



INCORPORATING BEHAVIOURAL AND BIOPHYSICAL FACTORS IN IRRIGATION DEMAND MODELLING

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Presentation Outline

- Background
- Behavioral Factors
- Biophysical Factors
- Integration
- Model Testing
- Conclusions

Background

- Research aims:
 - Review existing demand modelling methodologies
 - Incorporate behavioural factors into irrigation demand models
 - Incorporate uncertainty explicitly in demand models

Background

- Models reviewed:
 - PRIDE, IQQM Crop Model 2, CLASS CGM, Tiddalik, SWAGMAN Farm, MSM, PERFECT, TERM-Water, WRAM, SALSA
- Characteristics analysed:
 - Biophysical Factors, Behavioural Factors, Supply Factors, Time-step, and Spatial scale
- Example:

<i>Model</i>	<i>Biophysical Factors</i>	<i>Behavioural Factors</i>	<i>Supply Factors</i>	<i>Time-step</i>	<i>Spatial scale</i>
PRIDE	Crop factors, soil characteristics	Autumn irrigation, reduction factors	Main channels	Daily to monthly	Farm to district

Behavioral Factors

- Farming objectives:
 - Maximize wealth
 - Minimize risk of income variability (or yield loss, or water shortage, etc.)
 - Minimize farm management complexity
- Activeness
 - Amount of time and money spent on collecting farm-related information
 - Use of technology
- Personal beliefs, perceptions and experiences
 - Risk attitude
 - Rainfall forecasts
 - Allocation forecasts

Behavioral Factors

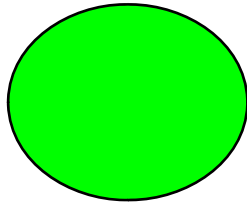
- Conflicting farming objectives example

Example Farm:

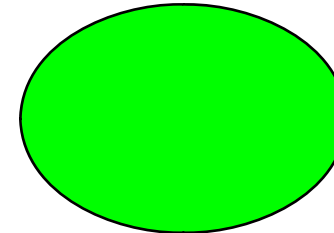
Irrigable area = 200ha
Water Entitlement volume = 400 ML
Expected profit = \$400/ha
Normal water usage = 4 ML/ha
Normal irrigation area = 100ha

Example Allocation Scenario:

Initial allocation = 50%
(200 ML allocated volume)
Final allocation probabilities:
>=50% allocation = 100 % chance
>=80% allocation = 80% chance
>=100% allocation = 20% chance

Option 1: No Risk and Low Profit

Irrigation area = 50ha
Expected profit = \$20,000
Expected water use = 200ML
Risk of water shortage = Chance of not getting 50% allocation = 100% – 100% = 0%

