Whole-farm Economic Modelling

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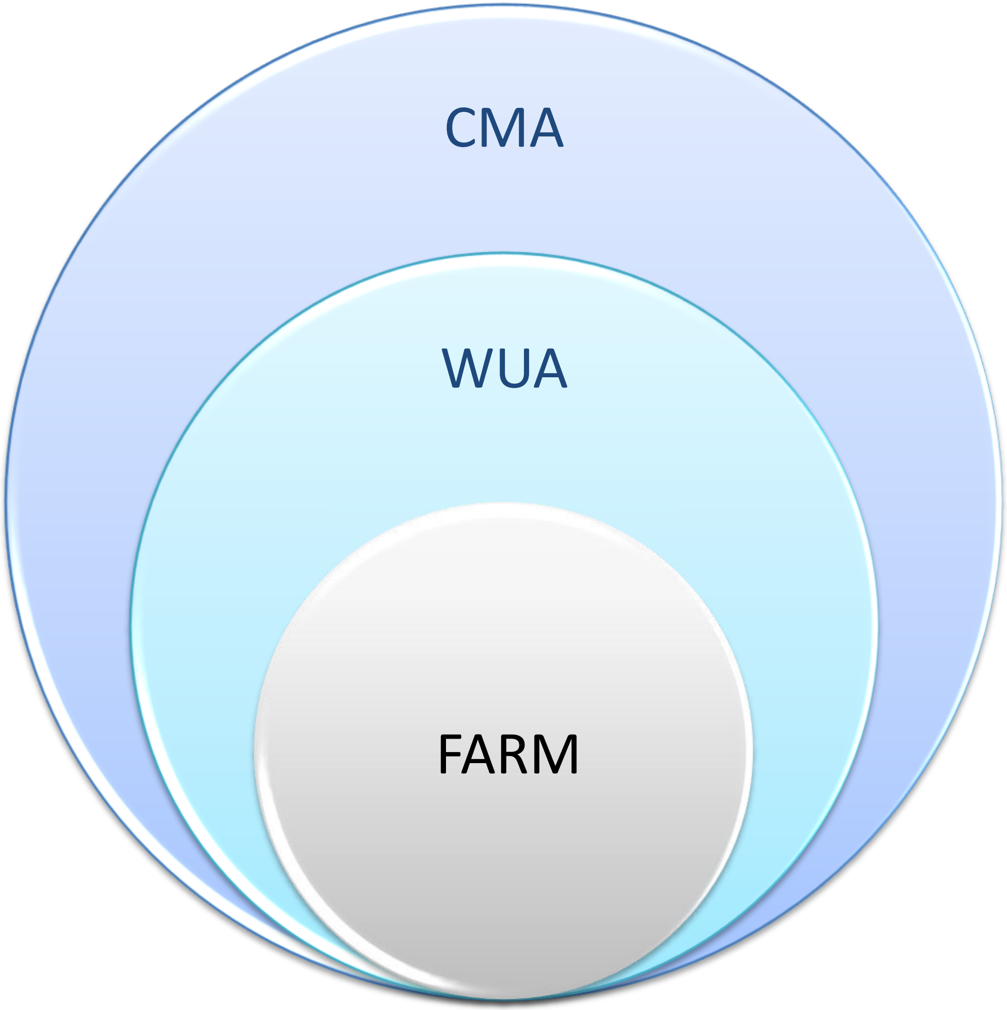
31 August 2011

Another project sponsored by www.wrc.org.za

Introduction

- Preferred approach
- Factors to consider
- Research priorities
- Evaluate progress
- Summary
- Conclusions

