

Tradeable recharge credits in Coleambally Irrigation Area: Report 3

**Designing experiments to test tradeable recharge
credits in the Coleambally Irrigation Area**

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CSIRO & BDA Group

John Ward



For more information on the issues discussed in this document please contact the following people:

For information on experimental economics:

John Ward
CSIRO Land and Water
Urrbrae
(08) 8303 8685 (ph)
(08) 8303 8590 (fax)
j.ward@csiro.au

Or: *Stuart Whitten*
CSIRO Sustainable Ecosystems
GPO Box 284
Canberra, ACT 2601
(02) 6242 1683 (ph)
(02) 6242 1705 (fax)
stuart.whitten@csiro.au

For information on biophysical modelling of recharge and recharge management in the Coleambally region (including the SWAGMAN[®] series of models):

Dr Shahbaz Khan
CSIRO Land and Water
Griffith, NSW 2680
(02) 6960 1500 (ph)
(02) 6960 1600 (fax)
shahbaz.khan@csiro.au
www.clw.csiro.au/division/griffith/

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This paper is the first in a series from a two-year research program. The focus in this paper is on laboratory tests of alternative institutional frameworks using experimental economics techniques. Papers in this series are:

- *What are the issues?*
- *Economic impact of tradeable recharge credits and other net recharge abatement policies for the Coleambally Irrigation Area*
- *Designing experiments to test tradeable recharge credits in the Coleambally Irrigation Area*
- *Laboratory tests of alternative institutional frameworks*
- *Field trial and farm case studies*
- *Biophysical modelling for linking farms with regional net recharge targets*
- *Experiences, lessons and findings*

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Executive Summary

This report summarises the process involved in the design and evaluation of strategies to address the challenges to the cost effective reduction in groundwater recharge in the Coleambally Irrigation Area, NSW. The project is aimed at developing and simulating a tradeable recharge credit system for the Coleambally Irrigation.

The primary aim of the project is to simulate an on-ground trial of a recharge credit trading scheme in the Coleambally Irrigation district. There is a range of identified *potential* impediments to an effective and efficient market in recharge credits and solutions. A total of 11 potential impediments have been identified:

- The existence of a subtractable (or rival) and non-excludable common pool resource;
- The absence of or poorly defined property rights;
- The presence of thin markets;
- Mismatched annual credit supply and demand;
- The method of recharge credit distribution;
- The method of risk assignment;
- A lack of suitable mechanisms to reward recharge reduction performance;
- Insufficient variability in recharge reduction costs;
- The presence of capital constraints;
- The presence of information constraints; and
- The presence of extrinsic and intrinsic non-market preferences that dominate decision making.

Potential solutions to each of these impediments are being investigated.

There are additional potential impediment/solution combinations than can be investigated with available resources and not all solutions are feasible given current institutional and political constraints. Hence, it was necessary to shortlist solutions for investigation. To that end all proposed potential solutions were qualitatively ranked based on the criteria of:

- likely significance of the impediment in the CIA;
- potential of the solution to improve efficiency; and
- potential administrative and political feasibility.

Three investigative techniques will be used to further evaluate the significance of these impediments and the effectiveness of potential solutions:

- a field demonstration where farmers can participate in a simulated recharge trading scheme that is representative of the area drawing irrigation water from the Coleambally Irrigation Association (CIA);

- lab experiments with student participants using the simulated recharge trading scheme, and;
- a simulated on-ground trial phase.

In a consensus process with the project team and insights from farmer demonstrations, the short list of potential impediment/solution combinations for further investigation were prioritised. The result is a set of recommendations for farmer demonstrations, student experiments and, pending the results from these two processes, the implementation of the simulated on-ground recharge reduction trading scheme (referred to as the Paper Trial).

Final selection of the solutions to test via student experiments and farmer demonstrations is an iterative process. Solution choices for experimental testing and simulated recharge trial will be based on the review of the results from the project's initial field demonstration. The prioritisation process has already provided considerable guidance. The following points summarise the main themes of the research project team deliberations of future project investigation and procedure.

1. Weak incentives to trade and the forecasted gains from trade are small in both absolute terms and ordinal terms when compared to the magnitude of net farm income.
2. To address the property rights issue in the simulation trial, the research team favoured the temporary obligations approach. Their recommendation was that project participants should be asked to agree to temporary obligations to reduce recharge by altered farm management. This was viewed as one of the only possible ways to address the property rights impediment that is practicable given existing institutional constructs and deference to political feasibility.
3. The project team determined that the simulated recharge trading trial should proceed with small trading numbers. While thin markets were recognised as a potential impediment, expanding the number of participants was not seen as a viable option. This was partly due to biophysical parameters in the CIA and partly due to practical constraints in managing experiments. A viable alternative treatment for thin markets, should they prove to be a problem in demonstrations and experiments could set residual credits and funds aside for an "external" trader who could act strategically in the market to account for a broader set of social benefits. This approach could also potentially address the problem of mismatched credit supply and demand. Thus, the project team supported exploration of the potential of an external trader solution at least in experiments, and potentially in the on-ground trial.
4. The project team is fundamentally committed to a performance based assessment of the trial to examine efficiency and innovation. However, they also strongly believe that the trial should reward farmers for good management but not penalise them for random effects of weather that are beyond their control. It is proposed the trial use a normalised performance based system, assigning random rainfall risk to the government to compare to variable recharge allocation levels (assigning rainfall risk to farmers). Normalisation, expressed as constant recharge allocation levels was seen as an administratively and politically feasible way to control risks associated with mismatched credit supply and demand while preserving incentives for landholders to reduce recharge.

5. While it is not feasible within the constraints of the current Commonwealth Market Based Instruments (MBI) program, a longer term effort to investigate the potential of a multiple year period recharge credit trade system with banking of recharge credits/debits could yield (better results). The perennial nature of farm management and weather variation, means that the dynamic performance of the system will only really be understood after several years. Certainly some understanding of a multiple year credit trade system with banking can be gained through laboratory experiments and this is encouraged by the project team.

Finally, the methodology for project economic experiments is detailed in the report. This includes a description of the catchment recharge credit trade simulation framework and formal treatments to test identified impediment solutions and policy initiatives with laboratory experiments.

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1 Introduction

This report comprises part of a series detailing the outcomes of research into the exploration and development of tradeable recharge rights as a tool to manage irrigation induced salinity in the Coleambally Irrigation Area (CIA) in western New South Wales (NSW). This project is a pilot under the National Market Based Instruments Pilots Program. The pilot is based on developing cost-effective incentives to individual irrigators that reflect their collective impact on shared groundwater aquifers. The shared nature of the groundwater aquifer means that one individual's actions may impact on other irrigators and the wider community, and therefore appropriate incentives should reflect these interrelationships.

A key aspect of the research is the design of a practical mechanism that reflects the institutional requirements of an effective cap and trade instrument and the biophysical relationships and constraints in the Coleambally system. These issues include the setting and allocation of the "cap" that effectively allocates responsibility for individual recharge contributions to the shared groundwater aquifer and the rules for a trading framework that would facilitate a differential adjustment by individual farmers. Other aspects of importance include allocation of risk (both scientific and seasonal) and year-to-year flexibility offered by banking and borrowing mechanisms within the cap and trade framework.

