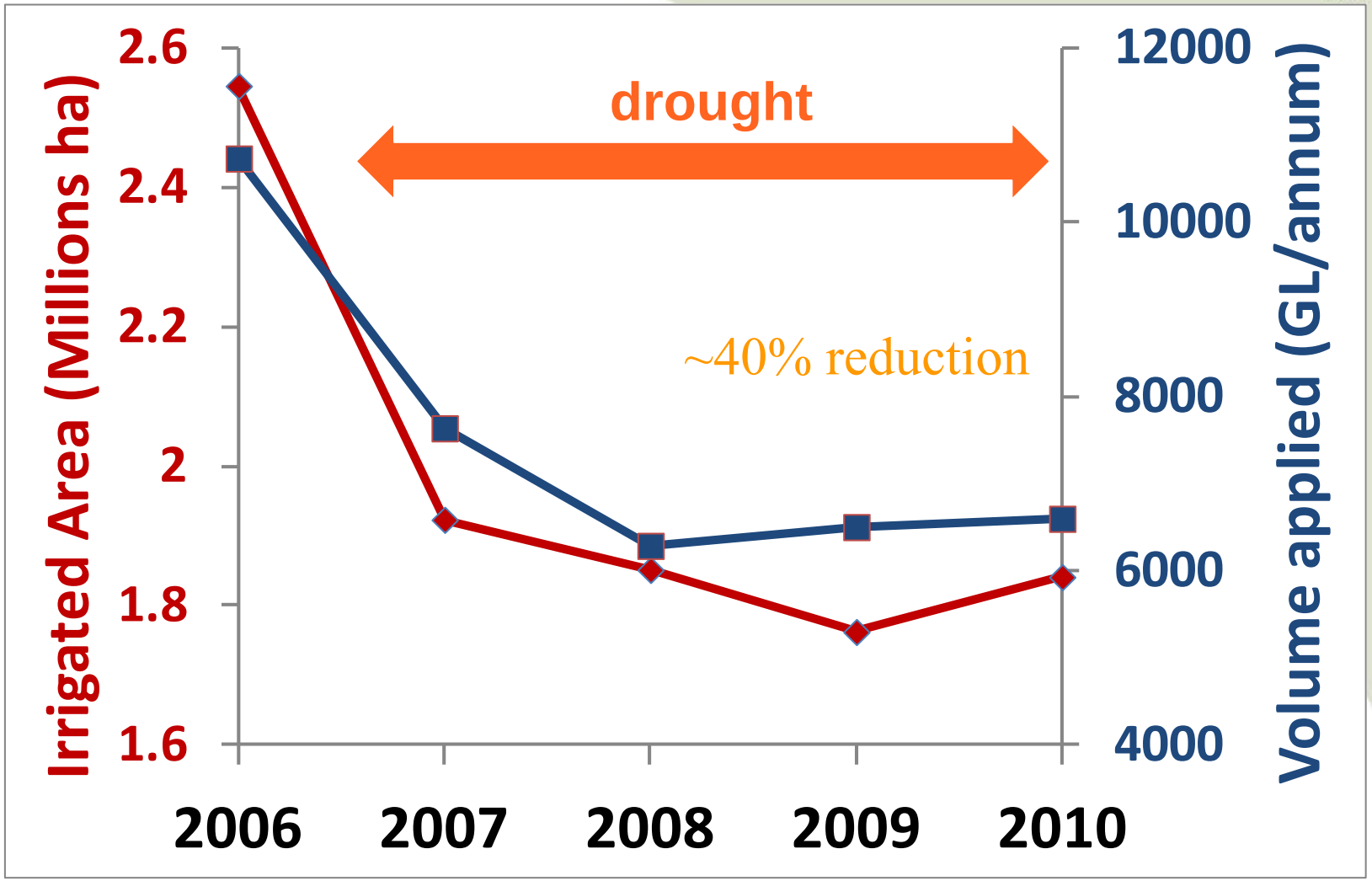


Major Irrigation Areas
~2.5 M ha

Australian Water Use (2007-08)



Impact of Drought



Drivers of Technological Change

- ***Reduced water access – volume available and reliability of supply***
- ***Decreasing availability of skilled farm labour and increasing costs of labour***
- ***Increasing energy costs***
- ***Increased market demand for quality/tracebility of product***
- ***Increased market competition***
- ***Increased regulation to demonstrate resource stewardship***

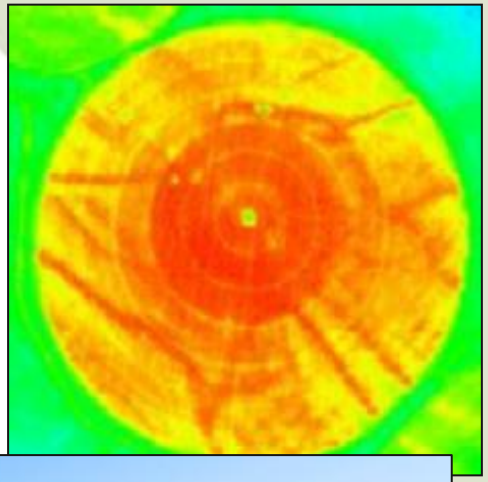
Technological Responses

National/Regional Level focus on:

- **Converting channels into pipelines**
- **Storage management**
- **Water trading and range of water products**
- **Buying back water for environment**

On-Farm Level focus on

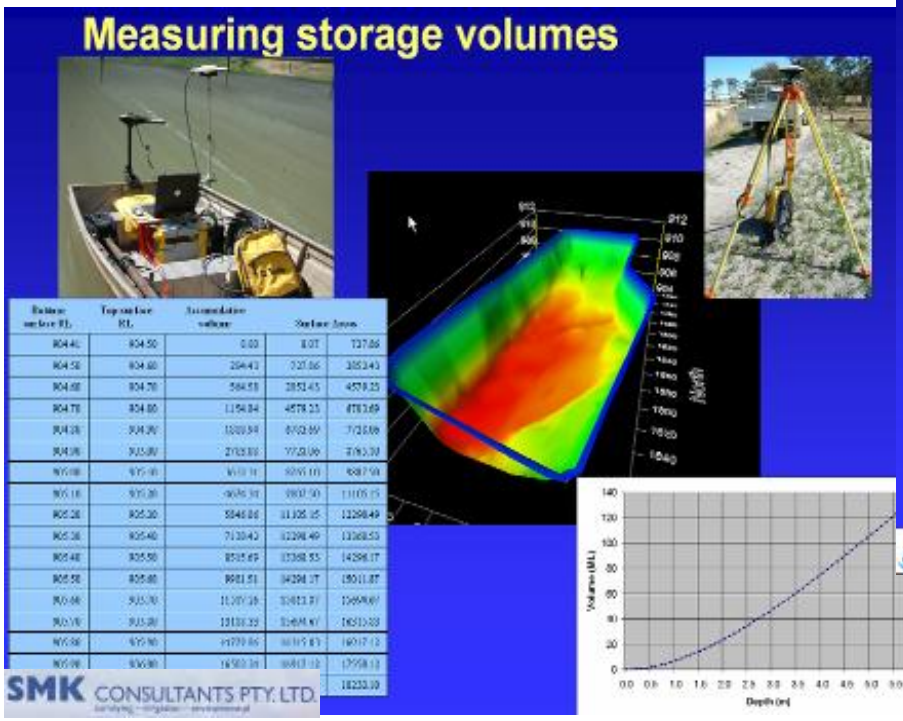
- **Reducing storage and distribution losses** (evaporation and seepage)
- **Precision application systems**
- **Improved furrow management**
- **Spatial/temporal sensing and data management**
- **Spatially varied irrigation**
- **Prescription control of inputs**
- **Automated responses**

