NATIONAL RESEARCH FLAGSHIPS

Economics of sourcing water for environmental flows – Murrumbidgee irrigation case study area

Dr Ejaz Qureshi, Dr Mac Kirby,
Dr Jeff Connor and
Dr Sarah Ryan
CSIRO

- Background
- Focus of the current study
  - Potential on-farm and off-farm water savings options
  - Assumed water available for acquisition in the market
- Analytical approach
- Results
- Conclusion

NATIONAL RESEARCH FLAGSHIPS

CSIRO

Water scarcity and quality concerns




- Greater recognition that water is over-allocated to consumptive use
    - scarcity and quality concerns
- Finding a balance is a major challenge
- Acquiring water for environmental flows could
    - lead to a reduction in water available for irrigation.
    - have a major impact on the regional and national economies
- A significant effort is needed to maximise both on-farm irrigation system and off-farm channel efficiency along with acquiring water from willing irrigators.

NATIONAL RESEARCH FLAGSHIPS

Recent Initiatives

- Commencement of National Water Initiative in 2004 to improve the productivity and efficiency of water use while maintaining healthy water systems.
- Key aims of NWI are to
  - expand trade in water by creating more secure water access entitlements and by removing impediments
  - provide water for specific environmental outcomes
- Living Murray Initiative to restore the health of the River Murray by increasing environmental flows

NATIONAL RESEARCH FLAGSHIPS

CSIRO

PM Water Security Plan

- Recently, the PM announced a 10 point plan to improve water efficiency and address over-allocation
  - A cornerstone of the package is a commitment of almost $6 billion over 10 years to modernise irrigation infrastructure both on- and off-farm to save water and increase efficiency of water use.
  - Saved water will be shared on a 50:50 basis between irrigators and the environment.
  - Government will invest up to $3 billion over 10 years to address over-allocation by providing assistance to irrigators – structural adjustment.

NATIONAL RESEARCH FLAGSHIPS

CSIRO

Opportunities

- A range of possible approaches for sourcing water for environmental flows
  - Water savings from the redevelopment of regional water supply systems or
  - Water use efficiencies associated with management or technology changes by water users or
  - Off-farm irrigation efficiency improvement
  - Acquire water from willing sellers (irrigators) through markets
- Find policy instruments and/or optimal level of water that minimise the opportunity costs of achieving environmental objectives is desirable

Focus of the current study

- Assess how agricultural sector opportunity costs of delivering water for environmental flows are likely to vary.

- Estimate a supply function for provision of water through upgrades in current on-farm irrigation systems, channel efficiency improvement and acquisition of water from willing irrigators

- Estimate cost of sourcing water from alternative options and determine the least cost water acquisition strategy.

NATIONAL RESEARCH FLAGSHIPS

CSIRO

Water savings options, potential water savings (ML/ha) and average estimated costs

Potential water savings option	Water savings (ML/ha	Average savings (ML/ha)	Estimated annualised cost ($/ML)
Channel system efficiency			
Lining/piping supply channel system (GL/channel)	23 to 30	30	434 to 1917
Lining on-farm channels	0.06 to 0.24	0.15	377 to 946
On-farm recycling and storage	0.1 to 2.5	1.3	22 to 44
On-farm irrigation efficiency			
Laser levelling on rice farms	0.1 to 0.4	0.25	190
Irrigation flow rates monitoring on rice farms	0.3 to 2.5	1.4	3 to 25
Soil moisture monitoring and irrigation scheduling	0.1 to 3.0	1.55	1 to 220
Irrigation management with fine tuning on horticulture farms	0.25 to 0.75	0.50	11
Conversion to drip irrigation system on horticulture farms	2 to 3	2.5	193
Conversion to centre pivot irrigation system on horticulture farms	0.6 to 1.0	0.8	177

Potential water savings from alternative efficiency improvement options in Murrumbidgee

Water savings option	Total water savings (GL)
Lining/piping supply channel system	30
Lining on-farm channels	27
On-farm recycling and storage	56
Sub-total channel and storage savings	113
Laser levelling on rice farms	26
Irrigation flow rates monitoring on rice farms	27
Soil moisture monitoring and irrigation scheduling	97
Irrigation management with fine tuning on horticulture farms	16
Conversion to pressurised drip irrigation system on horticulture farms	73
Conversion to pressurised CP irrigation system on horticulture farms	23
Total water savings	375

what is the price of water?