Many of the practical issues involved in developing and implementing such a cap and trade framework were explored in our first background report titled 'Tradeable recharge credits in Coleambally: What are the issues?' The specific focus in this report is on investigating the impediments to the implementation of key aspects of recharge credit institutions for the Coleambally Irrigation Area in more detail using a combination of farmer demonstrations, laboratory based experiments, and, a simulated trial with Coleambally irrigators.

1.1 Background

As a general rule market-based instruments (MBI) use markets and market like mechanisms to influence the choices made by land managers. In contrast to policy approaches using explicit directives, they are designed to encourage innovative behaviour through the price signals of market exchange. The potential advantage of MBI approaches is that they can achieve environmental goals at a less and hence more affordable cost to the community.

The approach in Coleambally Irrigation Area in technical terms is a Tradeable Recharge Entitlements Scheme.¹ The basic design proposed requires farmers to select and abide to modified crop management patterns associated with a prescribed annual level of recharge reduction. Modified crop management and hence variable recharge rates are achieved by altering the farm composition of rice, fallow, irrigated and

¹ See our first research report for a discussion of the importance of terminology in acceptance of such schemes. The correct technical term is 'entitlements' however use of 'credits' is likely to evoke a more positive response by landholders to the scheme.

dryland wheat, lucerne and canola. The SWAGMAN recharge model has been employed to determine farm specific recharge rates as a function of irrigation application and the spatial location of the farm in the Coleambally landscape. Each crop has varying levels of groundwater recharge, influenced predominately by soil type, volume of irrigation water applied and depth to watertable. Rice in particular is generally a recharging crop whereas winter crops and lucerne are generally discharging crops. All crops have varying economic returns, measured as the crop gross margin. The challenge therefore is to determine the mix of crops that minimises recharge to the watertable but maximises (or at least maintains) economic returns to the farmer. By varying the limit on estimated total farm net recharge, the opportunity cost (measured as changing gross margin) of recharge abatement can be calculated.

A key aspect of designing a practical Tradeable Recharge Credit Scheme is the need to carefully consider the details of the implementation of a functioning and effective recharge market including consideration of a range of implementation options. Ultimately, the goal is to discover ways to achieve cost effective and continuing recharge reduction. However, there are potentially a number of impediments to implementing a cost effective and functioning tradeable recharge entitlement policy.

To investigate the significance of potential impediments to recharge credit trade and the efficacy of potential solutions, three investigative techniques will be used in this project:

Farmer demonstrations - The farmer demonstrations employ computer simulation games, developed as part of the project, that enable farmer participation in recharge trading. The simulations are constructed to resemble the key recharge reduction, crop mix and economic decision sets confronting farmers in the catchment. The simulations provide a participatory, heuristic approach to familiarise farmers with potential institutional and market structures and reveal farmer insights and behavioural responses to simulation protocols and rules.

Laboratory experiments - The laboratory experiments use students in computer simulation games of the economics of recharge credit trade in the CIA. The primary focus of the laboratory experiments is to test the significance of impediments and the efficacy of potential solutions to improve design of a proposed simulated on-ground trial (referred to as the Paper Trial). Policy experiments are generally motivated by the type of policy question that interests managing agencies and the experimental environment is typically designed to resemble those aspects of the naturally occurring environment that are the policy target. This enables economists to utilise a formalised, replicable scientific method in formulating policy advice, especially when existing theories are inadequate. One advantage of the laboratory experiments is that they can be used to assess policy design features that could not necessarily be implemented given current political, institutional, or, administrative constraints.

A simulated trial - At the beginning of 2005, CIA farmers will be encouraged to participate in a simulated on-ground trial of a market exchange of tradeable recharge credits.² The simulation acts as a proxy to an actual on-ground recharge credit trading trial originally proposed. Prevailing drought conditions in the CIA and the resultant lack of demand for recharge credits precluded a meaningful and reliable on-ground trial. At the conclusion of the recharge credit trading session, salinity reduction benefits and the cost effectiveness of the trial will be evaluated.

1.2 Purpose and organisation of this report

The overall organisation of the project and this report follows on from the logic of the process of instrument and experimental design as illustrated in Figure.

The project has progressed through the process of **identifying the problem**. Work to date to identify the problem has involved comprehensively identifying the range of potential impediments to effective recharge credit market functioning and evaluating their significance for the trial. This has involved insights from economic theory, learning from past credit market experience and farming community knowledge to develop a comprehensive list of potential solutions to identified impediments. The results of this process are reported in Section 2: *Impediments to recharge credit trade, their significance and potential solutions*.

Work focussed on **developing solutions** and designing ways to **test solution options** is also now completed. One focus of effort has involved narrowing the list of impediments and solutions to a manageable level for treatment in the field demonstrations and the laboratory experiments, both acting as necessary precursors for the simulated trial.

The process of prioritisation and the result of its application are reported in Section 3:

Choosing solutions for investigation.

An additional focus of effort has been designing methodologies to reliably test solution options, culminating in the development of a simulation of recharge credit trade for use in field demonstrations and laboratory experiments. Further efforts have developed robust treatments to test the range of potential solutions in laboratory based experimental settings. This work is reported on in Section 4 of this report:

Experimentally testing proposed designs for tradeable recharge credit markets.

Section 5 provides a summary of the field demonstration of the recharge trading scheme held at Yanco Agricultural College with representatives of the Coleambally irrigation community.

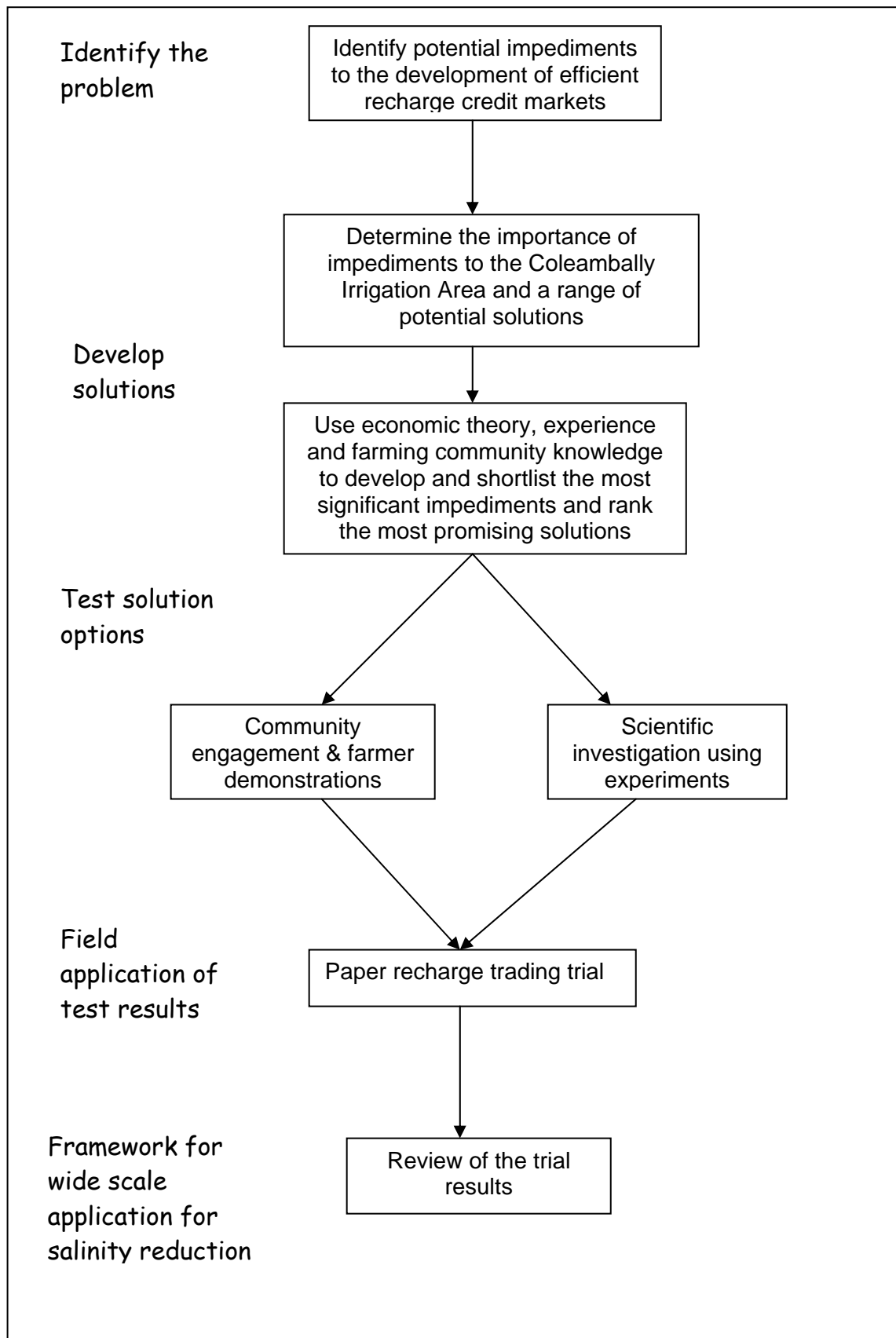
² The simulated on-ground trial with farmers is a contextualised computer based version of the paper trial indicated in the proposal. This was a more informative and practical solution given the ongoing impacts of drought during the research

