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The Crucial Role of Farmer Data in Effective Agricultural R&D

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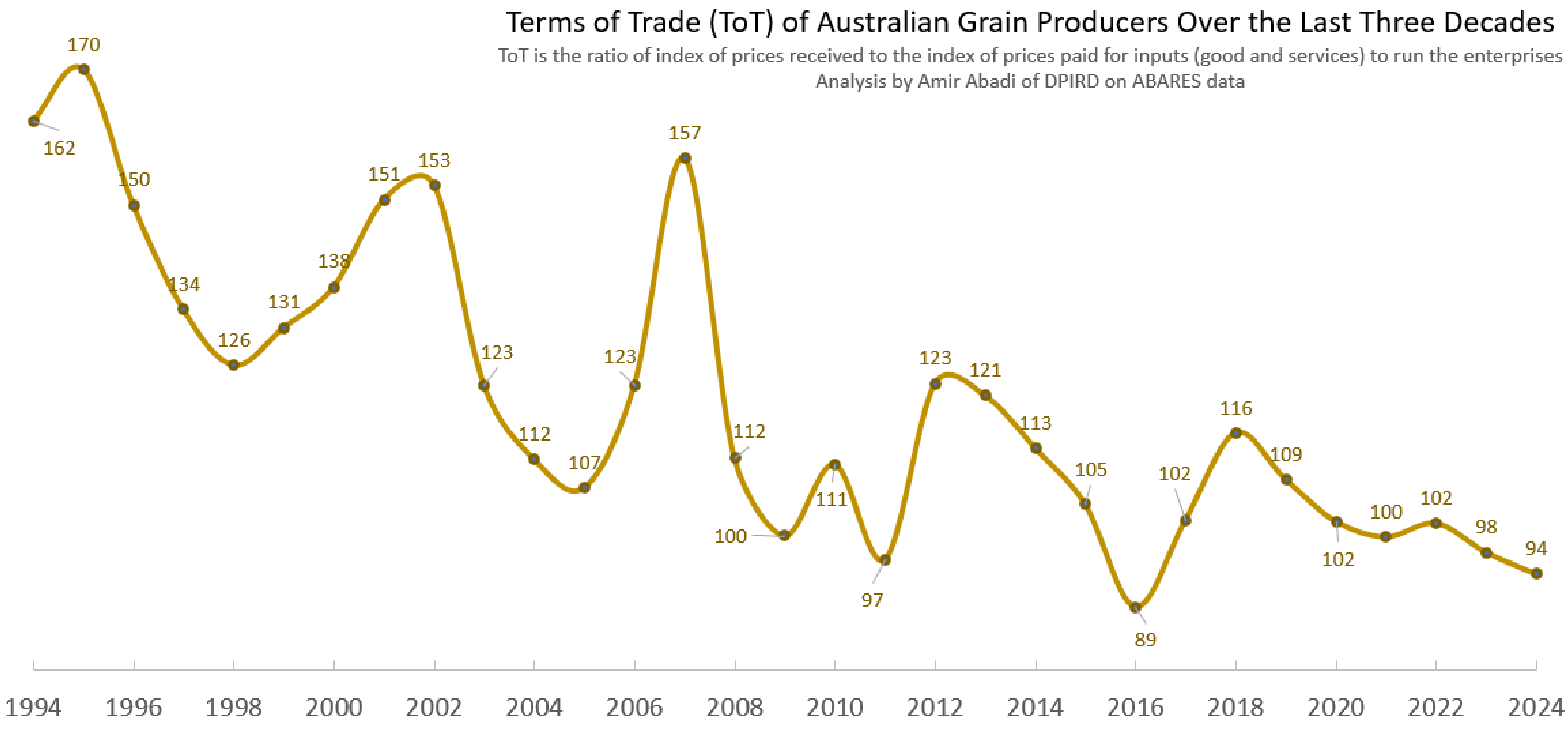
Productivity improvement is the key to enduring farm profitability