- What is the opportunity cost or true value of irrigation water?
- Estimation using mathematical models (for example)?
- Price (historical) in the market?

Opportunity cost of water of major activities in four states of water allocations

Activity	Very dry ($/ML)	Dry ($/ML)	Wet ($/ML)	Very wet ($/ML)
Rice	33	33	32	32
Grapes	229	228	223	223
Beef	82	16	16	16
Dairy	137	17	16	16
Sheep	79	77	11	11
Oilseed	29	29	9	9
Fruits	108	108	106	106
Legumes	40	40	21	21
Cereal	53	51	11	10

Total water allocated and assumed water available for acquisition

Activity	Total water allocated	Available water for acquisition
Rice	933	233
Beef	16	4
Dairy	5	2
Sheep	2	1
Oilseed	2	1
Legumes	2	1
Cereal	33	8
Total water (GL)	994	250

How much water should be sourced from each option?

- Unit water savings/ha and costs per unit saved water are different
- Initial capital and day to day management costs also vary along with their time of replacement
- Analysing different combinations of water savings options at different water sourcing levels becomes tedious and requires an appropriate modelling tool
- Determining optimal level of water sourcing can assist water resource managers and policy makers in achieving greater gains from limited funds

NATIONAL RESEARCH FLAGSHIPS

CSIRO

Mathematical programming model

- The objective function of the model was to minimise cost of acquiring water from alternative sources subject to
  - water savings potential in each option
    - on-farm efficiency improvement
    - river efficiency improvement
    - off-farm efficiency improvement and
    - acquisition of water from willing irrigators.
  - constraints on mutually exclusive water savings options
    - an upper limit that water can be saved from each group of savings options.

Objective

$$\min z = \sum_i \sum_j c_{i,j} \quad where \;\; c_{i,j} = f\left(x_{i,j}\right)$$

Constraints

$$\forall \; j : \sum_i x_{i,j} \geq b_j$$

$$\forall \; i : \sum_j x_{i,j} \leq a_i$$

$$\forall i, j : l_{i,j} \leq x_{i,j} \leq u_{i,j}$$

$$\forall \, g : \sum_j x_{g,j} \leq aa_g$$

NATIONAL RESEARCH FLAGSHIPS

CSIRO

Six scenarios examined

1. water sourced by efficiency improvement and up to 250 GL available to acquire from irrigators
2. water sourced by efficiency improvement and up to 150 GL available to acquire from irrigators
3. water sourced by efficiency improvement and up to 100 GL available to acquire from irrigators
4. water sourced by efficiency improvement and up to 50 GL available to acquire from irrigators
5. water sourced by efficiency improvement without option of acquiring water from irrigators
6. only option of sourcing water is by acquiring up to 250 GL from irrigators in the market