2 Impediments to recharge credit trade, their significance and potential solutions

Environmental policy analysts dating back to Dales (1968) and Montgomery (1972) have advocated tradeable credit approaches based on the argument that such approaches can increase economic efficiency, relative to approaches that allow less flexibility such as uniform standards. The basic idea of tradeable credit systems is that a responsible agency issues a limited number of credits to use a resource or release some emission into water or air. Trade in credits is allowed and all those who wish to use the resource or release emissions are required to have sufficient credits, in proportion to the volume of the resource consumed or the emissions released, to surrender to the managing authority at a prescribed time period.

The economic case for tradeable credit systems (e.g. Baumol and Oates 1988, p177) begins with the observation that costs of reducing emissions often vary significantly among producers. The opportunity to trade provides an incentive for those with lower costs to reduce emissions and thus not use all the credits available to them. The additional credits can be sold to producers facing high costs of emission reduction. Given the choice, it is more likely (and profitable) for high cost producers to purchase credits than reduce emissions. Thus, a market in tradeable emission credits can reduce the total cost of reaching an overall emissions goal.

Figure 1: Illustration of research process for design of instruments and experimental treatments



The economic argument for the efficiency of tradeable credit approaches to environmental policy rests on the assumption that there are no substantial impediments to the functioning of a tradeable permit market so that it may “perfect efficiency”³. The reality is that the full set of conditions necessary to ensure perfectly efficient markets are rarely if ever present in any setting. In many market settings there are numerous impediments to the satisfaction of these conditions.

The first steps in this stage of the research were to revisit the issues raised in our first report (an issues paper) using economic theory, previous experience with tradeable credits and context specific background research to:

- identify potential impediments to effective functioning of recharge credit trade and their likely significance in the CIA; and,
- identify potential solutions to the impediments.

Results of the process are laid out in Table 1 which summarises:

- The range of the 11 impediments that have been recognised by economists and policy analysts as potentially limiting the efficiency of markets for tradeable resource credits;
- The potential significance of these impediments given the specific biophysical, market, cultural and economic settings relevant to this pilot;
- Solutions that could be considered to deal with each impediment.

The following sections expand on the theoretical basis, literature based insights and salience to the CIA tradeable recharge credit project.

³ Technically the necessary conditions for a market to work in a “perfectly efficient” manner are:

The rationality condition – this is satisfied when consumers and producers act competitively to maximise utility and profits and minimise costs, given their individual circumstances and constraints.

The price-taker condition – this is satisfied when there are sufficient numbers of buyers and sellers such that no-one participant can influence the terms on which the transaction occurs.

The complete information condition – this is satisfied when all participants have a full and complete knowledge of prices in all markets. That is, participating individuals must know the prices and costs of all the opportunities available to them and the consequences of them enacting on that decision.

The complete set of markets condition – this is satisfied when a market exists for all potential transactions and contingencies, with fully specified and enforced property rights, such that buyers and sellers can exchange assets freely (i.e. transaction costs are effectively negligible). Satisfying this condition requires that there is a complete set of markets for all goods and services including those normally thought of as externalities or public goods. To satisfy these criteria, market systems must send accurate signals to participating individuals about relative resource scarcities. (Common, 1995).

Property rights grant to individuals the benefits gained by using a resource. Bromley (1991) and Randall (1978) state that non-attenuated property rights for natural resources:

1. are completely specified, so that it can serve as a perfect system of information about the rights that accompany ownership, the restriction on those rights and the penalties for their violation;
 2. are exclusive, so that all rewards and penalties resulting from an action accrue directly to the individual empowered to take action;
 3. are transferable so that rights may gravitate to their highest-value use;
 4. are enforceable and completely enforced (an un-enforced right is no right at all).
-

Table 1 Potential impediments to efficient recharge credit markets, their significance and potential solutions

| SOURCE OF MARKET IMPEDIMENT | SIGNIFICANCE TO THE CATCHMENT | POTENTIAL SOLUTIONS |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. COMMON POOL RESOURCE</p> <p>a. The absence of fully defined rights precludes market exchange for all aspects of the resource</p> <p>b. Poorly defined property rights reduce market efficiency by creating:</p> <ul style="list-style-type: none"> • decisions confounded by a social dilemma • uncertainty/unreliability in market outcomes • free riding behaviour • high transaction costs (from potential litigation) | <p>HIGH</p> <p>The <i>Status Quo</i> Property Rights Arrangement is:</p> <p>No current specification in water rights of water or soil quality standards (eg constrained requirements for recharge management)</p> <p>Implicit but poorly defined right (or obligations) of farmers to manage recharge as they like.</p> <p>Without more explicit definition of either farmer rights to recharge or rights to water and soil quality for those impacted by recharge induced salinity, no market for recharge credit can be established.</p> | <p><i>The Status Quo</i> - Currently farmers are required to adopt practices that potentially reduce rice production and hence recharge but are not monitored on recharge reduction performance.</p> <p><i>Obligations by farmers</i> to reduce recharge assigned to participants for the duration of the trial in form of tradeable recharge entitlements.</p> <p><i>Non-property right solutions</i> based on community governance, covenants and agreements</p> |
| <p>2. PROPERTY RIGHTS</p> <p>c. The absence of defined rights precludes market exchange</p> <p>d. Poorly defined property rights reduce market efficiency by creating:</p> <ul style="list-style-type: none"> • Uncertainty/unreliability in market outcomes • low market participation • high transaction costs (from potential litigation) | <p>HIGH</p> <p>The <i>Status Quo</i> Property Rights Arrangement is:</p> <p>No current specification in water rights of soil or water quality standard (eg no requirement for recharge management)</p> <p>Implicit but poorly defined right (or obligation) of farmers to manage recharge as they like.</p> <p>Without more explicit definition of either farmer rights to recharge or rights to soil or water quality for those impacted by recharge induced salinity, no market for recharge credit can be established.</p> | <p><i>The Status Quo</i> - Currently farmers required to adopt practices that potentially reduce recharge but are not monitored on recharge reduction performance; this arrangement implicitly assumes recharge entitlements are assigned to farmers.</p> <p><i>Obligations by farmers</i> to reduce recharge assigned to participants for the duration of the trial in form of tradeable recharge entitlements.</p> <p><i>Property rights assigned to beneficiaries of improved management</i>: whose collective interest is represented by an External Trader</p> |
| SOURCE OF MARKET IMPEDIMENT | SIGNIFICANCE TO THE CATCHMENT | POTENTIAL SOLUTIONS |

| | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>3. THIN MARKETS</p> <p>An insufficient buyers and sellers effects market efficiency through the processes of:</p> <ol style="list-style-type: none"> Market dominance and concentration of permits (strategic rent seeking): individuals can readily influence market outcomes reducing efficiency. Permit hoarding (strategically impedes new entrants) And a thin market reduces market efficiency by raising relative costs of transactions: fewer participants implies a lower probability of finding trading partners to resolve market demands. | <p>HIGH</p> <p>Both a geographically constrained area and small number of farms in pilot suggest thin markets could be problematic;</p> <p>Alternatively, some experimental economics findings suggest the numbers in this trial are sufficient to avoid thin market problems (Smith, 1982)</p> <p>Hoarding not a likely issue in the short to medium term due to the number of relatively small players but could emerge in the longer term.</p> | <p>Obligations by farmers to reduce recharge participants (in exchange for payment) for the duration of the trial in form of tradeable recharge entitlements.</p> <p>Incorporate an External Trader (eg. A State representative of those impacted by CIA drainage)</p> <p>Rationale: the solution should deepen the market.</p> |
| <p>4. MISMATCHED ANNUAL CREDIT SUPPLY AND DEMAND</p> <p>Random natural events such as flood or drought can lead to systemic under or overachievement of recharge reduction, leading to most participants incurring either excess credits or debits, regardless of land management practices.</p> | <p>HIGH</p> <p>Recharge is systemically related to highly variable climate.</p> <p>Regardless of land management changes, in a period of high rainfall, there will be high demand for recharge units with insufficient supply and <i>vice versa</i>.</p> | <p>“normalised” recharge reduction performance for credit/debit accounting by dividing individual percentage of recharge goal achieved by the mean average percentage of goal achieved or median rainfall used to establish constant allocation levels.</p> <p>Credit Banking: involving a multiple period trial with the allowance for banking credits and debits and a requirement to clear all accounts at some end period (eg 5 years).</p> <p>Rationale: the solution should remove random systematic over or undersupply of credits. Dividing by the mean should result in equalised demand and supply; residual differences are a good proxy for results of non-random effects.</p> |

| SOURCE OF MARKET IMPEDIMENT | SIGNIFICANCE TO THE CATCHMENT | POTENTIAL SOLUTIONS |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>5. METHOD OF ENTITLEMENT DISTRIBUTION AMONG FARMERS</p> <p>The primary issue is procedural fairness: <i>Status Quo</i> is input based fixed payment per unit input. Shifting to a performance based system will tend to change expected costs, income and income variability. If the distributional changes arising from the initial allocation of entitlements are perceived as inequitable program participation could decline.</p> | <p>MEDIUM</p> <p>Preliminary focus group with catchment farmers suggests the equity of entitlement allocation is an issue, but have not yet tested perceived equity of credit trade options.</p> | <p>Community determined distribution of initial entitlements: (group consensus)</p> <p>Administrative assignment of entitlements: Distribution based on proportional reduction of individual farm's maximum recharge potential, capped to catchment recharge goal.</p> <p>Rationale: testing the solution in farmer demonstrations and planned post experiment surveys should reveal farmers' perceptions of fairness.</p> |
| <p>6. RISK ASSIGNMENT</p> <p>Changing to a performance based system shifts the risk of a less than intended recharge reduction from Government to farmers.</p> <p>There are three risks relating to returns that participants could face in a performance based system: a) Risk associated with random, exogenous events such as rainfall variability; b) risk of on-farm performance of management options in achieving recharge reduction; c) free riding by other farmers</p> <p>Farmers may perceive that the degree of financial risk that they face will increase as a result of shift from the <i>status quo</i> to a performance based approach couched within a common pool resource dilemma, reducing participation levels, or influence market decisions and effect efficiency.</p> | <p>MEDIUM TO HIGH</p> <p>Pilot could be organised in a way that changes the current arrangement: monitoring changed from management input to a performance basis: the change could effectively shift consequences of economic risk from random effects (climate) to farmers. This could increase the risk to farmers, thus reducing program participation, impeding market effectiveness.</p> | <p>Normalised performance based system with performance normalised. (see entry under market impediment 3: mismatched demand and supply for explanation).</p> <p>Normalised performance simply means an average climate position is assumed throughout the experiment rather than including stochastic climate variation.</p> |
| SOURCE OF MARKET IMPEDIMENT | SIGNIFICANCE TO THE CATCHMENT | POTENTIAL SOLUTIONS |

| | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>7. PERFORMANCE INCENTIVE FAILURE</p> <p>Recharge credits could be implemented based on “input” (ha of rice) or performance (e.g. estimated recharge reduction). Ultimately, the goal is improved performance. With an input based system the impacts of actions of farmers are not monitored and remain “hidden”. Thus with input approach, management actions positively influencing performance aren’t rewarded, management actions negatively influencing performance aren’t penalised.</p> | <p>MEDIUM FOR INPUT BASED APPROACH</p> <p>System creates no penalty for poor management of trees or perennial pasture after planting, although there are private motivations for such management</p> <p>LOW FOR PERFORMANCE BASED APPROACH – system creates incentive for good management of trees or perennial pasture after planting</p> | <p>Performance based system.</p> <p>Including two tiers of penalty for non-compliance;</p> <ul style="list-style-type: none"> a. An individual penalty; and, b. Socialised and equally imposed cost for the public good element of the common pool resource. |
| <p>8. INSUFFICIENT VARIABILITY IN RECHARGE REDUCTION COST</p> <p>Where there is little difference between participants in cost of recharge reduction there is little incentive to trade, with a potential for thin markets.</p> | <p>HIGH</p> <p>Gross margin, recharge reduction potential estimates to date from pilot site indicate substantial differences in recharge reduction costs are sufficient to encourage market exchange.</p> | <p>Social contracts and community governance</p> |
| <p>9. CAPITAL CONSTRAINT</p> <p>Analysis to date of farm management data indicates capital constraints may limit adoption of management options that increase farm income and reduce recharge.</p> | <p>UNCERTAIN</p> <p>Not all farms have access to capital and there are often significant constraints on farm planning requirements as requirements for loans.</p> | <p>No solution to be formally tested.</p> <p>However, alternate financial arrangements such as loan guarantees or annual payment schemes could be successful in overcoming the constraint.</p> |

| SOURCE OF MARKET IMPEDIMENT | SIGNIFICANCE TO THE CATCHMENT | POTENTIAL SOLUTIONS |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>10. INFORMATION CONSTRAINT</p> <p>Analysis to date of farm management data indicates information constraints may limit adoption of management options that stabilise farm income and reduce recharge.</p> | <p>UNCERTAIN</p> <p>If potential to reduce recharge in ways that are minimally effect income are not understood, this could stop adoption. Extent to which this may be the case is not yet understood.</p> | <p>No solution to be formally tested.</p> <p>However, <i>participation in recharge trading experiments</i> by farmers could improve information. Change in understanding will be assessed by survey before and after experimental sessions. Both farmer demonstrations and on-ground trial results communicated to area farmers will produce positive information externalities as a public good which should decrease the effect of information constraints</p> |
| <p>11. NON-MARKET OR EXTERNAL MARKET PREFERENCES DOMINATE DECISION MAKING</p> <p>Analysis to date of farm management data indicates non-market or external market preferences may limit adoption of management options that increase farm income and reduce recharge.</p> | <p>UNCERTAIN</p> <p>Limited time to work on-farm for participants with off-farm job, preference for more leisure with less profitable management may be dominate determinant of management chosen for some farmers rather than profit.</p> | <p>No solution to be formally tested.</p> |