Holistic Systems Approach



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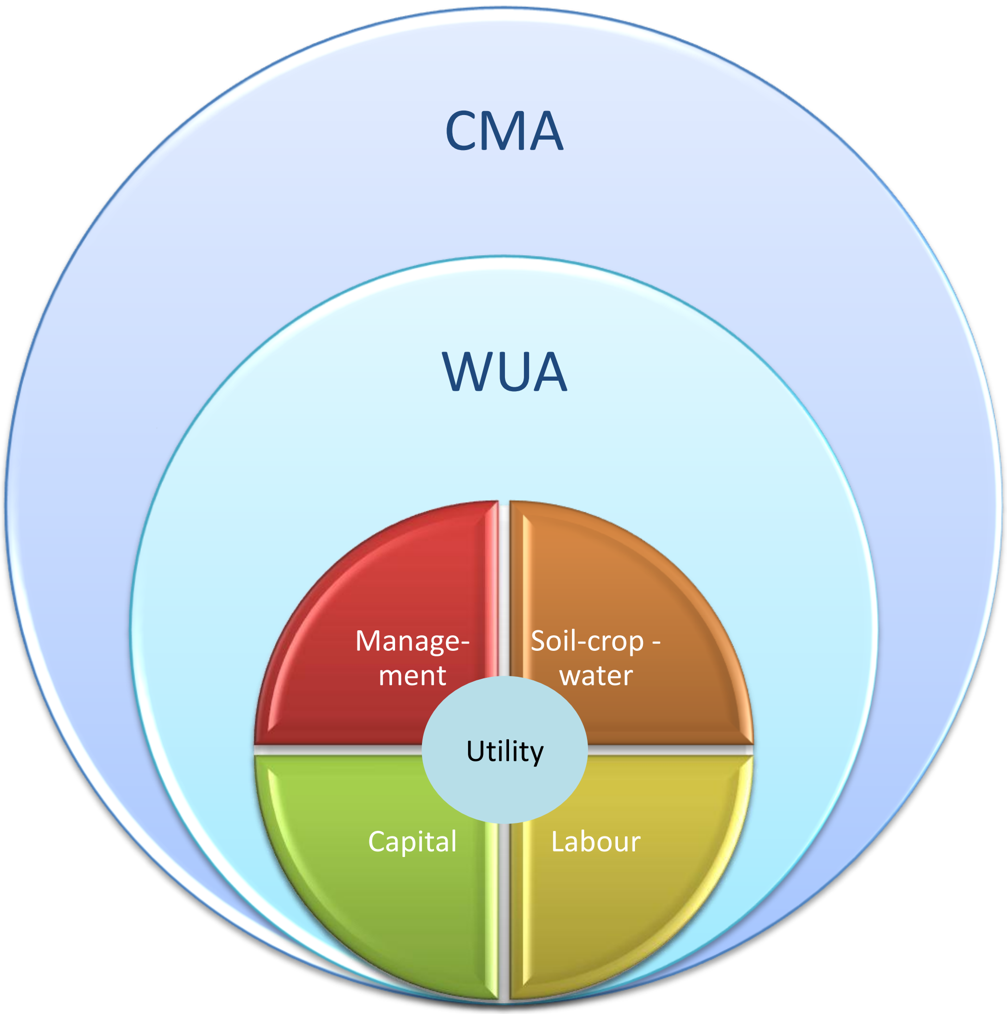
Holistic Systems Approach



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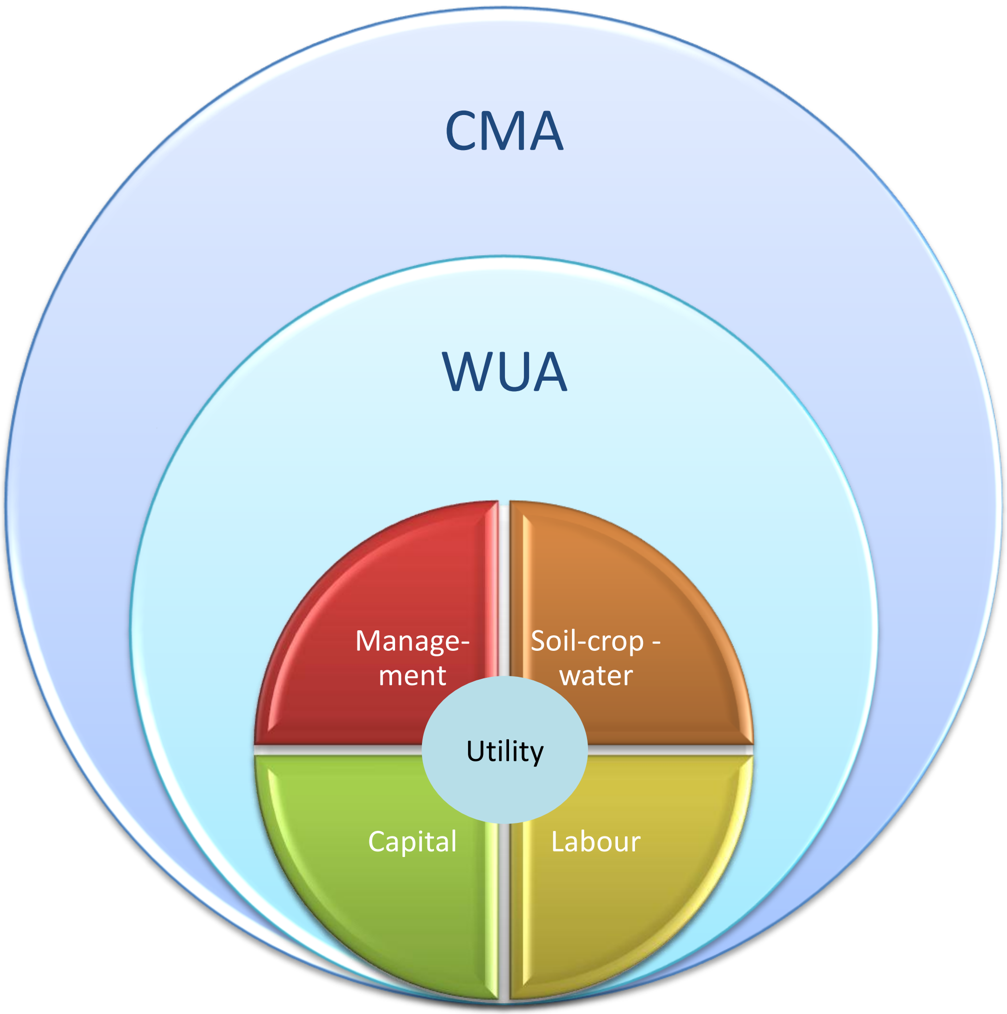