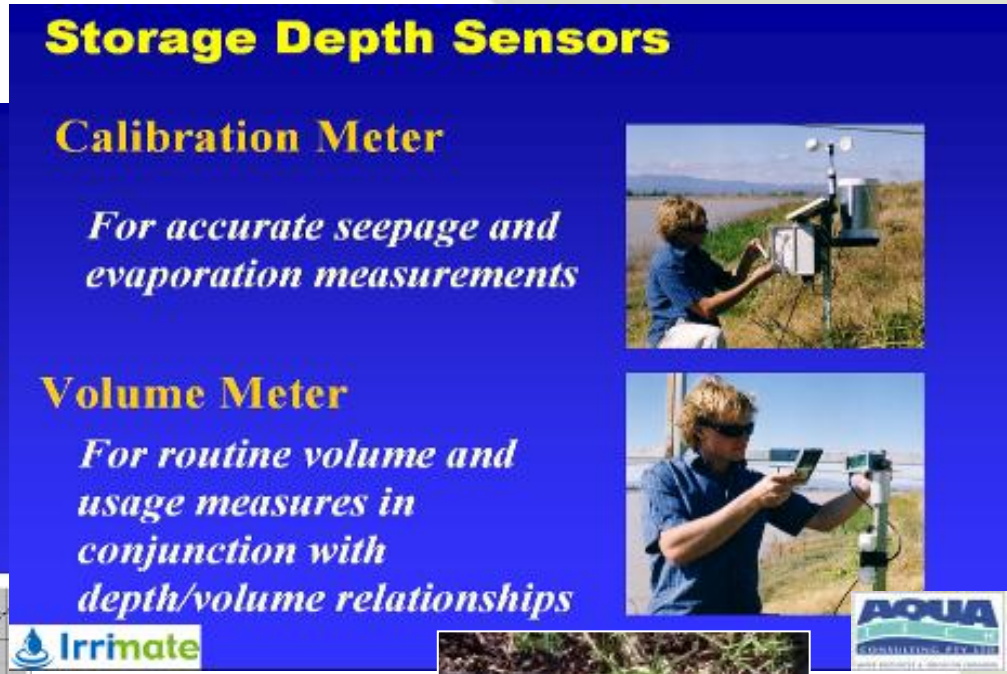


Reducing Storage and Distribution Losses

- *Performance monitoring – seepage & evaporation*
- *Reducing losses – seepage & evaporation*
- *Industry/catchment benchmarking*
- *Software calculators*

Partners





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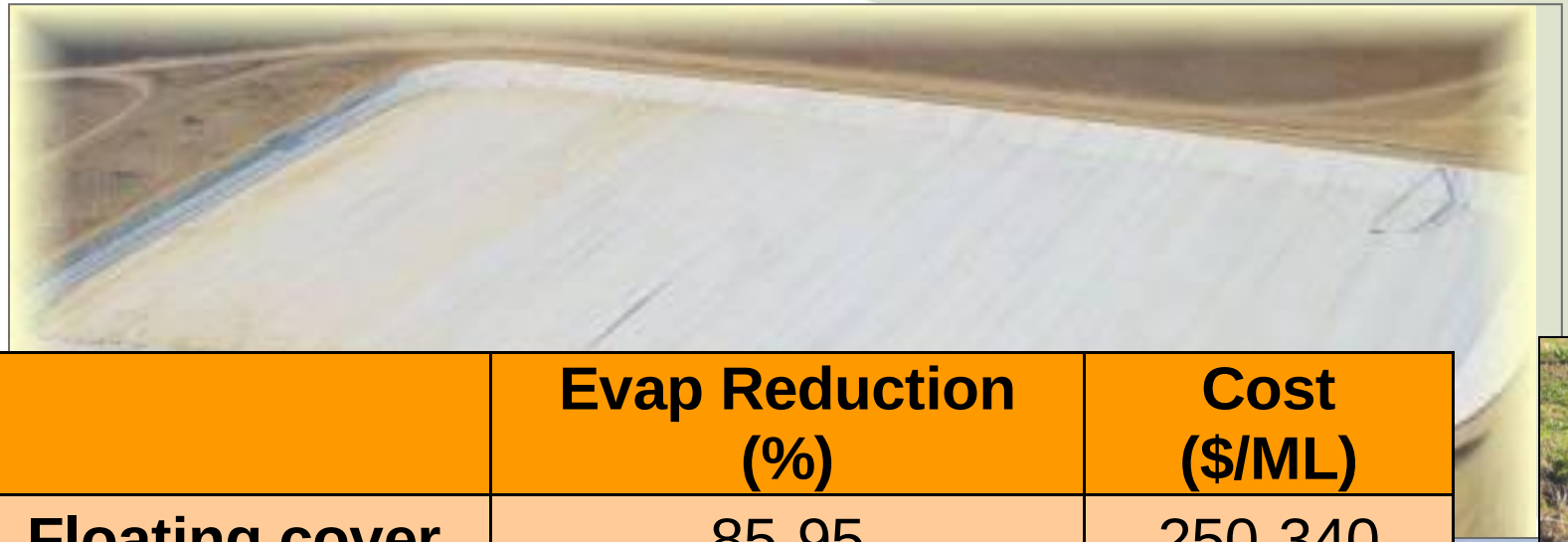
Evaporation Reduction



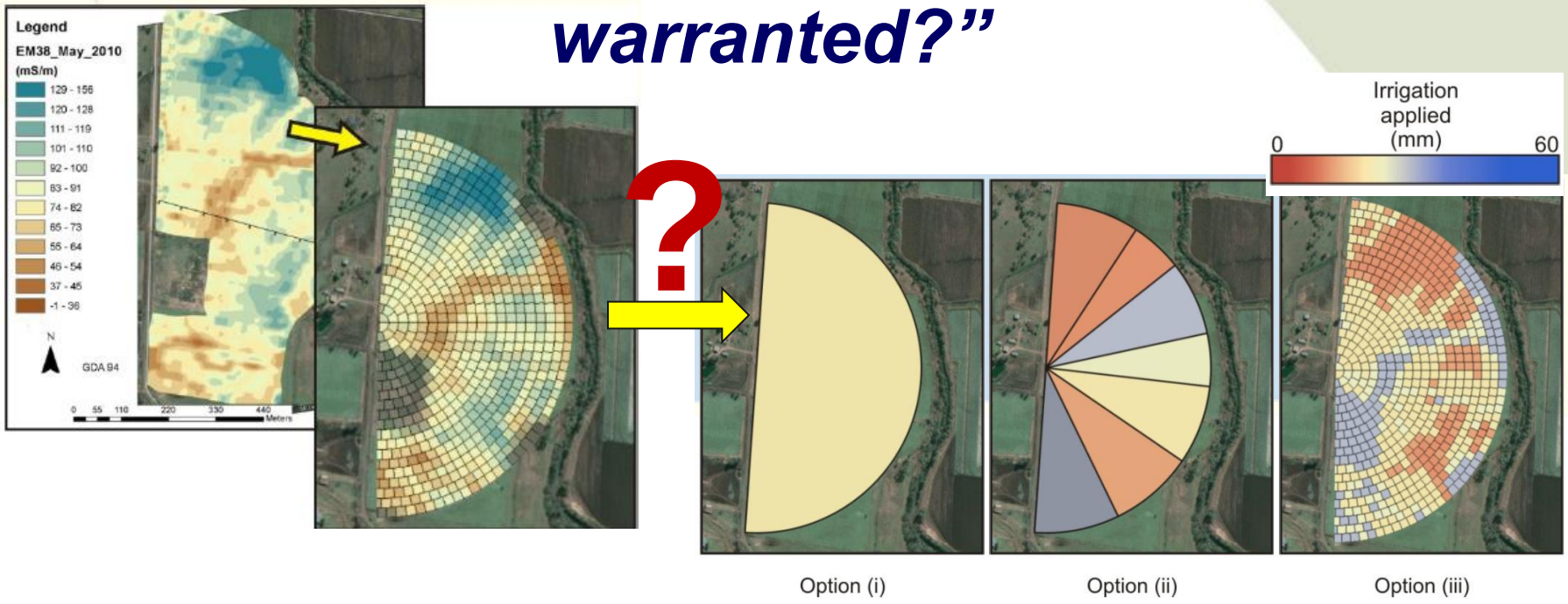
	Evap Reduction (%)	Cost ($/ML)
Floating cover	85-95	250-340
Shade cloth	60-80	300-400
Monolayer	5-40	130-790