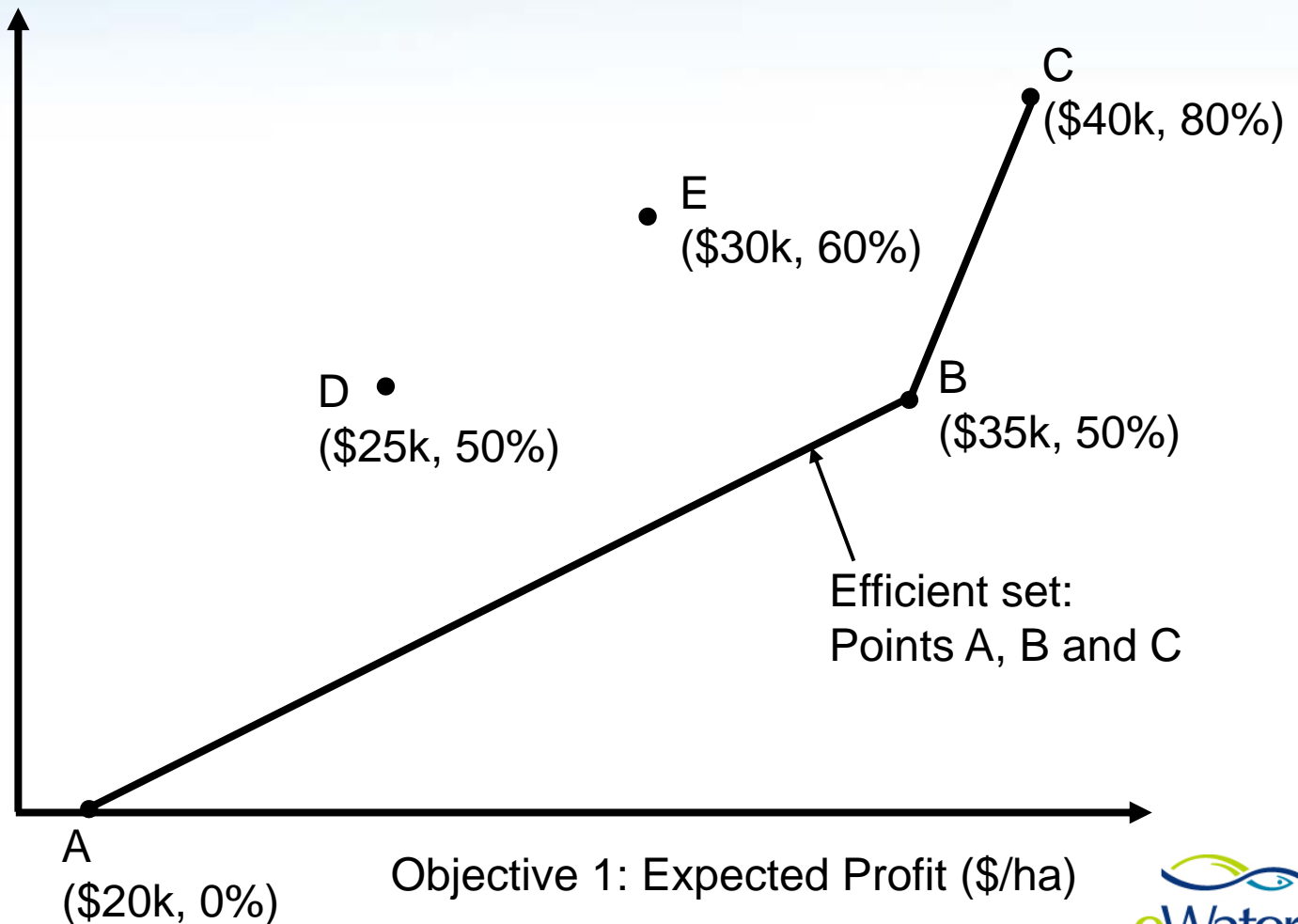
Option 2: High Risk and High Profit

Irrigation area = 100ha
Expected profit = \$40,000
Expected water use = 400ML
Risk of water shortage = Chance of not getting 100% allocation = 100 %– 20% = 80%