- In the recent 5 seasons:
  - value of agricultural production > $10 billion annually (over $19 billion in 2022.
- Continuing to meet emerging global consumer demands requires sustained profitability.
- Terms of Trade of growers have been declining for the past two decades
  - ToT is the ratio of prices received for commodities (e.g. wheat) to prices paid for inputs
- Farmers are “price takers” when they sell and when they buy inputs.
- Profitability is maintained by increase in productivity (e.g. yield improvements)

Productivity improvement is the key to enduring farm profitability

- Productivity improvements come from R&D outputs and farmers improving efficiency of operations.
- Analysis **specific farm data** is the key to improve efficiencies in the use of water, nutrients and radiation for growers, advisors and R&D providers.
- The **what, why, how, when, where and how** often of the data is collected is the key to improved decision making leading to sustained profitability
- Accounting for variability, counterfactual and inflation is important in the determination of cause and effect in data collection from farm practices and research trials.


Terms of Trade (ToT) of Australian Grain Producers Over the Last Three Decades
ToT is the ratio of index of prices received to the index of prices paid for inputs (good and services) to run the enterprises
Analysis by Amir Abadi of DPIRD on ABARES data
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WA Farmers Doing More with Less

R&D and improved management enabling farmers to extract more revenue out of a more variable and warming climate