2.1 Common pool resource: difficulty in exclusion and rival consumption

Nature of the potential impediment

Managing the environmental consequences of rising groundwater and subsequent waterlogging and soil salinity loads is complex and likely to require a combination of economic instruments and community involvement in coordinating aggregate management strategies (Common 1995, Randall 1981). In contrast to a conventional common pool resource facing groundwater aquifer abstractors, the social dilemma facing CIA constituents is the use of the porous, adsorptive capacity of the soil fraction between the soil surface and the aquifer water table. Irrigation beyond the evapo-transpirational capacity of a crop mix, reduces the ability of other irrigators to make use of the adsorptive resource. The difficulty in excluding beneficiaries is a characteristic shared with public goods, the rival or subtractable nature is a characteristic shared with private goods.

When joint outcomes depend on multiple actors contributing inputs or actions that are costly and difficult to quantify and there is lack of institutional protocols to restrict usage, incentives exist for individuals to act opportunistically. A social dilemma occurs when individuals are tempted by short-term gains, and hence over-use the common pool resource, thereby imposing group shared costs on the common pool community. Individual over-use will eventually lead to rising water tables and lower crop productivity for all farmers.

In heterogenous settings for a common pool resource such as the Coleambally irrigation area, all appropriators may be made better off by the adoption of a group agreed rule, albeit some will benefit more than others depending on the nature of the sharing rule. Hence, the opportunity exists for some individuals to free ride and benefit from the reduction in recharge by others. The information revelation provided by price signals in a competitive market is proposed as one solution, assuming the design of property rights can overcome the subtractability dilemma. Alternatively, group crafted coalitions, facilitated by communication and reinforced by punitive and non-punitive sanctioning mechanisms have proved to be robust solutions to the social dilemma (Ostrom *et al.* 1992, Tisdell *et al.* 2004).

The impediment

The social dilemma resulting from the common pool nature of groundwater recharge in the CIA is the kernel of the research problem. It is viewed as the most significant impediment facing the functioning of a recharge trading scheme.

Potential solutions

Temporary recharge rights for farmers - Creating a market for (temporary) tradeable recharge rights, assigned and vested in the individual, specifying the number of recharge units for each farm, for a given crop management regime and stipulating individual recharge obligations. Temporary obligations and rights can be assigned for the duration of the experimental solution.

Provide a forum for group discussion – socially derived solutions may be suitable to resolve the inherent tensions farmers face with a common pool resource dilemma. Providing the institutional structures to facilitate the crafting of robust community coalitions, specifying sharing rules and individual management may provide meaningful resolutions.

2.2 Property rights arrangements for recharge

The nature of the potential impediment

As Common (1995) and Hanley *et al.* (1997) point out, failure to assign well-defined property rights is often the cause of natural resource market failure. When there are no markets for processes such as pollution rights, valued outputs of land management such as clean water remain independent of and external to the information revealed by the price signals of conventional markets. Consequently this may lead to inaccurate pricing signals, prompting excess production of economic dis-benefits. For example, farmers may not adequately manage recharge because they receive no price signal about the irrigation salinity damage from their actions.

Property rights grant individuals the benefits gained by using a resource. Rights can be poorly or well-defined. Well-defined rights can only exist where there is a social mechanism that specifies the obligations of both right holders and those excluded, and binds individuals to those duties and obligations through property rights enforcement mechanisms (Bromley 1991).

Based on the original work of Commons (1931), Coase (1960) is commonly attributed with first recognising the fundamental role of property rights in realising the gains from trade⁴.

Coase recognised that efficiency should be possible regardless of whether property rights are assigned to the parties causing damages or the parties suffering the consequences. Applying Coase's logic to the CIA, a functional tradeable recharge credit approach would require either one of two possible property rights arrangements. One arrangement would assign property rights to the farmers who create groundwater recharge. The alternative would assign property rights to beneficiaries including those outside the CIA, possibly downstream water users experiencing adverse impacts of recharge (and the effects of increasingly saline soils or irrigation water). The first arrangement allows irrigators experiencing adverse

⁴ The Coase theorem states that given the conditions for competitive markets exist, negotiating (or transaction) costs are negligible, property rights are non-attenuated and affected consumers can freely negotiate with each other, an economically efficient allocation will arise irrespective of the distribution of property rights. That is, there is no possible reallocation of a resource (including groundwater recharge) that would improve the utility of one person without a reduction in the utility of at least one other person. Meeting these conditions characterises an efficient market outcome. Market efficiency can be achieved if the transactions are cost-less or at least negligible. That is the specification, transfer and enforcement of rights occurs without practical costs. Transaction costs between bargaining parties are broadly categorised as information costs, bargaining or contracting costs and enforcement costs. Transactions require accurate knowledge of the cost of abatement, identification and knowledge of willing participants, the opportunities and strategy of exchange and the nature of the goods to be exchanged. The gaining of relevant information is not costless and a lack of information can prevent or compromise transactions. The relativity, incidence and extent of the costs in obtaining this information, as perceived by the individual participants remains an important policy issue. The negotiating and contractual arrangements similarly confer costs to the participants, measured as time or opportunities lost as do the specification and costs of arbitration and enforcement when needed.

impacts of salt draining from CIA farms to compensate CIA farmers to reduce recharge by purchasing permits. Alternatively CIA farmers can buy the right to recharge from downstream users, compensating them for a loss of water or soil quality. A famous tenet of economic theory, the Coase theorem suggests that with either assignment of property rights, voluntary trade in recharge rights would occur until the possibility of mutually shared benefits is exhausted and the efficiency of outcomes would be invariant to the property rights assignment.

Significance of the impediment – Current property rights arrangements represent a highly significant impediment to establishing salinity credit trading in the CIA. In NSW where the trial will take place, as in virtually all other Australian States, there are no recharge obligations nor are there currently any arrangements that would allow those who may suffer adverse consequences of CIA irrigation induced salinity to compensate CIA farmers for reducing their impact. Similarly, downstream property rights do not specify a water or soil salinity standard to be met by CIA irrigators. The temporary (and hypothetical) assignment of recharge rights is especially important for the Simulated Trial phase of the project. Experimental treatments can be used to undertake formal and replicable testing of a large range of counter-factual property right arrangements.

Potential solutions

The Status Quo - Currently farmers are required to adopt restrictions to rice production that potentially reduce recharge but are not monitored on alternate measures of recharge reduction performance; this arrangement implicitly assumes recharge entitlements are assigned to farmers.