Monolayers

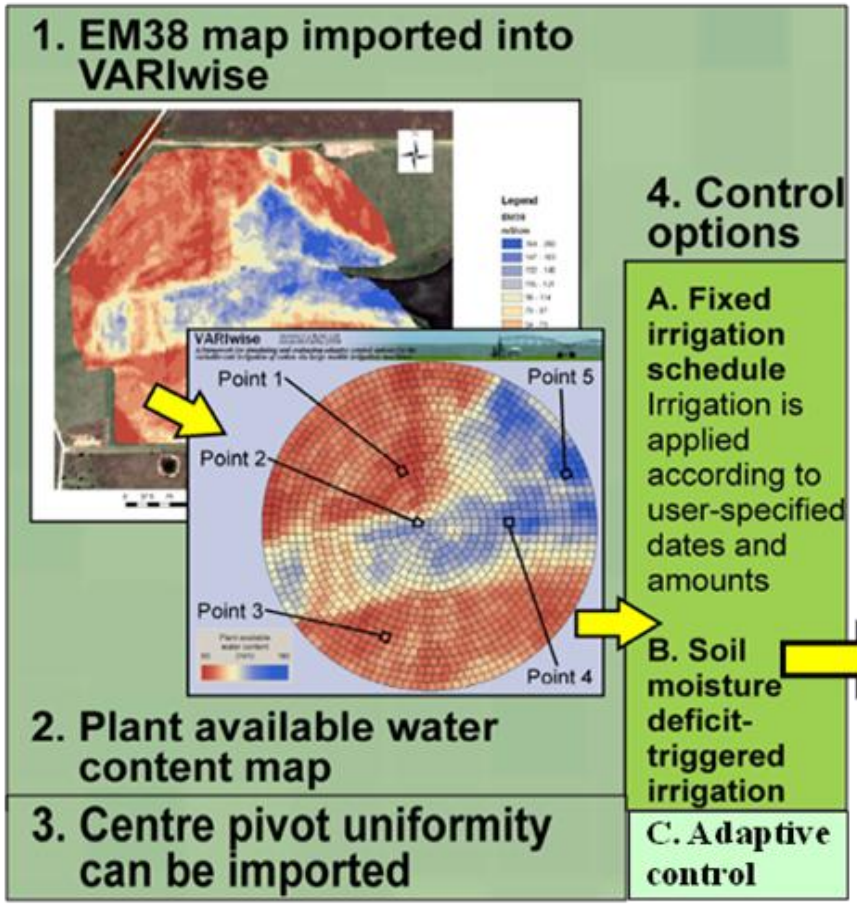
Spatially Varied Irrigation

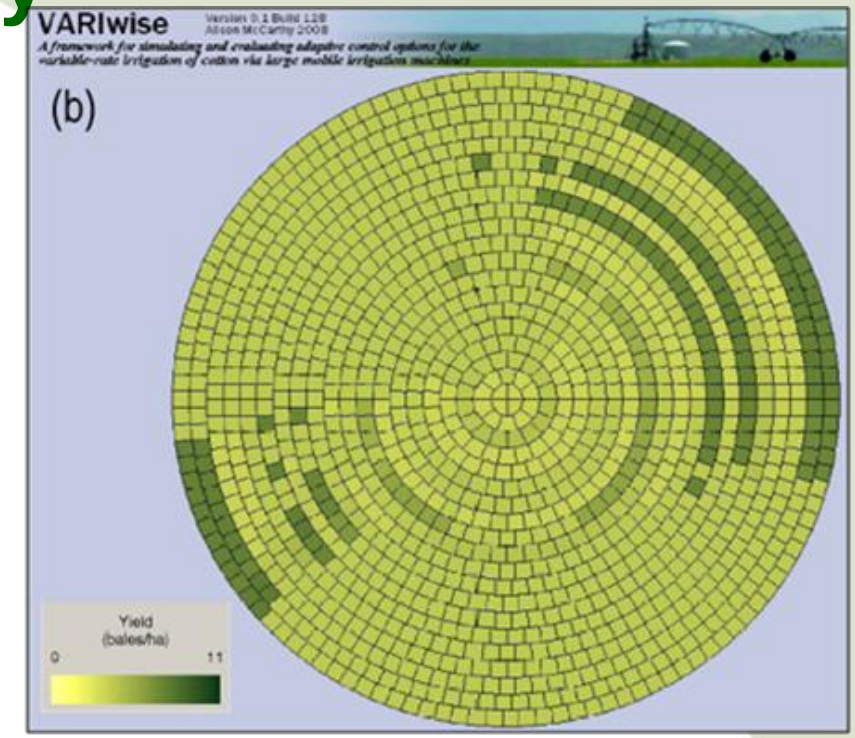
"Just because you can doesn't mean you should"

"What level of precision/control is warranted?"



Effect of soil monitoring location and irrigation non-uniformity

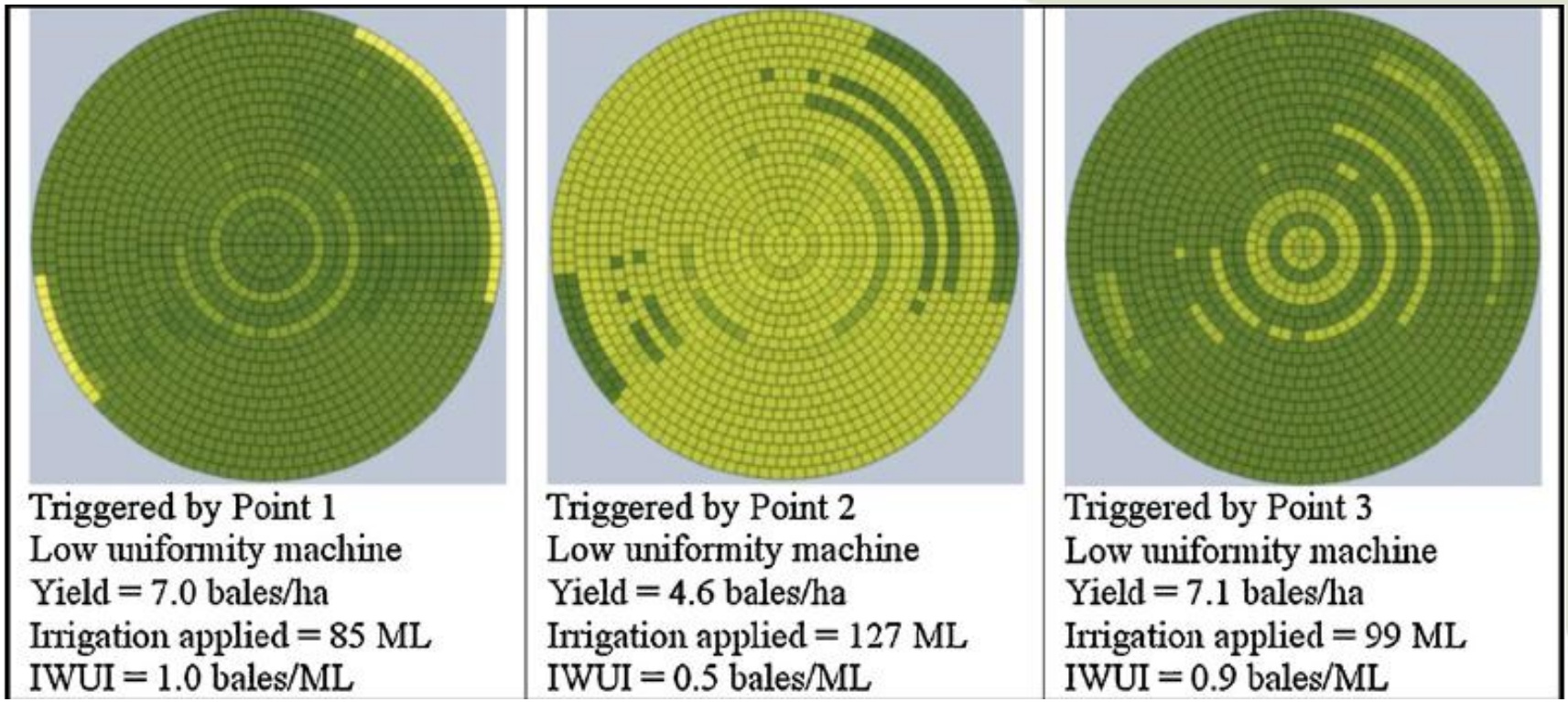




Sensor location	Variability in machine uniformity	Yield (bales/ha)	Irrigation water use efficiency (bales/ML)
Point 1	Low	7.0	0.7
	High	7.0	1.0
Point 2	Low	7.1	0.7
	High	7.0	1.0
Point 3	Low	7.1	0.8
	High	4.6	0.4
Point 4	Low	6.8	0.7
	High	7.0	1.0
Point 5	Low	7.4	0.9
	High	7.0	0.9