Gross Value of Agricultural Production of WA

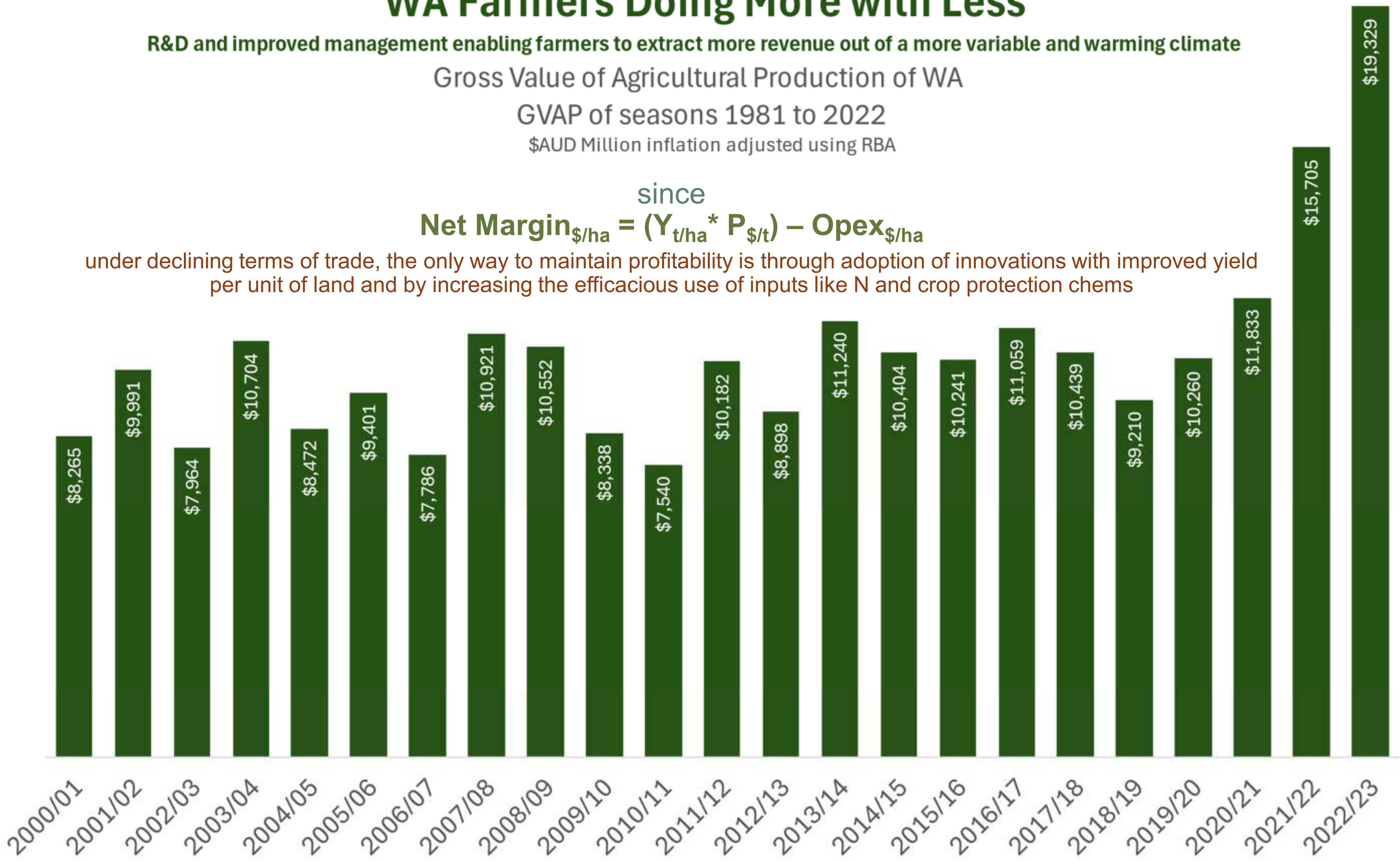
GVAP of seasons 1981 to 2022

$AUD Million inflation adjusted using RBA

since

$$\textbf{Net Margin}_{\$/ha} = (Y_{t/ha} * P_{\$/t}) - \textbf{Opex}_{\$/ha}$$

under declining terms of trade, the only way to maintain profitability is through adoption of innovations with improved yield per unit of land and by increasing the efficacious use of inputs like N and crop protection chems



Q: Why collect farm data?
A: To make improved decisions and make more profit
Q: What are the components of good farm decisions when there is so much variability?

1. **Actions:** List of practical, alternative, things a farmer may want to, or need to do, on a particular field or a crop;
2. **Events:** List of foreseeable states of nature e.g. rainfall and prices (L, M, H)
3. **Consequences:** Payoffs for each combination of action and state of nature;
4. **Likelihoods:** What are the probabilities that each of the listed events may occur?;
5. **Decision Criteria:** How will farmer choose the alternative available actions?
    - Includes appreciation of, and consideration for, risk preference of grower
    - Ranges from high risk aversion i.e. high dislike of variability in GM to moderate risk aversion.

Collecting farm data should enable good decisions under risk
The why question with examples

1. **Actions:**
    - grow wheat or canola, and how much input to apply to, it given the season and the likely response of crop to climate and inputs.
2. **Event:**
    - before seeding, what may be the yields under each rainfall deciles of 1, 5 and 9 (poor, average and good season).
3. **Consequences or payoffs:**
    - estimate of gross margin (GM) of each candidate crop with the anticipated yields, price and variable costs for the specified events.
4. **Likelihoods of events:**
    - Specify for each event (decile), subjectively but as realistically as possible, the likelihood of experiencing those deciles for that season.
5. **Farmer's choice criteria:** with consideration for risk appetite of grower
    - Maximising gross margin– e.g. choosing a crop that has the highest simple average payoff (gross margin) of the three likely states of nature.
    - Maximising expected payoff – e.g. estimating probability-weighted average (mean) GM of each option and choosing the highest one (assumes farmer is risk neutral i.e. is just happy making a $1Million as they are loosing a $1M for a farm with net-worth of $10M and 85% equity.
    - Maximising risk adjusted payoff, also known as maximising expected utility, or maximising certainty-equivalent GM – risk aversion accounted for.
    - Other criteria such as, Maximizing the minimum payoff, Maximizing the maximum payoff, Safety-first or maximizing expected GM subject to a probability of exceeding a minimum level, “stochastic dominance” – refer to agricultural economics literature for further explanation.

What data may be useful to collect?