Temporary Obligations for farmers - Temporary obligations to reduce recharge could be assigned to participants for the duration of the pilot in form of tradeable recharge credits (or entitlements).

Property rights assigned to downstream beneficiaries – This solution would involve assigning rights to limit recharge (and consequent salinity impacts) to downstream beneficiaries whose collective interest could be represented by an External Trader. The approach would require capping allowable recharge from the catchment as a first step. The external trader could then sell recharge units as demanded. Farmers could achieve their recharge cap by either purchasing recharge units through market exchange or by adopting land management practices that reduce recharge.

2.3 Thin markets: insufficient market participants

Nature of the potential impediment –

Thin markets are characterised by small numbers of buyers and sellers. Limiting the number of buyers and sellers introduces the potential for market failure in a number of dimensions, including: market dominance, strategic behaviour, concentration of environmental impact (or permit hot spots), permit hoarding, the prevention of market entry by new farms and reducing the benefits of trade by increasing the relative cost of transaction costs. Price volatility and restricted liquidity of supply also characterise thin markets, often associated with tradeable natural resource rights. The United

States EPA's emissions trading program, introduced in 1976, foundered because of thin markets and concerns about hot spots (Goodstein 2002, p. 330).

The probability of successfully negotiating a satisfactory exchange in thin markets is diminished as the number of traders is reduced. That is the transaction costs of establishing the marginal benefits and costs of recharge reduction may outweigh the potential benefits of exchange, especially if there is a low probability, both real and perceived, that there are likely to be only a few units traded. Recharge rates are likely to be strongly affected by the level of uncertainty of economic returns and market success.

Thin markets increase the likelihood of dominance by a few individuals, resulting in distorted and sub-optimal market outcomes. The rent seeking behaviour of monopolies and monopsonies are extreme examples. Although not confined to thin markets, there is an increased opportunity of permit hoarding and a potential impedance of new market entrants. Permit hoarding can also lead to a concentration of recharge in localised regions, potentially in areas of high salinity impact.

Significance of the impediment – At the time of writing there are approximately 300 farms that could potentially participate in the pilot. Feedback from the Yanco field demonstration indicates a willingness by farmers to explore, participate and support market based solutions for groundwater recharge. The geographically constrained trading zones and relatively small number of participants would support the conclusion that thin markets may be a moderately to highly significant impediment to the recharge credit market.

Additionally, economic modelling of the CIA and the Yanco field results indicate that despite farmer support for market exchange, the gains from trade are minor in both absolute terms and when compared to net farm income. Additionally there were only a few market transactions, reinforcing the notion that the relativity of market transactions costs may be high.

However, relatively small numbers do not necessarily mean that the problems associated with thin markets will arise. Smith (1982) advances a countervailing view on the axiom of large numbers of buyers and sellers, coined as the Hayek hypothesis. Based on empirical results, Smith proposes that optimal solutions can be achieved in markets characterised by very limited numbers of buyers and sellers. In addition, in a one-year trial it is unlikely that much hoarding would occur because excess credits would have no value at the end of the year. Overall, we rate the potential significance of the thin market impediment as high.

Potential solutions

Do nothing – If experiments confirm that small numbers have little influence on market efficiency proceeding to a simulated trial with small numbers could be justified.

Expand trial participation – An obvious solution to thin markets would involve an increase in the number of potential participants, though this creates obvious challenges given the limited resources for the project and the exploratory nature of the trial.

Incorporate an external trader – Introduction of a broker (e.g. the Coleambally Irrigation Association) who could buy and sell strategically in the market to counteract thin market problems.

2.4 Mismatched annual credit supply and demand

With some potential credit trade market designs, random natural events such as flood or drought could lead to systemic under or overachievement of recharge reduction. This could lead to most participants incurring either excess credits or debits, regardless of land management practices. Regardless of land management changes, in periods of high rainfall, there is potential for high demand for recharge units associated with insufficient supply and, excess supply correlated with severely reduced demand in times of drought.

Significance of the impediment – Because the pilot will occur in a small area with relatively uniform weather, the pilot will be sensitive to annual variations in rainfall that are systematically correlated over all participants. Therefore the potential for mismatched annual supply and demand is rated as a significant potential impediment of pilot scheme effectiveness.

Potential solutions

Normalised performance - A normalised accounting system for recharge reduction targets can be established by dividing individual percentage of recharge goal achieved by the mean average percentage of goal achieved or employing the median of historic rainfall. By using a “normalised” rainfall schedule to establish recharge targets, systematic over- or undersupply of credits should be avoidable. Those who do better than average will have credits, those who do worse will have debits, and credit supply and demand should be approximately matched regardless of the weather year.

Credit banking – This would involve extending the trial to multiple years with allowance for banking of credits and a requirement to clear all recharge credit accounts at some ending period (e.g. in five years). This should allow farmers to offset excess demand in some years from excess supplies accumulated in previous years.

2.5 Method of initial recharge entitlement distribution

Perman *et al.* (1999, pp.316-317) note that the initial distribution of property rights determines the division of net gains which accrue to negotiating parties. Thus, a major challenge in designing a recharge permit system is the mechanism used to allocate initial permits to individuals. Auctions and free distribution are the two main procedures employed by governing agencies in the allocation of transferable resource permits. Revenues from auctioning permits go to the state. Free distribution of entitlements implies that benefits accrue to those granted the entitlement (Tietenberg 1998).

Purely from an efficiency perspective, auctions are preferred by economists (Baumol and Oates, 1988). However, efficiency is often not the sole criteria guiding choice of initial distribution in real world policy settings. Procedural justice, equity and wealth distribution outcomes tend to be important factors influencing policy directives as well (Bromley 1991, Howe 1996, Randall 1978, 1987, Syme *et al.* 1999).

Consequently, grandfathering (the free distribution of permits) maintains a position of pareto neutrality for irrigators and is often viewed as the most appropriate allocation mechanism in many actual policy settings. Grandfathering provides greater political control over permit distribution, allowing adjustments according to social norms of equity, fairness and affordability (Tietenberg 1998).

There are a range of specific implementations of either permit auctions, or grandfathering type permit allocation that could be considered in the trial including (but not limited to):

- Proportional distribution calculated according to land area, current cropping practices or landscape position;
- Equal allocation of total permits amongst farmers regardless of land holding or landscape position;
- A scalar of the maximum recharge potential;
- Historical net recharge adjusted for recent farm management; and
- Net recharge according to optimal farm management.

Significance of the impediment – A primary issue identified in feedback from local stakeholders is the perceived fairness of entitlement distribution. These concerns are not unique. Commentators such as Tietenberg (1998) suggest that the issue is a persistent and widespread problem in initiating effluent markets. The *status quo* in the catchment is an input based, regulatory instrument constraining rice production. Shifting to a performance based system will tend to change expected costs, income and income variability. If the distributional changes arising from the initial allocation of entitlements are perceived as inequitable, program support is likely to decline. The distribution of entitlements is rated as medium significance to the pilot scheme.

Potential solutions

Temporary Obligations for farmers (as described for the property rights impediment) - Temporary obligations to reduce recharge could be assigned to participants for the duration of the pilot in form of an allocation of tradeable recharge entitlements. Because contracts are entered into voluntarily this should be perceived as fair.