Soil moisture deficit triggered irrigations

(weather profile 1, Sicot 73)



Triggered by Point 1
Low uniformity machine
Yield = 7.0 bales/ha
Irrigation applied = 85 ML
IWUI = 1.0 bales/ML

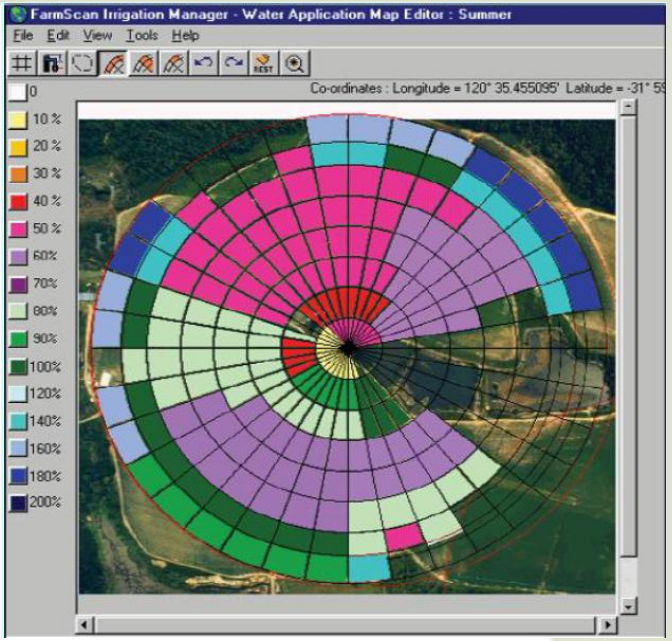
Triggered by Point 2
Low uniformity machine
Yield = 4.6 bales/ha
Irrigation applied = 127 ML
IWUI = 0.5 bales/ML

Triggered by Point 3
Low uniformity machine
Yield = 7.1 bales/ha
Irrigation applied = 99 ML
IWUI = 0.9 bales/ML

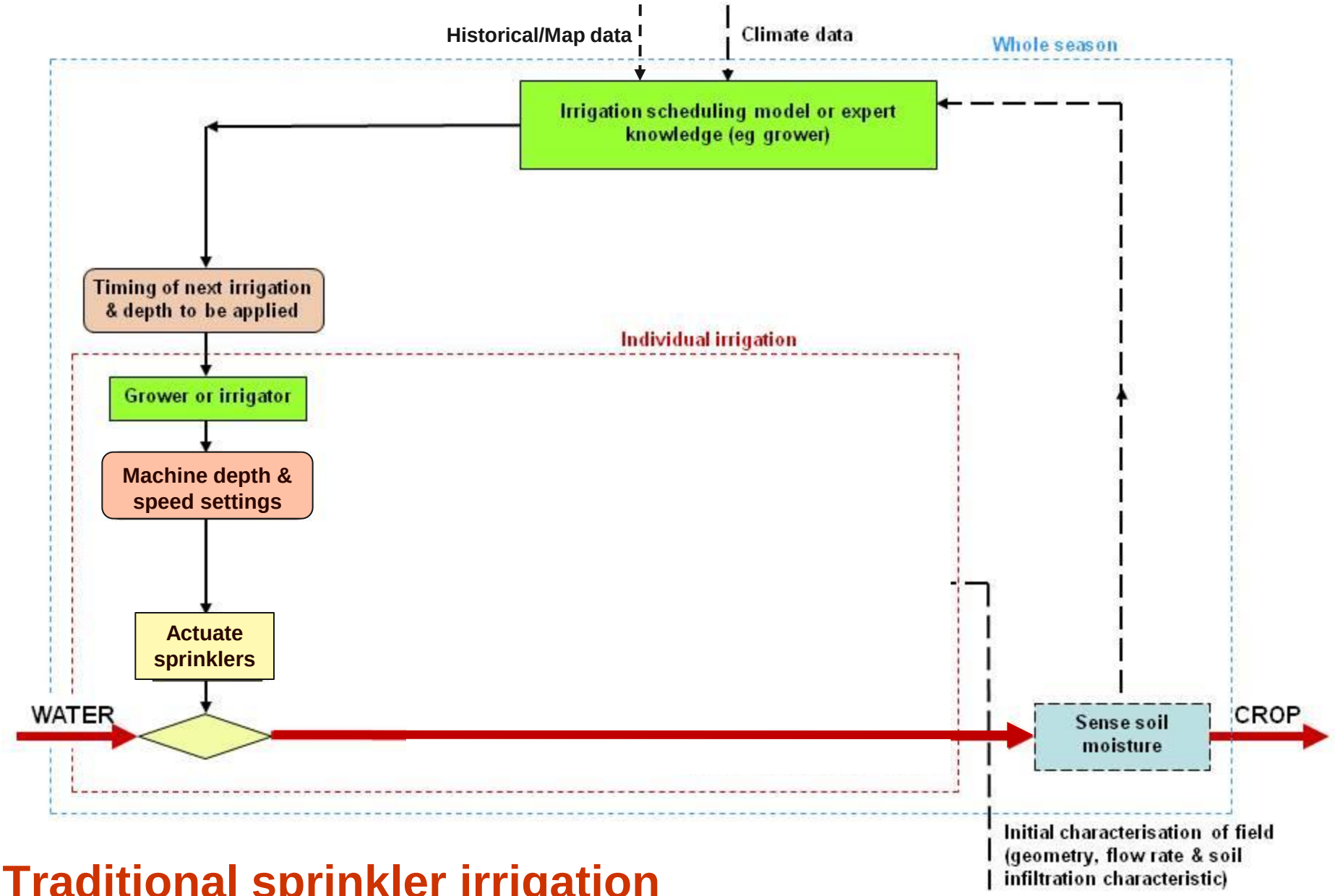
⇒ Selection of input sensor location is critical to performance