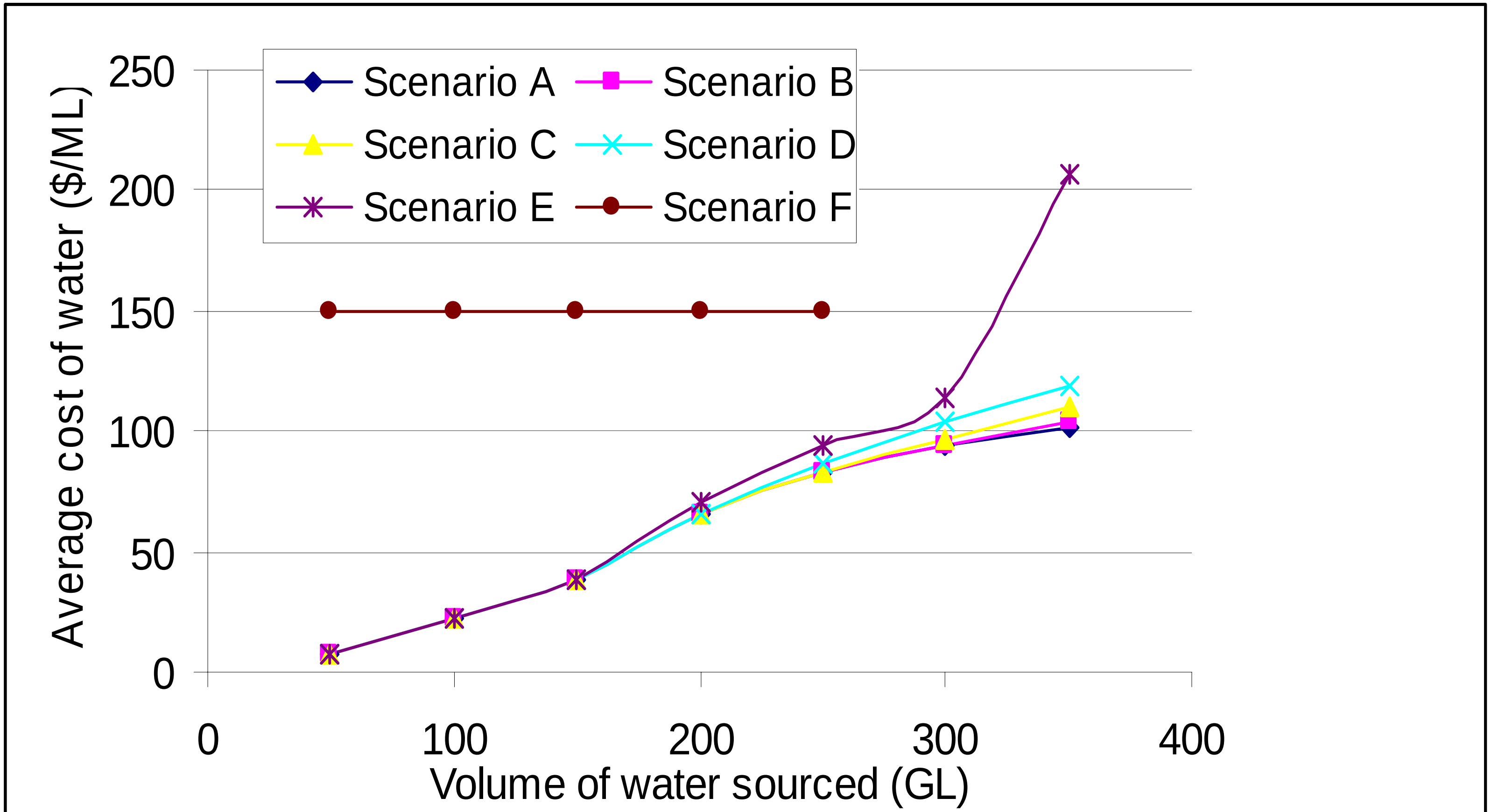
Optimal water sourcing at each volume of water acquisition across options in Scenario A (GL/year)

Vol	LSCS	LOFCH	OFRSS	LASRICE	IRRMBADJ	SMMIS	IRRMGT	PREIRRDR	PREIRRCP	Acquis
50	0	0	0	0	27	7	16	0	0	0
100	0	0	42	0	27	15	16	0	0	0
150	1	0	56	0	27	50	16	0	0	0
200	2	0	56	0	27	60	16	0	0	40
250	2	0	56	0	27	60	16	0	0	90
300	2	0	56	0	27	60	16	0	0	140
350	2	0	56	0	27	60	16	0	0	190

Proportion (0-1) of sourcing water (GL) from efficiency improvement and from acquisition

	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E		Scenario F	
Vol	Effic	Acquis	Effic	Acquis	Effic	Acquis	Effic	Acquis	Effic	Acquis	Effic	Acquis
50	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0		1.0
100	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0		1.0
150	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0		1.0
200	0.8	0.2	0.8	0.2	0.8	0.2	0.8	0.2	1.0	0.0		1.0
250	0.6	0.4	0.6	0.4	0.6	0.4	0.8	0.2	1.0	0.0		1.0
300	0.5	0.5	0.5	0.5	0.7	0.3	0.8	0.2	1.0	0.0		
350	0.5	0.5	0.6	0.4	0.7	0.3	0.9	0.1	1.0	0.0		