Data Type	Estimate/Measure and Record	Impacts	Validate with
Climate projection of season	Probability of deciles 2, 5 & 9	Opex, yield	R&D Experts
Projected harvest price		Revenue	Experts
Land use choices made	Allocation to each crop	Net worth (equity)	Industry BM
Inputs used (type and price)	At purchase/app date/harvest	Opex, yield, GHG	Advisors
Soil Q:Physical/Chemical	soil type, pH, w-logging, fertility		Own record
Rainfall	Amount (GSR and Summer)	Profitability	R&D Experts
Temperature	Amount and duration	Profitability	
Soil macro nutrients	N, P, K…. & application rate	Opex, yield, GHG	
Soil micro nutrients	Level and rate applied		
Pathogens/Weeds/Pests	Loss anticipated & actual yield loss	Opex, yield	
Inputs applied (e.g. N)	Level and rate applied	Opex, yield, GHG	
Grain production volume	Yield	Profitability	
Cost of production	Per item by soil and crop type	Opex, GHG	Advisors
Grain quality	Protein, Screenings, …	Revenue	Industry BM
Grain prices received	Amount harvested by grade		
Water use efficiency	Grain yield of crop		
Nutrient Use Efficiency	Yield and grain quality	Revenue, Opex	
Crop Protection Efficiency			
Profit = (Y * P) - VC - FC	Per unit of land, tonne of grain, …	Net worth (equity)	Own records

Some ways of analysing the farm data?

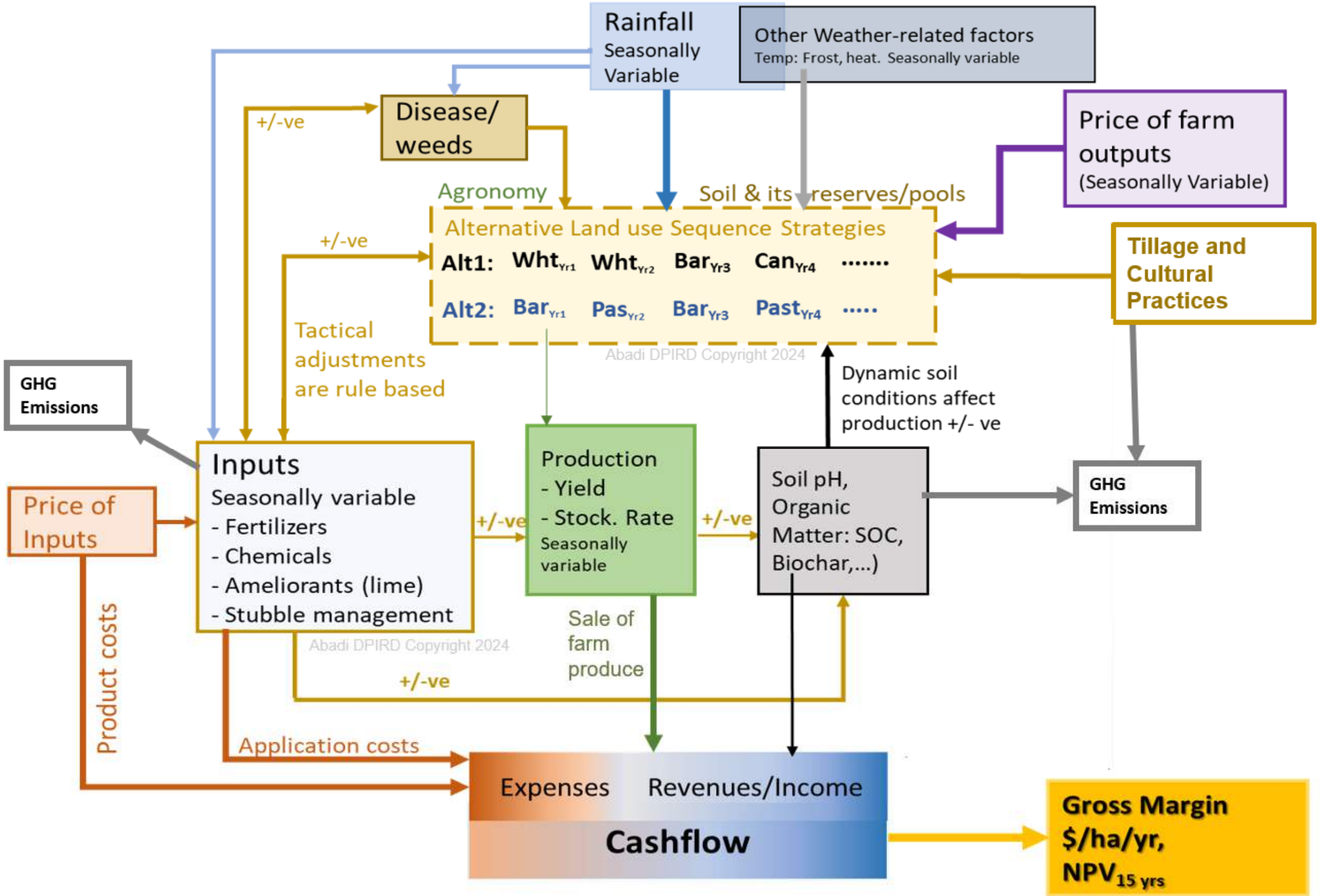
Data Type	Analyse	As compare to	Determines/Affects
Climate projection of season	Probability weighted yield	Hist Avg or simple average	Crop type, area, input level
Projected harvest price			
Land use choices made	Land use history, crop%	Expert advice, past records	Profitability
Inputs used (type and price)	Ratio: price input/ P output	Alternative inputs	App rate, crop yield
Soil Q:Physical/Chemical	Variation & change	Last year, no input zone	Yield and grain quality
Rainfall		Past records and 5-yr avg	
Temperature			
Soil macro nutrients	Crop response to Nil, L, H	Zones with Nil, less & more	
Soil micro nutrients			
Pathogens/Weeds/Pests			
Inputs applied (e.g. N)	Crop response to treatment		
Grain production volume	Response to treatment	Other soils, zones, treatment	Revenue, GHG
Cost of production	Per unit of land and weight	Zones with Nil, less & more	Yield and grain quality
Grain quality	Per tonne of grain	Nil/other treatments,	Price received for grain
Grain prices received		Prices offered by other buyers	Revenue
Water use efficiency	Yield per mm of rainfall	Similar farms, zones, inputs	Future land use/input rates
Nutrient Use Efficiency	Yield per kg of input used		Future input type and rate
Crop Protection Efficiency	Yield per unit of input used		
Profit = (Y * P) - VC - FC	YiYo variability	Producitvity zones and inputs	Future land use/input rates