Spatially varied irrigation

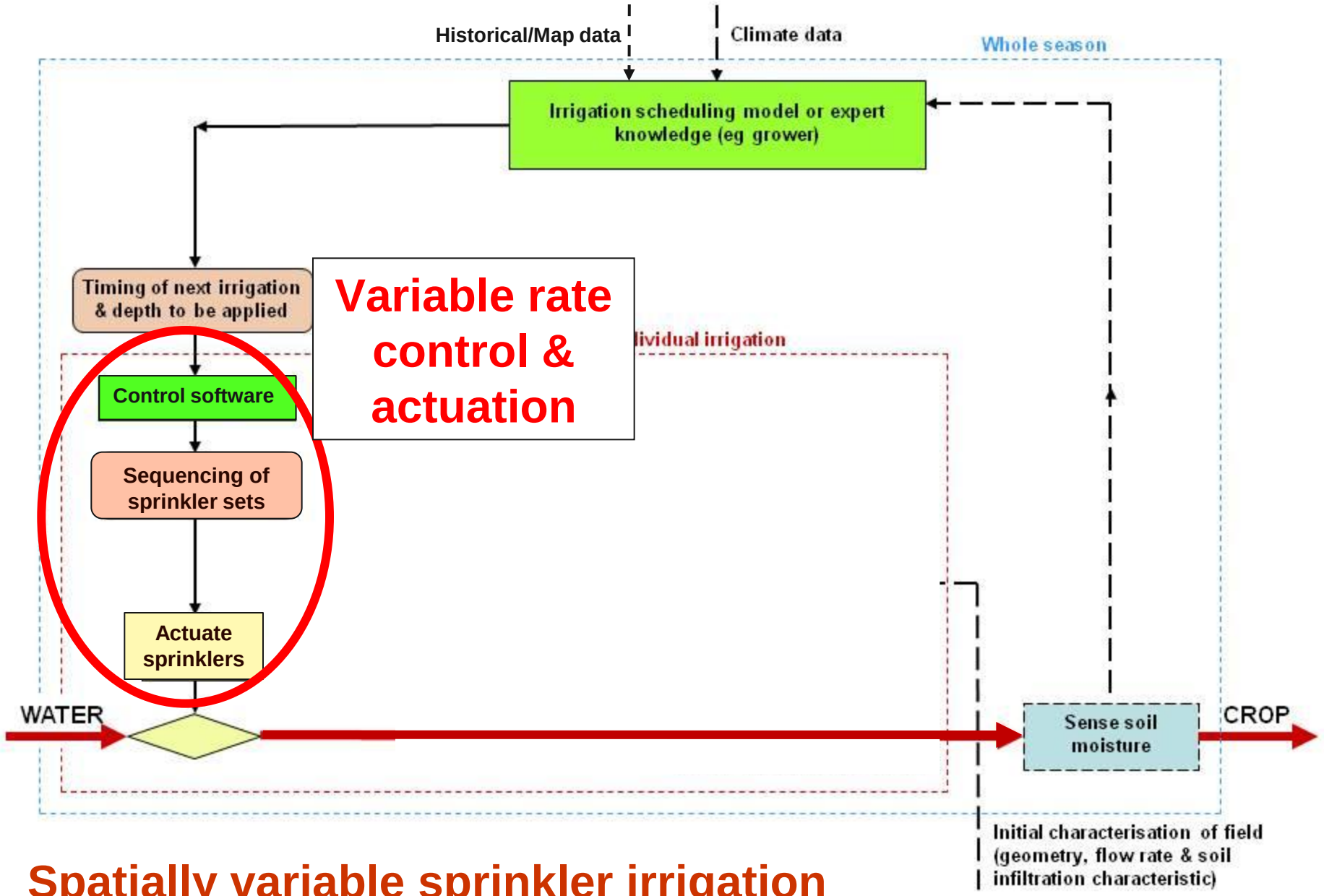
- predicated on the hypothesis that the crop is non-uniform and the water requirements are similarly non-uniform
- assumes that yield will be maximised if each plant is supplied with water exactly matching its individual requirements
- able to deliver differential amounts of water to different areas of the field



Greatest difficulty faced in the implementation of precision irrigation is associated with determining appropriate prescriptions for the application of water and nutrients *(Evans et al, 1996)*



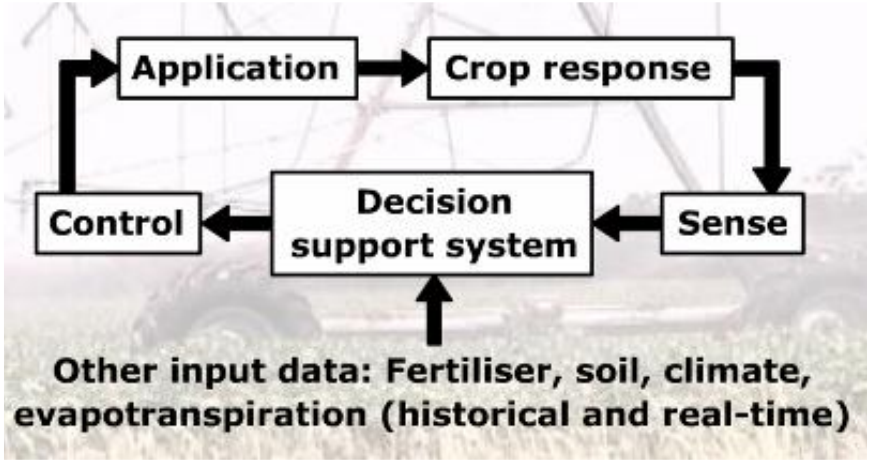
Traditional sprinkler irrigation



Spatially variable sprinkler irrigation

But a prescription irrigation system is one that also:

- Knows what to do;
- Knows how to do it;
- Knows what it has done; and
- Learns from what it has done.

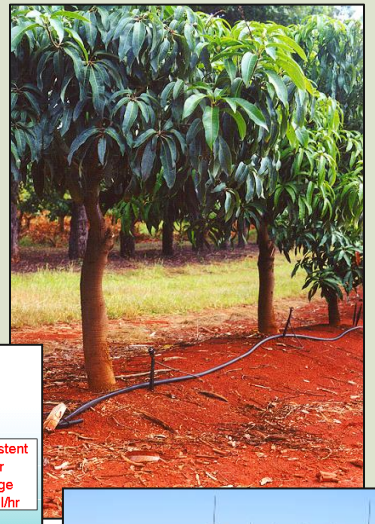


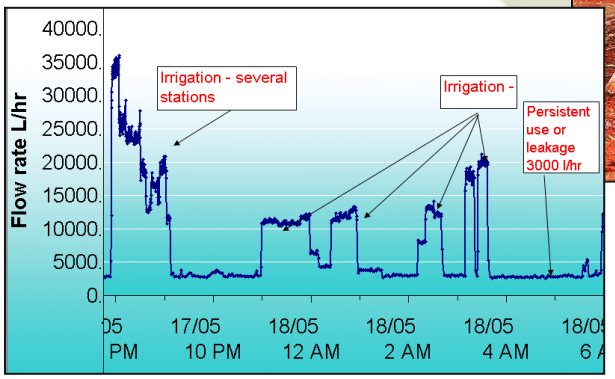
Adaptive Control Framework

Prescription and Adaptive Control for Irrigation

Essential Components

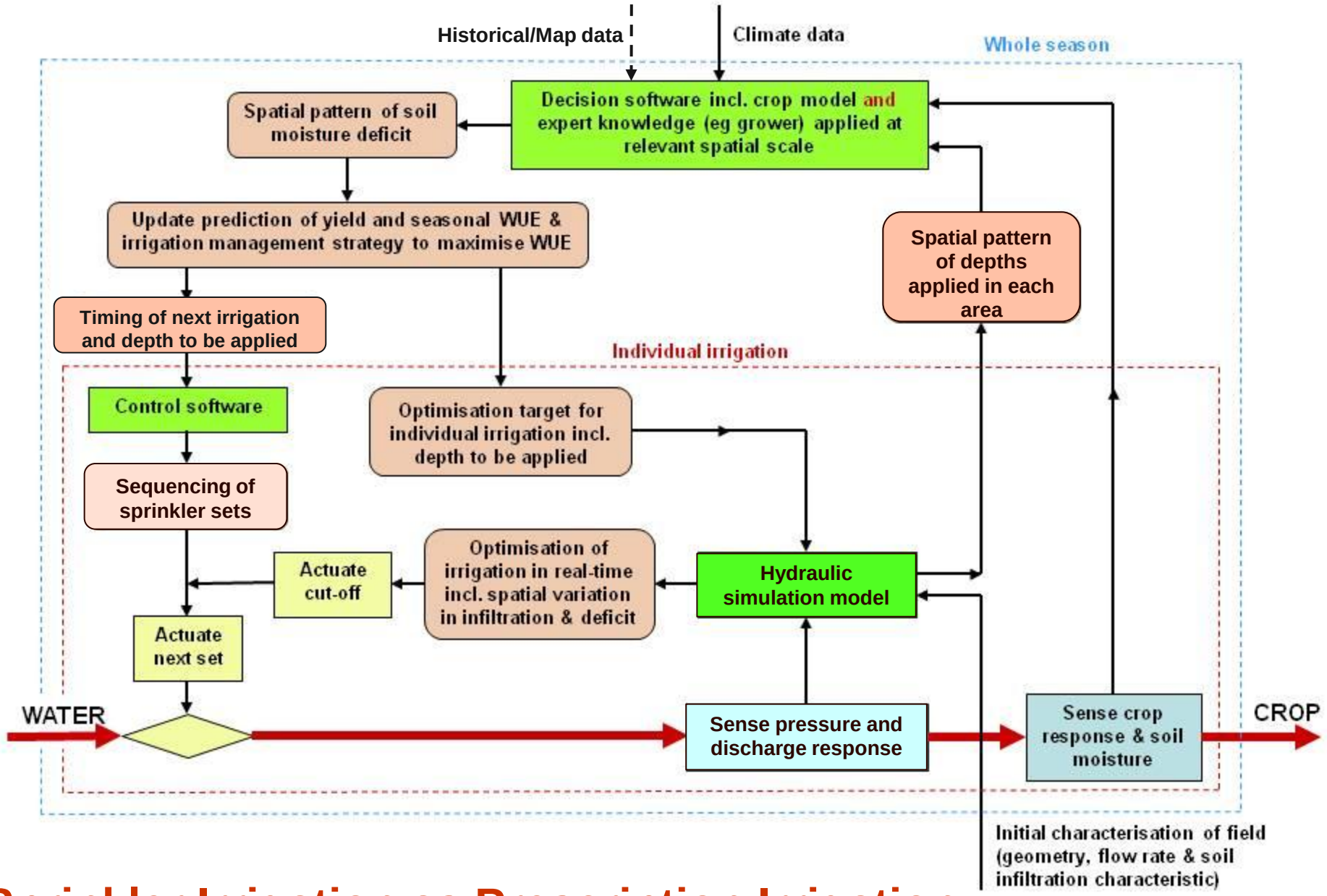
- Tools for measurement of the application
- Ability to evaluate/optimise the application
- Control guidelines
- Feedback