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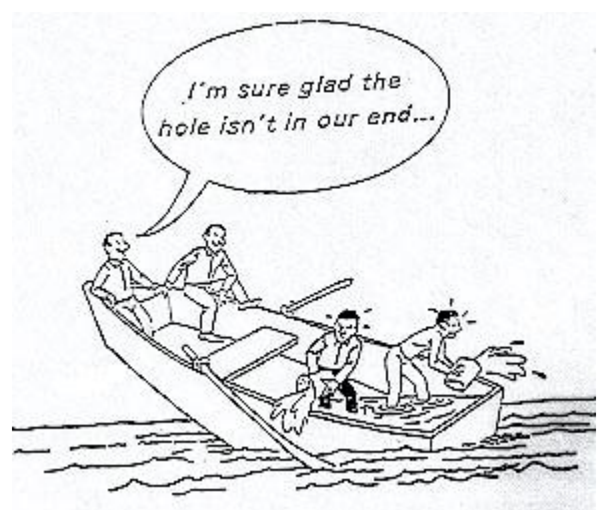


Irrigation Economics Research

- Need information regarding the relationship governing the transformation of water resource inputs to crop outputs
  - Soil water is a stock resource (Dynamic)
    - Irrigation decisions in one period influence the availability of water in subsequent time periods and ultimately crop yield
  - Stochastic nature
    - Weather (crop water demand and runoff)
    - Water deficits will increase crop yield variability
    - Risk preferences
  - Applied water vs consumed water
    - Farmer control gross water applications
    - Water consumption determines crop yield
- Opportunity cost of resource (limited availability)
  - Forgone profit of using resource for another purpose
  - Allocating scarce resources (water, capital, land & labour)

Priorities
Backeberg & Oosthuizen (1991)

- Crop simulation for optimal water and energy use on a whole-farm basis
- Analysis of decision process, utility profiles and risk preferences of irrigation farm managers
- Dynamic and stochastic modelling of irrigation farming systems
- Analysis of appropriate technology for subsistence, emerging and commercial farming

"Development of a decision support system for increasing the economic efficiency of water and energy use for irrigation at whole farm level." (1996)

- Main concern was with the development of economic models and methods to increase water and energy use efficiency at a whole farm level
  - FARMS –simulation model
    - SPILCOST - dragline
  - SIMCOM – optimisation model

- FARMS – simulation model
  - Spreadsheet 1
    - Comprehensive enterprise budget generator
    - Linked to whole-farm cash flow
  - Spreadsheet 2
    - Add overheads
    - Balance sheet / Income statement
  - Spreadsheet 3
    - Risk simulation (crop yield, prices, interest rates, hail)
  - Risk efficiency applications
    - Energy management strategies
    - Crop rotations
    - Irrigation scheduling
  - Ignores opportunity cost of irrigation water