What does the analysis of farm data tell us?

Data Type	Determines/Affects	Contingent on	Impacts
Climate projection of season	Crop type, area, input level	Manager's desire to know	Opex, yield
Projected harvest price			Revenue
Land use choices made	Profitability	Skill, preference, rain, market	Net worth (equity)
Inputs used (type and price)	App rate, crop yield	Market power: buyer/seller	Opex, yield, GHG
Soil Q:Physical/Chemical	Yield and grain quality	Cultural practices, Inputs	
Rainfall		Input levels	Profitability
Temperature		Rainfall/Input Levels	Profitability
Soil macro nutrients		Rainfall, timing	Opex, yield, GHG
Soil micro nutrients		Rainfall	
Pathogens/Weeds/Pests		Climate, IPM	Opex, yield
Inputs applied (e.g. N)		Rain and temeprature	Opex, yield, GHG
Grain production volume	Revenue, GHG	Climate, input (timing/rate)	Profitability
Cost of production	Yield and grain quality	Climate and other inputs	Opex, GHG
Grain quality	Price received for grain	Rainfall, temp, key inputs	Revenue
Grain prices received	Revenue	Market power: buyer/seller	
Water use efficiency	Future land use/input rates	Temp, Nutrient, IPM choices	
Nutrient Use Efficiency	Future input type and rate	Rainfall, temp, key inputs	Revenue, Opex
Crop Protection Efficiency			
Profit = (Y * P) - VC - FC	Future land use/input rates	Skill, climate, market	Net worth (equity)