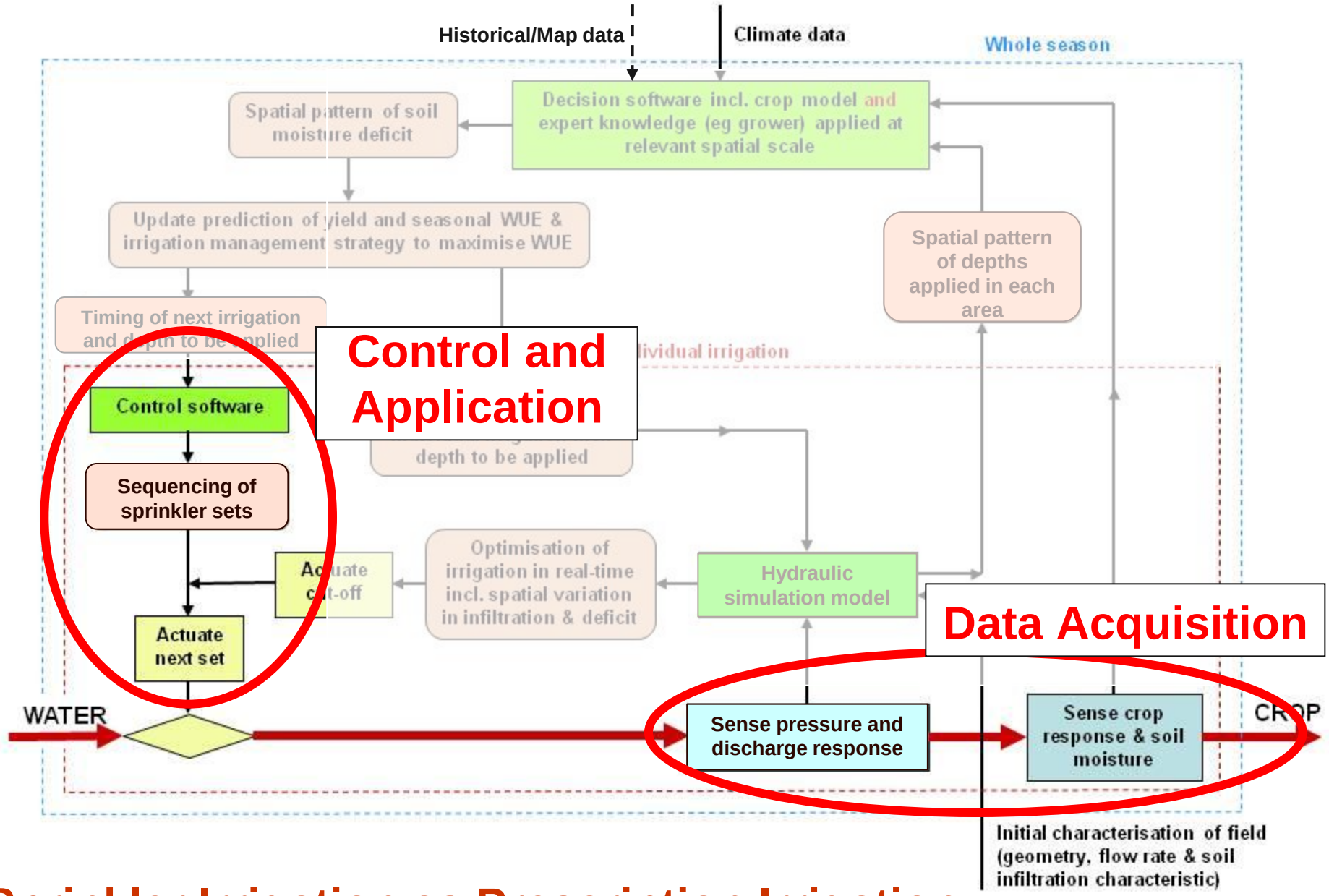


Optional components

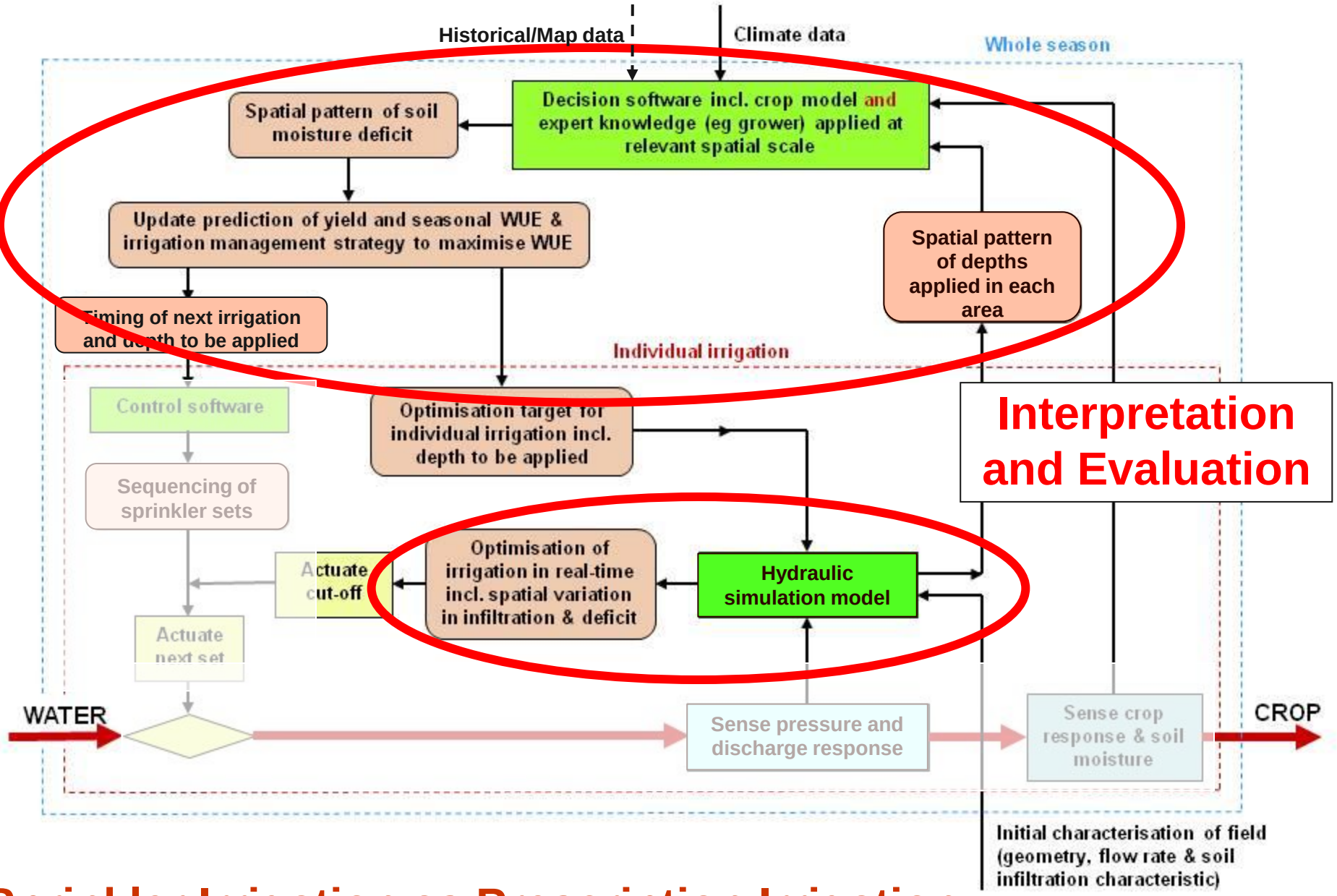
- Ability to cope with spatial variability
- Ability to cope with temporal variability
- Automation
- Real time control automation