Behavioral Factors

- Conflicting farming objectives

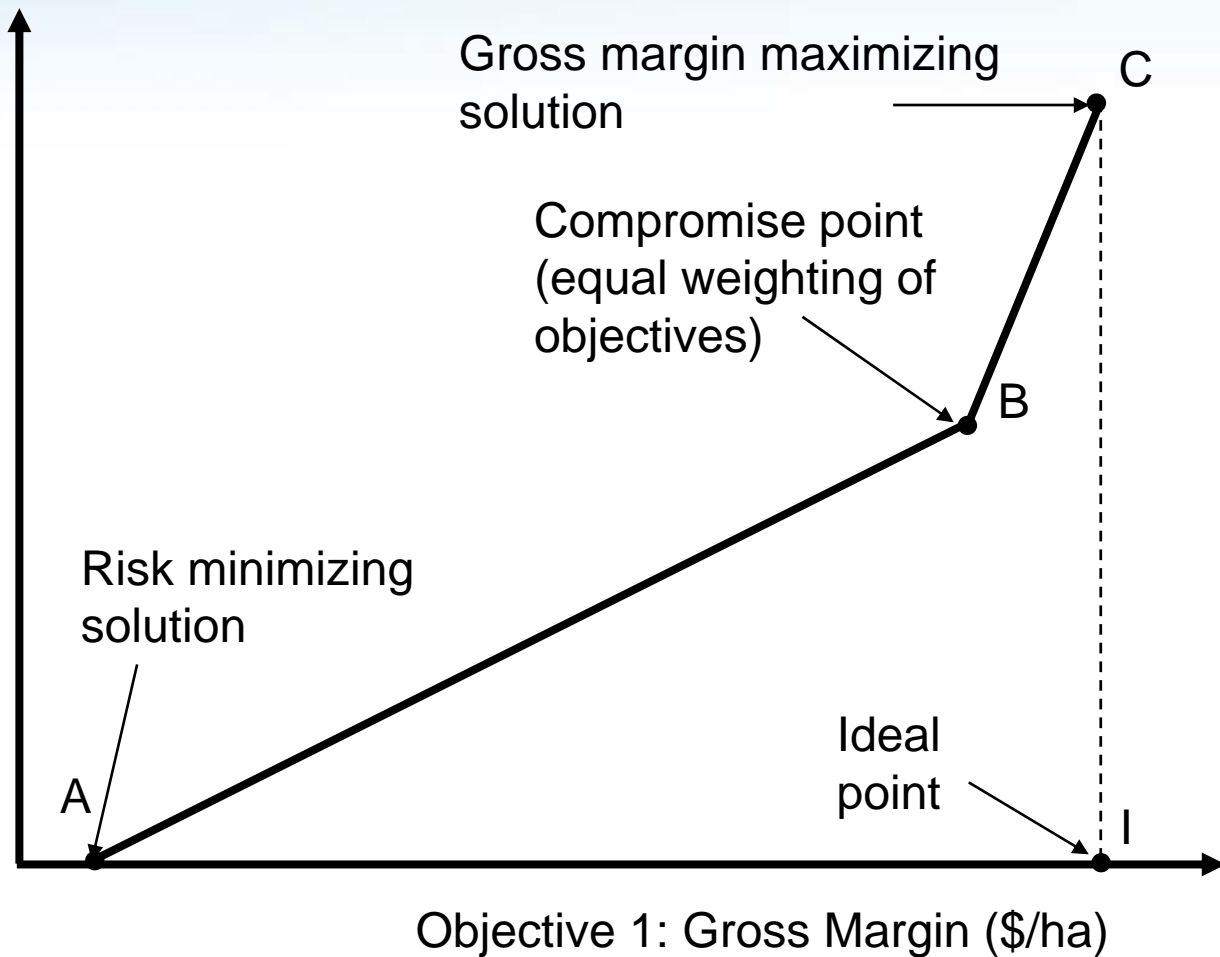
Objective 2:
Risk of Yield
loss due to
water
shortage (%)



Behavioral Factors

- Compromise Point (tradeoff)

Objective 2:
Risk of Yield
loss due to
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Behavioral Factors

- Risk of suffering a water shortage

Given that:

chance of water shortage is proportional to volume of water required

Let:

chance of shortage = $k \times$ volume required

Where: k = rate of change in chance with respect to allocated volume, this is determined by allocation probabilities.

Then for a unit area of a crop: (CWR)

(chance of shortage / area) = $k \times$ (volume required / area)

Thus: chance of water shortage is proportional to crop water requirement (CWR)

- Therefore: minimising CWR is equivalent to minimising chance of suffering a water shortage

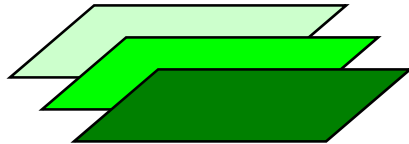
Biophysical Factors

- Cropping unit (like a paddock)
 - Crop (sow dates, crop factors, growth stages, max. root depth, ponding requirements, expected water usage)
 - Crop area
 - Irrigation system (trigger depth, ETc/SMD scheduling, drainage options, application rates)
 - Soil type (depth of layers, saturation level, hydraulic conductivity, wilting point, field capacity, surface storage depth, initial water table depth)

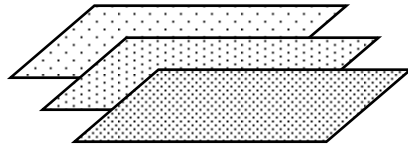
Biophysical Factors

- Cropping unit (like a paddock)