Matrix of some farm data that may be useful for R&D collaboration

Data Type	Timing/Priodicity	Scale/Source	Estimate/Measure and Record	Analyse	As compare to	Determines/Affects	Contingent on	Impacts	Validate with
Climate projection of season	Key growth stages	Farm/Block	Probability of deciles 2, 5 & 9	Probability weighted yield	Hist Avg or simple average	Crop type, area, input level	Manager's desire to know	Opex, yield	R&D Experts
Projected harvest price		Futures/Forwards						Revenue	Experts
Land use choices made	Annualy	Paddocks/Farms	Allocation to each crop	Land use history, crop%	Expert advice, past records	Profitability	Skill, preference, rain, market	Net worth (equity)	Industry BM
Inputs used (type and price)	Key growth stages	Market	At purchase/app date/harvest	Ratio: price input/ P output	Alternative inputs	App rate, crop yield	Market power: buyer/seller	Opex, yield, GHG	Advisors
Soil Q:Physical/Chemical	Annually	Paddock and soil	soil type, pH, w-logging, fertility	Variation & change	Last year, no input zone	Yield and grain quality	Cultural practices, Inputs		Own record
Rainfall	Daily	Farm/Block	Amount (GSR and Summer)		Past records and 5-yr avg		Input levels	Profitability	R&D Experts
Temperature	Key growth stages	Paddock and soil	Amount and duration				Rainfall/Input Levels	Profitability	
Soil macro nutrients	Annually	Soil, field zone	N, P, K.... & application rate	Crop response to Nil, L, H	Zones with Nil, less & more		Rainfall, timing	Opex, yield, GHG	
Soil micro nutrients			Level and rate applied				Rainfall		
Pathogens/Weeds/Pests	Key growth stages		Loss anticipated & actual yield loss				Climate, IPM	Opex, yield	
Inputs applied (e.g. N)		Soil, zone, season	Level and rate applied	Crop response to treatment			Rain and temeprature	Opex, yield, GHG	
Grain production volume	Annually	Soil, field zone	Yield	Response to treatment	Other soils, zones, treatment	Revenue, GHG	Climate, input (timing/rate)	Profitability	
Cost of production	Key growth stages		Per item by soil and crop type	Per unit of land and weight	Zones with Nil, less & more	Yield and grain quality	Climate and other inputs	Opex, GHG	Advisors
Grain quality	Annualy	Paddock and zone	Protein, Screenings, …	Per tonne of grain	Nil/other treatments,	Price received for grain	Rainfall, temp, key inputs	Revenue	Industry BM
Grain prices received	By time of sale	Crop type	Amount harvested by grade		Prices offered by other buyers	Revenue	Market power: buyer/seller		
Water use efficiency	Annualy	Soil, field zone	Grain yield of crop	Yield per mm of rainfall	Similar farms, zones, inputs	Future land use/input rates	Temp, Nutrient, IPM choices		
Nutrient Use Efficiency			Yield and grain quality	Yield per kg of input used		Future input type and rate	Rainfall, temp, key inputs	Revenue, Opex	
Crop Protection Efficiency	Key growth stages			Yield per unit of input used					
Profit = (Y * P) - VC - FC	Annually	Farm and field	Per unit of land, tonne of grain, …	YiYo variability	Producitvity zones and inputs	Future land use/input rates	Skill, climate, market	Net worth (equity)	Own records



A useful framework for coherent integration of farm data, with information from research trials, commodity markets, and industry benchmarks.

Q: what to share and learn and why!

Recall:

$$Margin_{\$/ha} = (Y_{t/ha} * P_{\$/t}) - Opex_{\$/ha}$$

Conclusion

- Experimenting with own farm trials, and learn from trials of other growers, advisors, and researchers, is least costly when done over small areas over several seasons.
- Cooperate and reciprocate in sharing farm and research trial data for systematic learning by individuals, farming community and R&D institutions.
- Implement, measure and record the fate of a counterfactual in conjunction with innovation being trailed and treatments applied to it.
    - e.g. when trialing a new crop, say a pulse, grow a strip of wheat, or another usual crop, next to the trial, and grow the counterfactual with usual care and inputs.
- Advisors conducting analysis of profitability of alternatives land uses and inputs should do that with consideration of risk. Results of risk-adjusted outcomes outlined in this presentation is more informative than typical gross margins.

Conclusion

- Advisors comparing costs, prices and gross margins or net margins (profit) over more than three years, should index the values for inflation (CPI). A dollars buys less now than it did five years ago.
- Making evidence–based decisions backed by state-contingent decisions analytics improves making good decisions under climate variability and change.
- But remember, good decisions will in some seasons and under some circumstances lead to undesirable outcomes, which should have been foreseen and considered in the analysis.
- If actual outcomes are surprising and unanticipated then question how thoroughly the risks (states of nature and their probabilities) were accounted for.

Thank you

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