Sprinkler Irrigation as Prescription Irrigation



Sprinkler Irrigation as Prescription Irrigation



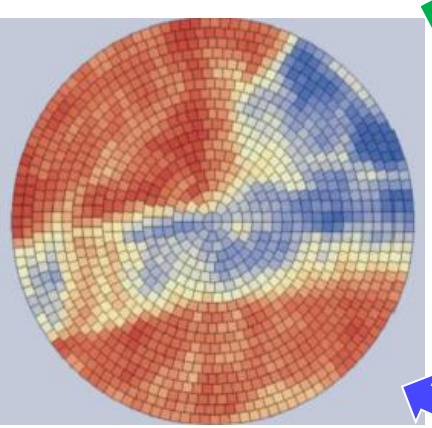
Sprinkler Irrigation as Prescription Irrigation

System for Centre Pivot & Lateral Move Machines

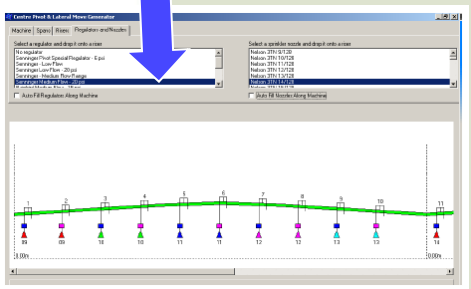
Adaptive control including spatially varied applications

VARIwise –Spatially varied modelling production inputs and crop performance

Measure flows and pressures



System becomes intelligent



nuLMHyd – Models hydraulic performance

Measure crop response with machine vision

Rainfall & weather

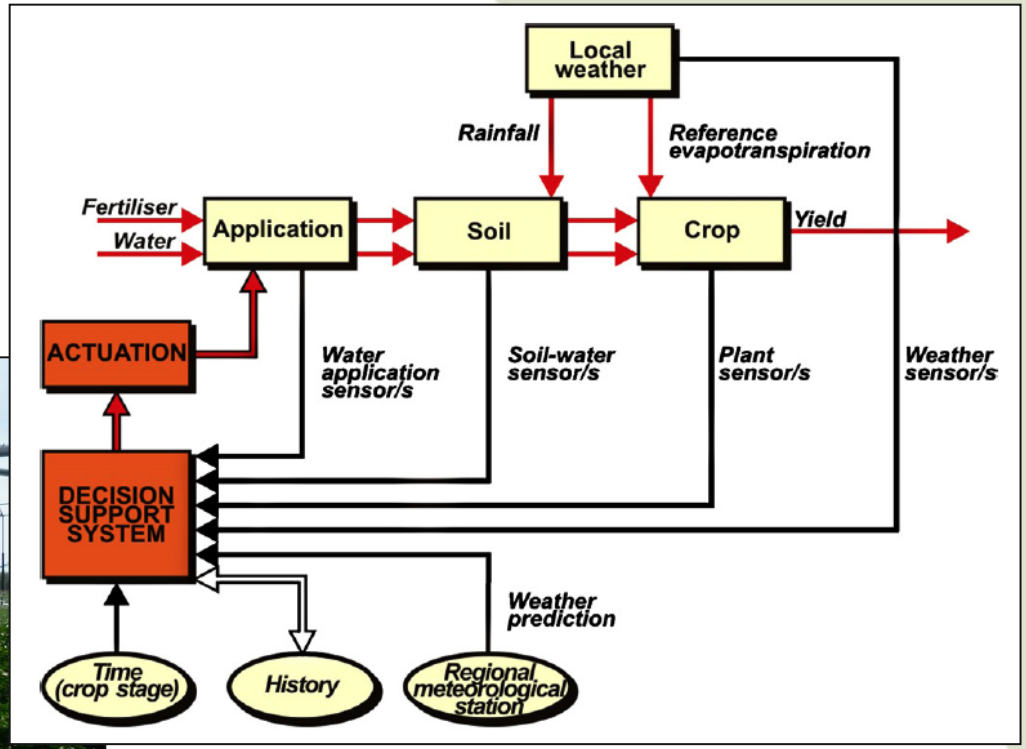
Soil

Crop inputs

‘VARIwise’

Adaptive control for spatially and temporally varied site specific irrigation

- **Spatial scale variations down to 1 m²**
- **Input of data at any temporal (time) scale**
- **Includes crop, soil and hydraulic models**



from: McCarthy, A C, Hancock, N H and Raine, S R (2010) Computers and Electronics in Agriculture , **70**(1) 117-128

Multiple Control Algorithm Options

Choice will depend on:

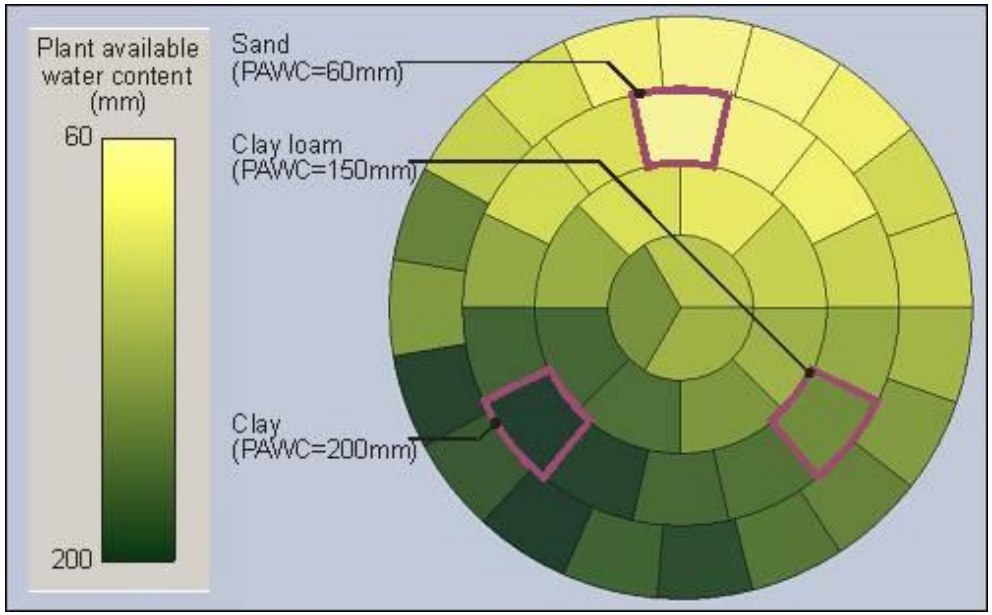
- **Measured data limitations (spatially and temporally)**
- **Knowledge of crop responses and interactions**
- **Objective target outcome**