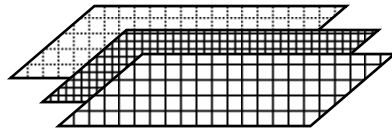
Different cropping options



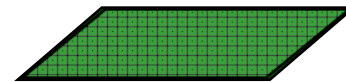
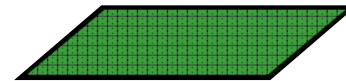
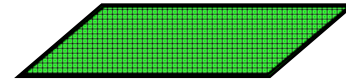
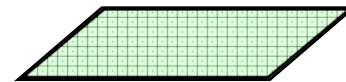
Different soil options



Different irrigation options



Different cropping units (paddocks)



Integration

- **Setting startup areas for cropping units**
 - Tradeoff (compromise) between conflicting objectives (maximize gross margins vs minimize risk of suffering water shortages)
 - Efficient set and compromise set of crop mixes
- **Rejection of irrigation orders**
 - For systems with lag time of several days
 - Canceling orders after heavy rainfall
- **Expected rainfall**
 - Conservative estimate, i.e. no rainfall

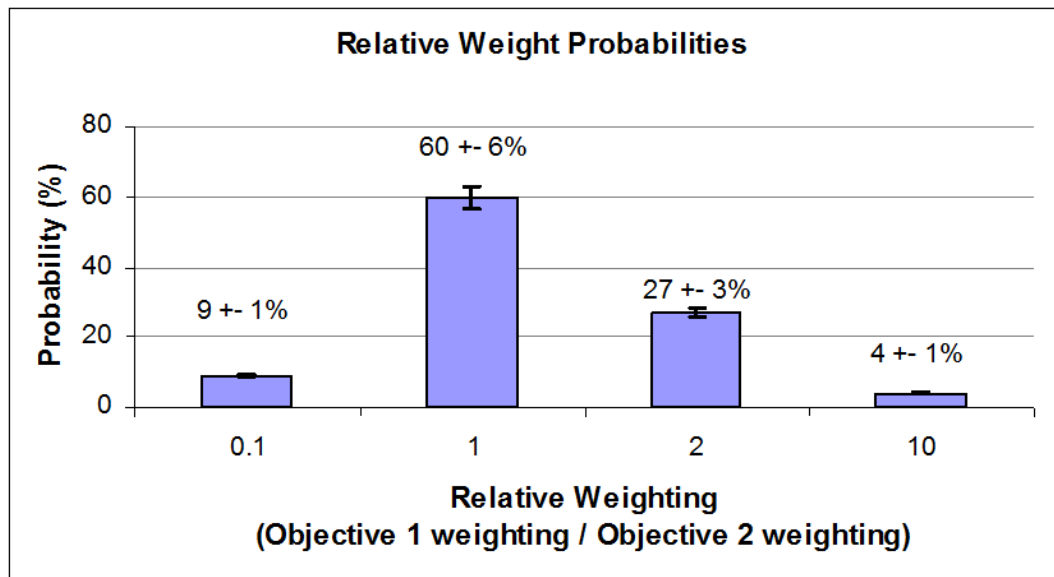
Model Testing

<i>Feature</i>	<i>Finley</i>	<i>Shepparton</i>
Area Normally Irrigated (ha)	150,000	51,000
Total Area (ha)	403,700	81,750
Entitlement Volume (ML)	900,000	181,500
Approximate water usage (ML/yr)	500,000	200,000
Main Agricultural Activities	Rice, cereal crops, pastures	Dairying, stone and pome fruit, mixed cropping and grazing
Water Order Data	Daily from 1998-2004	Weekly from 1994-2004
Climate Data	Daily data up to 2004	Daily data up to 2004
Cropping Data	Areas annual from 1998	Areas and yield for few years