- SIMCOM-optimisation model
  - Ceres-Maize crop growth simulation model linked to optimisation search algorithm
    - Single crop fixed area
    - Determine irrigation water applications
    - Maximise utility (risk efficiency) under limited water supply
      - Opportunity cost: water applications within season for maize
      - Does not consider other crops –> sub-optimal whole farm water use
  - Application
    - Value of irrigation scheduling information
    - Economic impact of energy load restrictions
  - Not a whole-farm application of water use optimisation

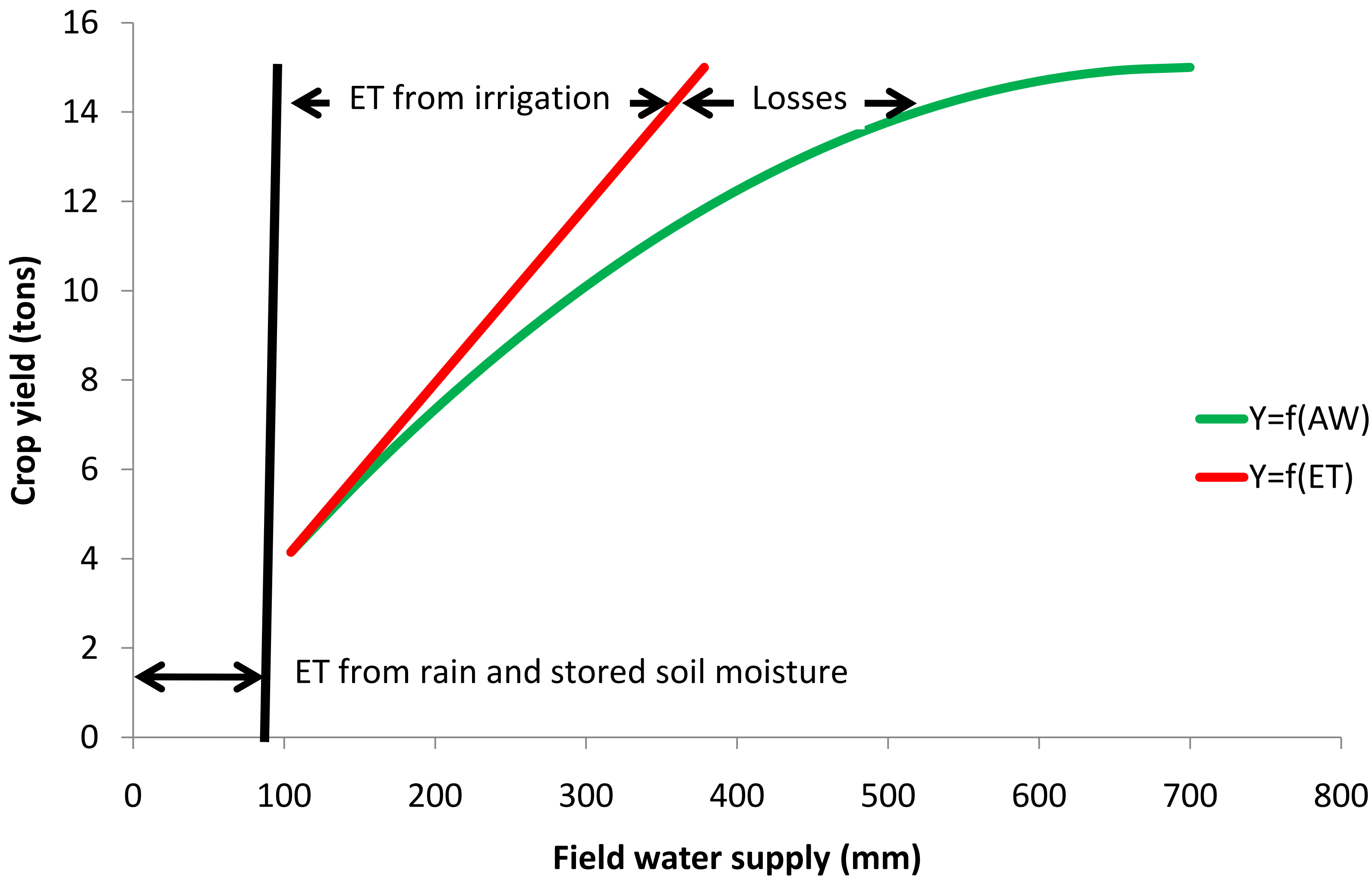
- Modelling water supply variability (hydrology) and environmental demand (IFR) on the economics of irrigation farming
  - Hydrological simulation (ACRU)
    - Quantify irrigation water availability
    - Quantify crop yield risk of wheat
      - Water budget calculations for specific irrigation strategy
      - Area planted affect water use per hectare
      - Relative ET deficits where used to calculate crop yield
  - Economic modelling
    - Simulation approach
    - Optimisation approach