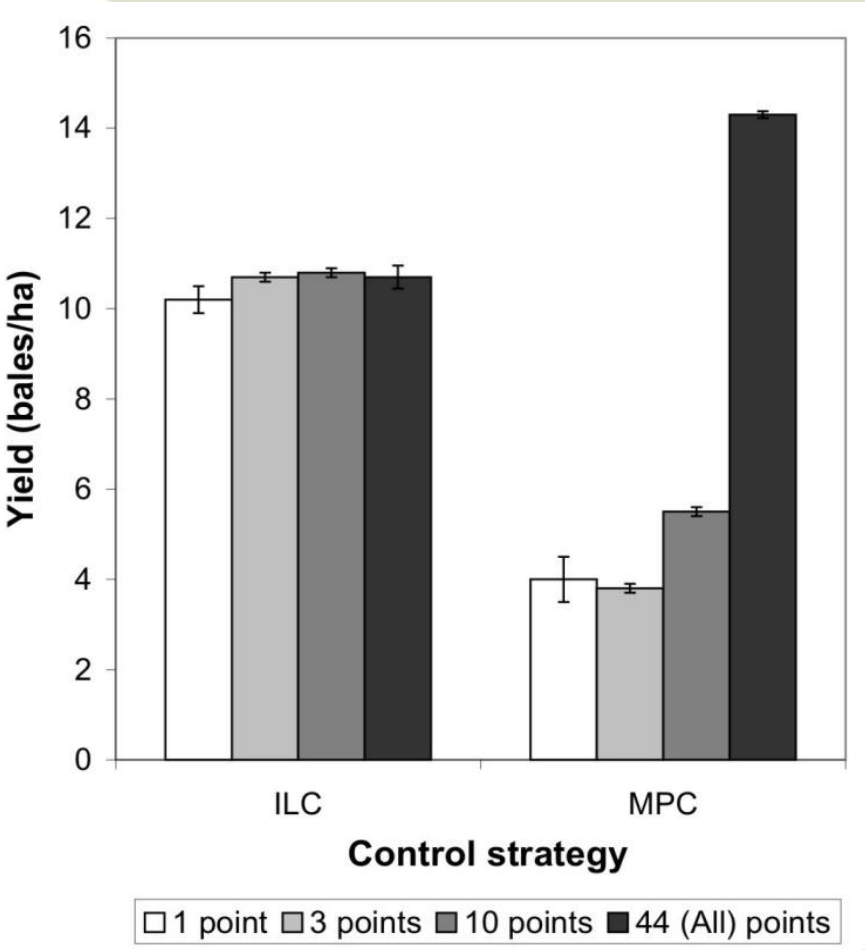
Two examples:

Iterative Learning Control (ILC) *– uses error between measured and desired to adjust next irrigation*

Model Predictive Control (MPC) *– uses a calibrated model to evaluate outcomes in advance*

How much infield data is needed?





Iterative Learning Control (ILC)

– ***best where data is sparse***

Model Predictive Control (MPC)

– ***needs intensive data set to maximise yields***

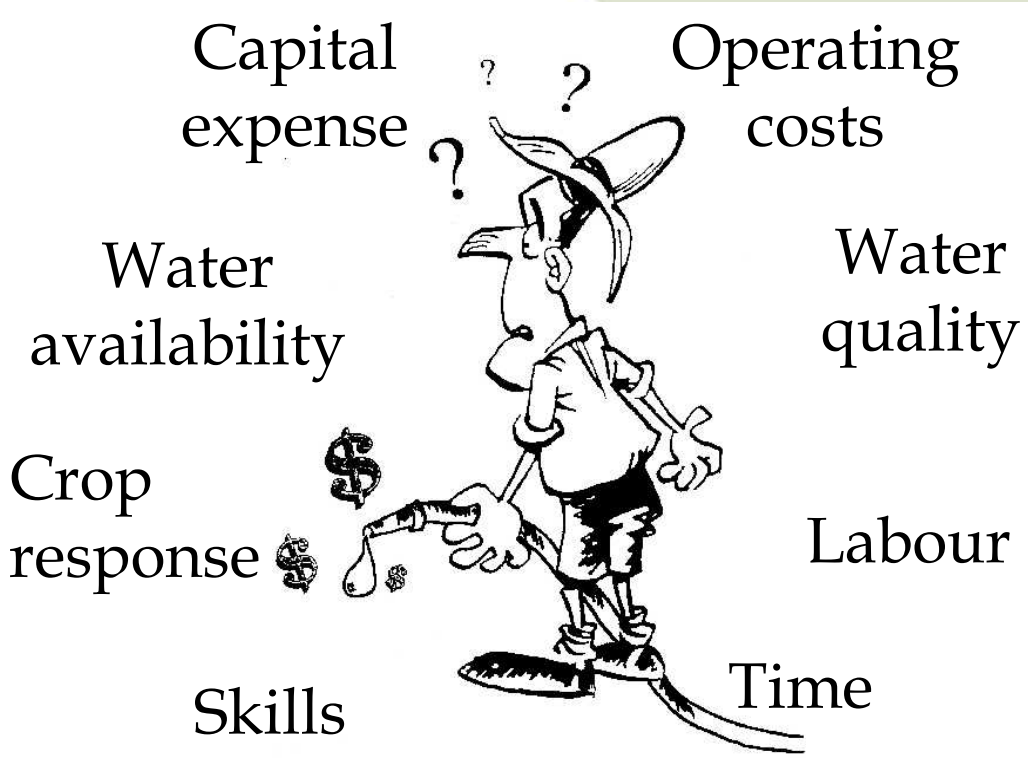
Technological adoption

- **Spatially variable irrigation may save water but uncertain yield benefits without improved prescription.**
- **Most likely makes sense where:**
  - ***High value crops sensitive to water applications***
  - ***Irrigation water is limiting or valuable***
  - ***High infield variability (e.g. topography, soils)***

We don't all do the same thing!

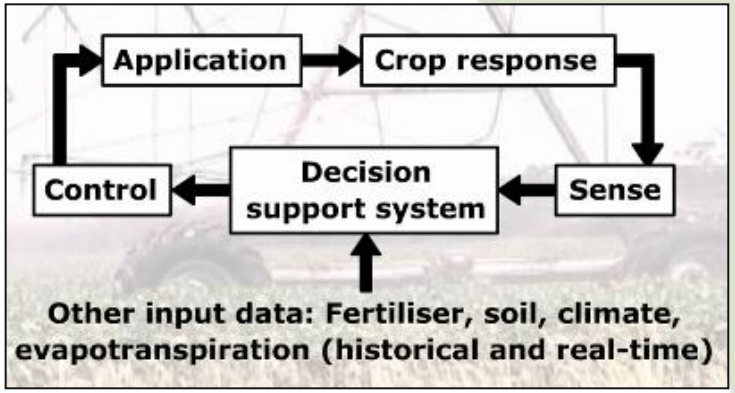
- ***Wide range of farm specific factors influence on-farm performance***
- ***No single technology/practice suitable everywhere***

⇒***"one size does not fit all"***



Conclusions

- ***Many of the challenges/drivers of future change are already apparent***
- ***Range of both regional and on-farm responses***
- ***Industry resilience dependent on ability to obtain volumetric and agronomic improvements***
- ***Automated closure of on-farm irrigation management loop***



⇒ ***The future of on-farm irrigation practice will require prescription adaptive control***

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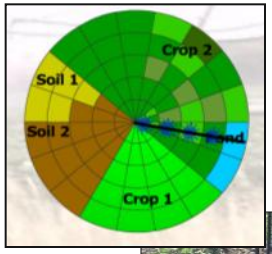

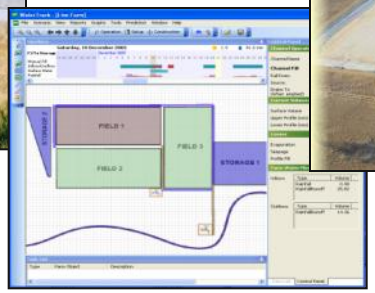

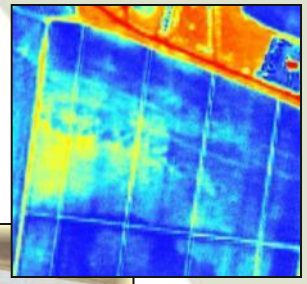

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