Model Testing

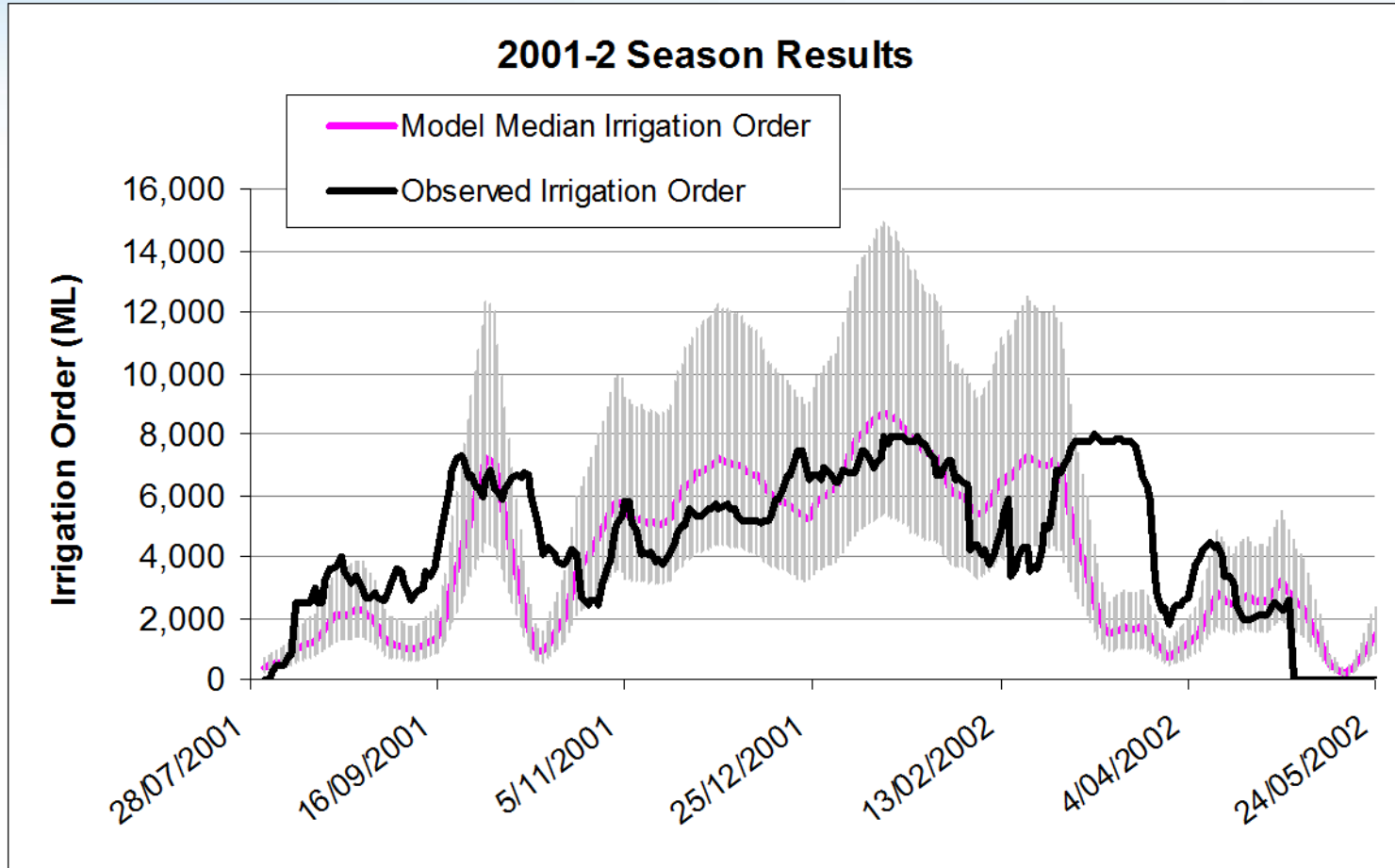
- Crop mixes

Crop Mix	Expected Gross Margin \$m	Expected Water Use ML	Annual Pasture ha	Rice ha	Winter Cereals ha	Perennial Pasture ha	Horticulture ha
1	106	1,143,000	61,000	33,000	33,000	24,000	4,000
2	105	1,035,000	61,000	33,000	33,000	12,000	4,000
3	103	980,000	50,000	33,000	33,000	12,000	4,000
4	24	400,000	50,000	1,000	0	12,000	4,000
5	21	393,000	50,000	1,000	0	12,000	3,000



Model Testing

- Water orders



Conclusions

- New demand model can be used for forecasting and policy/management analyses
- Model integrates behavioural and biophysical factors associated with irrigation demand
- Model has been successfully tested on two irrigation districts
- Model needs further testing in other irrigation seasons
- Modelling uncertainty needs to be classified in terms of contributions from behavioural and biophysical uncertainties