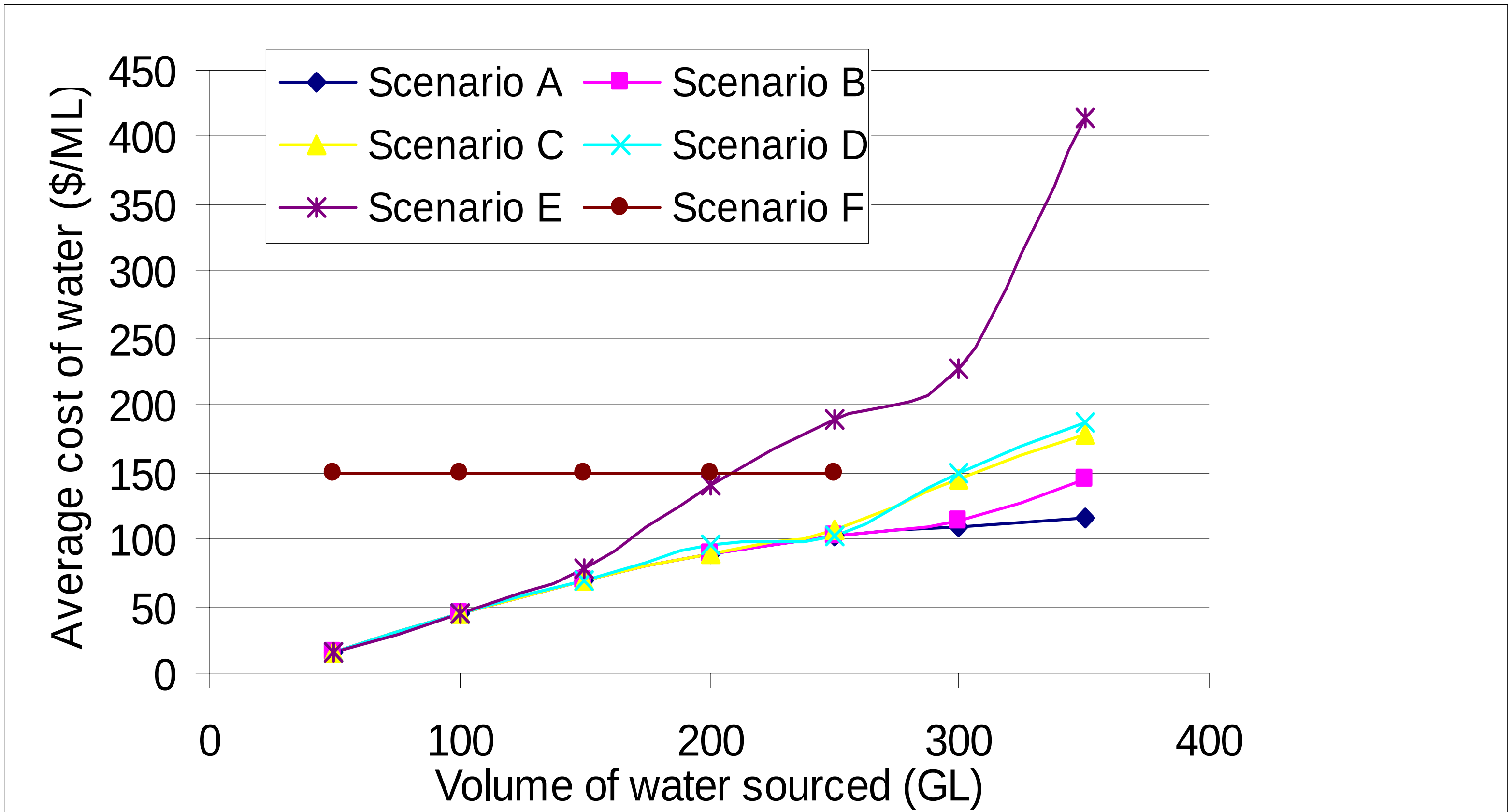
Summary of average total cost of sourcing water from alternative options



NATIONAL RESEARCH FLAGSHIPS

CSIRO

Summary of average total cost of sourcing water from alternative options when efficiency costs are doubled



NATIONAL RESEARCH FLAGSHIPS

CSIRO

Conclusions

- A mix of delivery options provides the least cost solution.
- It is efficient to invest in water savings efficiency options for initial 150 GL.
- Any further increase in water sourcing without market increases the average cost.
- Average cost of the first 150 GL is relatively small than the average cost of sourcing 350 GL
- When costs of efficiency improvement are doubled, the combination of water sourcing changes - investing in only up to 100 GL.
- Acquisition of 350 GL only through investment increases average cost from $116/ML to $414/ML.

NATIONAL RESEARCH FLAGSHIPS

CSIRO