FARMS –simulation

- Application 1
  - Determine risk efficient area to irrigate (Baseline)
  - ACRU simulated crop yield risk as inputs in FARMS
  - Simulate Cash flow risk of irrigating different areas
  - Choose amongst areas using SDRF
    - Risk preferences of decision-makers
- Application 2
  - Economic impact of water curtailment over long-run
  - Advanced risk simulation procedures to generate long-run risk matrixes

- CCODI-optimisation model
  - Optimise agricultural water use given water is allocated to maintain IFR under variable water supply
  - Water use optimisation
    - Y=f(ETa/ET)
    - ETa = f(AW)

Relationship between ET and crop yield & applied water and crop yield



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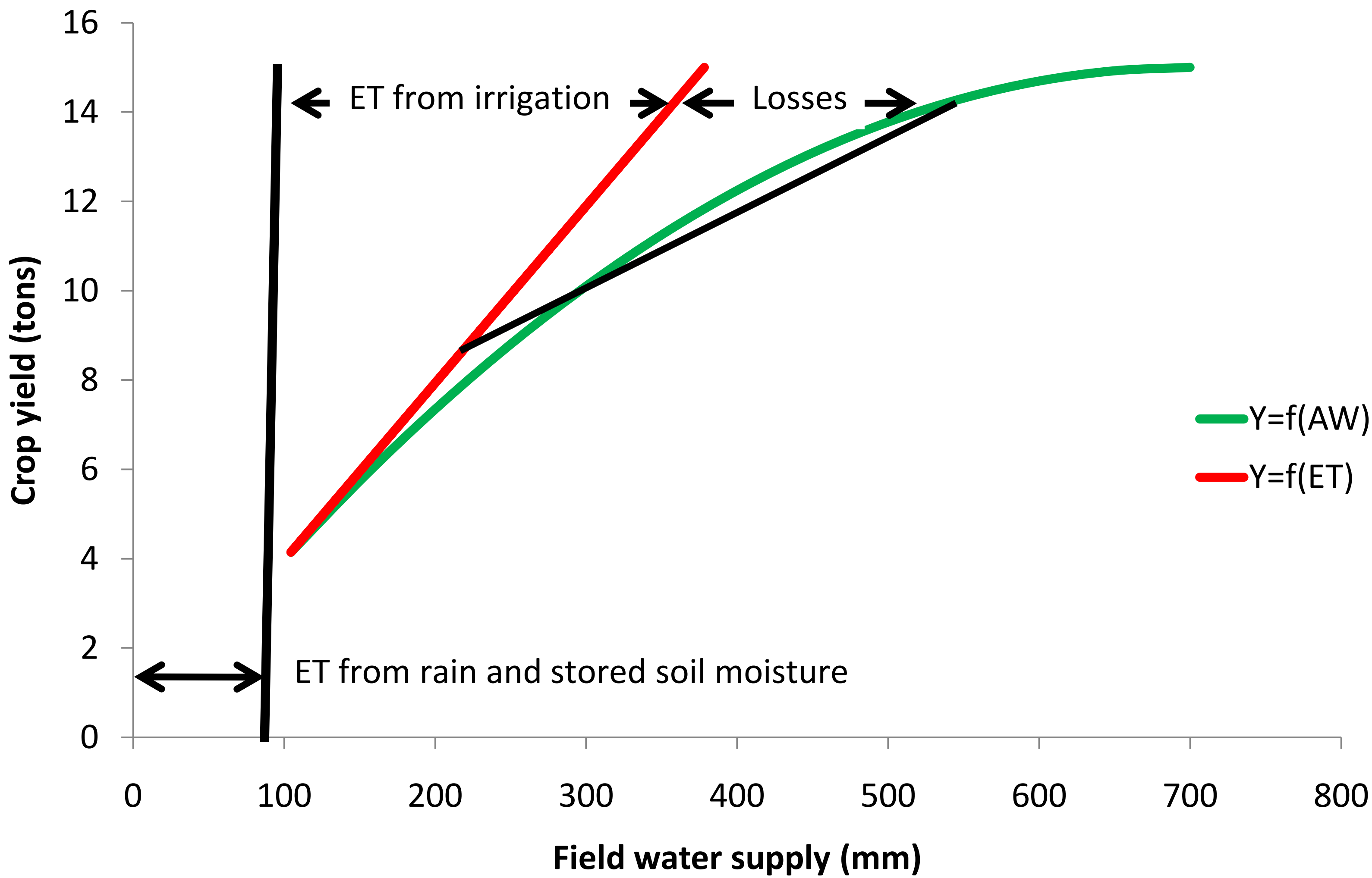