Administrative assignment of entitlements – This approach would involve capping total allowable recharge and assigning required recharge reduction targets to each farmer. For example, all farmers might be required to reduce recharge by a certain percent from current levels, or achieve some set recharge level.

Community determined distribution of entitlements – The government would agree with participants on a total catchment recharge target and scheme participants would decide how to share effort and allocation of entitlements among themselves. The approach would allow resolution within the group of any “within group” distributional fairness issues, and could employ the use of specialised SWAGMAN information about low cost recharge reduction opportunities.

2.6 Risk assignment: seasonal rainfall variation

Nature of the potential impediment –

The *status quo* relies on a CICL administered regulatory limit on rice production, and the subsequent limits on irrigation applications. Changing to a recharge performance based system may shift that risk to farmers. Farmers may perceive that as a result of shifting from the *status quo* property right to a performance based approach the degree of financial risk that they face will increase. This could reduce participation levels, or influence market decisions, modify appropriation levels and affect efficiency.

There are two risks relating to returns that participants could face in a performance based system: a) risk associated with random, exogenous events such as rainfall variability, and b) the risk of on-farm performance of management options in achieving recharge reduction.

It is often perceived fair to reward good management but unfair to penalise bad luck.

Significance of the impediment

Actual recharge outcomes will be fundamentally influenced by management and by random effects such as weather. It is clear the proposed performance based system involves more risk for farmers. How much more risk is unclear and will depend on program design. If increased risk is compensated by higher expected return it may not be a significant impediment.

Potential solutions

Normalised performance – A normalised accounting system for recharge reduction targets can be established by dividing the individual percentage of recharge goal achieved by the mean average percentage of goal achieved or employing the median of historic rainfall. By using a “normalised” rainfall schedule to establish recharge targets risk is reduced by eliminating the random impacts of weather on outcome. Residual variation in performance should be approximately correlated with returns accruing to either above or below average management.

2.7 Performance incentive failure

Nature of the potential impediment

The current scheme for recharge reduction relies on an input based regulatory system limiting the production of rice. Recharge management and evaluation is based on the expected recharge reduction of intended action rather than being dependent on the success or measured performance of farm based recharge management. With an input based system the actual individual recharge impacts of farmer land management actions are not monitored or quantified and can remain “hidden”. In its current form the input scheme does not penalise management practices that do not comply with targets and negatively influence performance. Nor does the current system reward innovative practices that improve recharge reduction performance.

Significance of the impediment – There is no current incentive provision for continued maintenance of the farm management practices implemented to reduce recharge. Similarly there is no disincentive for poor maintenance and farm management. In contrast to the existing input based scheme, the proposed pilot deploys a performance based scheme, issuing tradeable recharge credits (a revenue source for recipients) based on field evaluation of farm and crop management. Poor performance can be penalised by a reduction in the number of allocated recharge credits (*viz.* an imposed cost expressed as a reduction in trading revenue). The potential significance of not implementing a performance incentive (or a non-compliance dis-incentive) of the recharge credit trade pilot is judged as moderate. One reason it is not likely to be too great is that there are individual incentives to maintain crop investments once in the ground because better management increases potential returns.

2.8 Insufficient variability in recharge reduction costs

Nature of the potential impediment – In order for trade in recharge rights to occur the difference in the abatement costs across recharge sources must be of sufficient magnitude to provide an incentive for exchange.

Significance of the impediment – The variability of recharge volumes and abatement costs in the CIA are a function of landscape position, soil and rainfall variability and land management practices. The development of a recharge and salinity accounting tool (the SWAGMAN model) has been detailed by Khan *et al.* (2003). Predictions from the modelling framework describe levels of water table recharge, and will eventually characterise catchment water yields and balances, saline groundwater transport and inter-catchment impacts. The model enables prediction of the impact of current and alternative land uses on salt and water balances for CIA landscape elements at a surface water sub-catchment scale where similar farm actions are expected to have different salinity impacts. The addition of estimates of farm income as a function of land management practices to the recharge accounting framework establishes a relationship between landscape position, crop mix, farm management, farm income and recharge volumes.

Using the SWAGMAN derivations, the marginal cost of recharge abatement specific for a selection of farms within the CIA central sub-catchment and the available management options has been estimated.⁵ The variability in the estimated marginal value of the costs of recharge abatement for each farm over five crop mix options indicates they are of small but sufficient magnitude to encourage recharge trading. The gains from trades are small in both absolute and ordinal terms when compared to the net farm income. Compiled data indicate the extent of farm heterogeneity of abatement costs is likely to be an impediment to recharge trading.

Potential solutions – **Non-market, community governance based** management of recharge reduction.

⁵ See the 2nd report in this series detailing the econ modelling.

2.9 Capital constraints

Nature of the potential impediment

A large amount of anecdotal evidence suggests that many farmers face significant constraints in sourcing capital to undertake significant management changes. Analysis to date of farm management data tends to confirm that capital constraints may limit adoption of management options that increase farm income and reduce recharge.

Significance of the impediment – Not all farms have access to capital and there are often significant constraints on farm planning requirements as requirements for loans. The ability and flexibility to change farm management is the key driver of behavioural change that would lead to improved recharge management.

No solution to be formally tested.

However, *alternate financial arrangements* such as loan guarantees or annual payment schemes could be successful in overcoming the constraint.

2.10 Imperfect information

Nature of the potential impediment

Perman *et al.* (1999, p. 141) note that for markets to function perfectly efficiently, all participants (farmers, CICL, others) must be perfectly informed about direct and external effects of market decision-making. Less than perfect information may represent fundamental scientific uncertainty, or the limits of individual knowledge in a complex and dynamic world. Where lack of information is extensive and the potential external effects large and irreversible, government intervention to supply information may be an efficient policy.

Information provision may be justified where, even though the collective benefit of better information would exceed the cost of supplying the information. Intervention to provide information is justified where economies of scale can be achieved through government information schemes. This is especially important where information leads to decisions that modify the appropriation levels of public goods like recharge reduction. In the absence of intervention, the incentives for unregulated markets to provide sufficient information may be too weak or diffuse, and the subsequent sub-optimal resource allocation resulting from market failure may preclude any efficiency gains.

Significance of the impediment – Initial management surveys and gross margin estimates suggest that many farmers in the region are not adopting crop management options that minimise income effects and also reduce recharge. This finding suggests that imperfect information may be an impediment to markets in recharge credit trade.

No solution to be formally tested.

However, *participation in recharge trading experiments* by farmers could improve information. Both farmer demonstrations and on-ground trial results communicated

to area farmers will produce positive information externalities as a public good which should decrease the effect of information constraints.

2.11 Non-market preferences

Nature of the potential impediment – Humans are often motivated by social norms in ways that contradict assumptions that they will always act to maximise their individual economic gain. The implication is that some farmers may prefer management options that appear to be less profitable because of non-market preferences. For example, practices that reduce recharge and increase profit could require that more time be spent managing the farm. For example, those who prefer leisure to farm work may not be interested in the most profitable management option. Group behavioural norms may strongly influence individual behaviour and the expression of individual preferences.

Significance of the impediment – Existing data suggest that many farmers in the region are not adopting crop management options that minimise income effects and also reduce recharge. This finding suggests that non-market preferences may be an impediment to markets in recharge credit trade.

3 Choosing solutions for investigation

Clearly there are more potential impediments and solutions than can be investigated given project resources, requiring a prioritisation process to help focus on the most important impediments and solutions in project investigations. This section describes the process used to prioritise potential solutions and the recommendations arising from applying the process.