Optimisation approach

- Optimise agricultural water use given water is allocated to maintain IFR under variable water supply
- Water use optimisation
  - Y=f(ETa/ET)
  - ET = f(AW)
  - Water supply risk was modelled as deterministic equivalents
    - Deterministic model with no link between crop yield and water supply variability
- Application
  - Tradeoff between larger areas with full irrigation and smaller areas with deficit irrigation
  - Impact of irrigation efficiency increases
  - Return flow externalities

“Generalised whole-farm stochastic dynamic programming model to optimize agricultural water.” (2005)

WATER RESEARCH COMMISSION

- Optimise agricultural water use and irrigation technology investments under water restrictions
- Simulation-optimisation approach
  - SAPWAT-Excel to determine water use and crop yield risk of 350 different irrigation schedules
    - Inefficiencies where modelled using distribution uniformity of irrigation systems: ETa = f(AW, DU)
    - Y=f(ETa/ET)
  - Optimisation model was used to optimise water use between multiple crops, over the growing season
    - Amount of irrigation schedules determine level of optimality
    - Maximises certainty equivalents rather than utility

"Generalised whole-farm stochastic dynamic programming model to optimize agricultural water." (2005)

- SKELETON dynamic linear programming model
  - Evaluate the financial feasibility of investing in more efficient irrigation technology
  - Generalised procedures
    - Transferability between situations
  - Detail financial model
  - Simplified irrigation water use optimisation
    - Full irrigation water demand schedules
  - Incorporate risk into the model
    - Advanced risk simulation procedures to generate long-run risk matrixes

- Model financial feasibility of water curtailments taking the catchment operating rules and irrigation water supply reliability into account.
  - Integrated set of models
    - ACRU – simulated water availability on daily basis
    - Mike-BASIN – reconcile daily water demand with daily water availability
      - International flow requirements
      - Environmental flows
      - Catchment operating rules
    - ODI optimisation model provide irrigation water demand schedule
      - Explicitly models ETa = f(AW, DU) on weekly basis
      - Y=f(ETa/ET)

- Improve IrriCost to handle alternative irrigation systems combinations
- IrriCost
  - Uses irrigation system characteristics and management information to estimate fixed and operating cost of irrigation systems
    - Pivot and Sprinkler
    - Delphi
    - Different electricity tariffs structures
  - System combinations
    - Pivot , Sprinkler, Flood, Drip and Micro
    - Separate calculations for mainline and irrigation systems
    - Excel based
  - Design of the system plays important role in the reducing energy cost

Summary

Simulation approach

- Enterprise level
  - Single crop/ fixed area
  - Detail analysis of prescribed irrigation scheduling alternatives
  - Risk efficiency
- Whole farm (LR &SR)
  - Detail financial analysis
  - Predefined systems
  - Risk efficiency
- Opportunity cost ignored
  - Allocating resources

Optimisation approach

- SimCom
  - Single crop/ fixed area
  - Detail presentation of soil crop water sub- system
  - Opportunity cost within season
  - Risk efficiency
- Optimisation A
  - Output from simulation model
  - Good presentation of dynamics
  - Risk efficiency
- Optimisation B
  - Explicit modelling of Y=f(AW)
  - Risk efficiency
- Whole-farm (LR)
  - Simplification of crop-soil-water subsystem

Conclusions
Backeberg & Oosthuizen (1991)

- Crop simulation for optimal water and energy use on a whole-farm basis
  - Made huge strides but NO. Optimise FARMS (SR)
- Analysis of decision process, utility profiles and risk preferences of irrigation farm managers
  - Do we know enough about the decision process?
- Dynamic and stochastic modelling of irrigation farming systems
  - Long –run dimensionality problems

THANK YOU

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