3.1 Process for prioritising investigations

To prioritise issues for investigation, all solution/impediment combinations listed in Table 1 are evaluated by ranking with respect to four criteria. In each instance, a qualitative ranking of low, medium or high relative to the criteria is provided. The criteria are:

- the **significance of the impediment** to the catchment;
 - the degree of solution **alignment with existing institutional structures** and the ability to be administered by the processes of current recharge reduction initiatives;
 - the **administrative and political feasibility** of the solution; (some treatments that are highly feasible with current administrative and institutional settings may not be viewed as politically desirable or feasible); and
 - the potential for **market efficiency gains** estimated to result from implementation of the solution.
-

3.2 Results of the prioritisation process

The result of the process of choosing solutions for further investigation through a consensus process with the project team is shown in Table 2. Table 2 repeats qualitative ranking of the significance of impediments to recharge markets from Table 1. In addition, the table contains the current qualitative ranking of impediment/solution combinations. Ticks indicate a willingness and request by the project team to test the potential solutions in farmer demonstrations, laboratory experiments and to include the solution as a feature in the simulated trial.

The design process has been contingent on an iterative feedback process with the results from the first round of field demonstrations influencing choice of further laboratory experiments and the Simulated Trial design ultimately informed by all demonstration and testing results. The following are the main points of consensus and the as yet unresolved factors with regard to how the project investigation should proceed:

- To address the property rights issue in the simulated trial, a temporary obligations approach was constructed. Participants are assigned temporary obligations to reduce recharge in hypothetical farms by selecting between alternative management options and outcomes.
 - The simulated trial should proceed with small trading numbers. While thin markets were recognised as a potential impediment, expanding the number of participants was not seen as a viable option. A viable alternative treatment for thin markets, should they prove to be a problem in demonstrations and experiments, could set residual credits and funds aside for an “external” trader who could act strategically in the market to account for a broader set of social benefits. This approach may also address the problem of mismatched credit supply and demand.
 - The simulated trial should reward farmers for good management but not penalise them for random effects of weather that are beyond their control. Experimental results on behavioural response to variable tiers of risk will inform the design of the trial format. It is proposed that the trial use a normalised performance based system, assigning random rainfall risk to the government and compare this to variable recharge allocation levels (assigning rainfall risk to farmers). Normalisation, expressed as constant recharge allocation levels was seen as an administratively and politically feasible way to control risks associated with mismatched credit supply and demand while preserving incentives for landholders to reduce recharge.
 - Reflecting on community feedback, equity could be a crucial issue for the success of the on-ground trial. The notion of community determined distribution of entitlements is an interesting approach to deal with this issue. There is a high degree of interest in investigating the community attitudes toward this approach in the field demonstrations.
 - While it is not feasible within the experimental portion of the current Commonwealth MBI program, longer term efforts to investigate the potential of a multiple year period recharge credit trade system with banking of recharge credits/debits given how annual weather variations influence actual outcome, system dynamic performance will only really be understood after several years. Certainly some understanding of a multiple year credit trade system with banking can be gained through laboratory experiments.
-

Table 2 Summary of the evaluation process and proposed designs for on-ground trials, farmer demonstrations and laboratory experiments

| Market impediment | Solutions | <i>Significance of impediment</i> | <i>Administrative alignment</i> | <i>Political feasibility</i> | <i>Efficiency gain</i> | <i>Include as Simulated Trial feature^a</i> | <i>Test solution in Field demonstration</i> | <i>Test solution as experimental treatments</i> |
|-------------------------------------------------------------|------------------------------------------------------|-----------------------------------|---------------------------------|------------------------------|------------------------|-------------------------------------------------------|---------------------------------------------|-------------------------------------------------|
| <i>Common Pool Resource</i> | Temporary obligation for farmers | High | High | High | Low to medium | ✓ | ✓ | ✓ |
| | Social contracts | | Medium | High | High | ✓ | ✓ | ✓ |
| <i>Property rights</i> | Temporary obligation for farmers | High | High | High | High | | | |
| | Property rights assigned to downstream beneficiaries | | Low | Low to medium | Low | | | |
| <i>Thin markets</i> | Do nothing | High | High | High | Medium | ✓ | | ✓ |
| | Introduce external trader | | Medium | Medium | High | | ✓ | ✓ |
| <i>Mismatched annual supply and demand</i> | Normalised performance | High | High | High | High | ✓ | | ✓ |
| | Credit banking | | | | | | | ✓ |
| <i>Entitlement distribution</i> | Temporary obligation for farmers | Medium | High | High | Low | ✓ | ✓ | ✓ |
| | Community determined | | Medium | Medium | High | ? | ✓ | ✓ |
| <i>Risk assignment</i> | Normalised performance | High | High | High | Low | ✓ | ✓ | ✓ |
| <i>Performance incentive failure</i> | Normalised performance | Medium | High | High | Low/medium | ✓ | ? | ? |
| | Non-compliance penalty | | Medium | Medium/high | High | ✓ | ✓ | ? |
| <i>Insufficient variability in recharge reduction costs</i> | Non market social contracts | High | | | | | ✓ | ✓ |

| Market impediment | Treatment | <i>Significance of impediment</i> | <i>Administrative alignment</i> | <i>Political feasibility</i> | <i>Efficiency gain</i> | <i>Include as On ground trial feature</i> | <i>Test solution in Field demonstration</i> | <i>Test as experimental treatments</i> |
|------------------------------------|--------------------------------|-----------------------------------|---------------------------------|------------------------------|------------------------|-------------------------------------------|---------------------------------------------|----------------------------------------|
| <i>Capital constraint</i> | Alternate finance arrangements | Uncertain | Low/medium | Medium/high | High | | | |
| <i>Information constraint</i> | Field trial participation | Uncertain | High | High | Medium/high | | ✓ | |
| <i>External market preferences</i> | No specific treatment | Uncertain | Uncertain | | | | | |

^a Pilot Project team consensus on the status and priority of solutions, the significance of the market impediment and the importance to the three phases of the research program.

4 Experimentally testing proposed designs of a tradeable recharge credit market

In this MBI pilot project experimental economics will provide data and analytically based behavioural and policy insights, derived from the application of treatments in a formal, repeatable simulation of the CIA catchment. Experimental economics will be used to:

- 1) test the significance of market impediments in a setting calibrated to represent salient economic and biophysical features of the actual CIA Catchment;
- 2) pre test on-ground solutions providing input into paper trial design; and
- 3) test behavioural responses to longer term policy options that may require changes to current institutional structures.

This section describes the experimental economics methodology to be used in this project.

The first sub-section (4.1) describes the simulated catchment and trading environment which provides the setting for both the field demonstrations and the laboratory sessions. The objective of the simulation is to represent the economic decision-making and trading environment with the salient biophysical, economic and hydrological characteristics estimated for the Central sub-catchment of the Coleambally irrigation district.

The second sub-section (4.2) describes a set of formal experimental designs that can be used to test significance of impediments and effectiveness of solutions detailed in Table 1. Good experimental design requires translating potential impediment solutions into formal experimental treatments. Treatments are generally expressed in formal terms and in a controlled environment. The experimental design aims to satisfy at least three fundamental criteria. First, a prerequisite of experimental testing is the development of a set of metrics to accurately measure changes in behavioural responses and market efficiency observed in the simulation. Second, to ensure reliable analysis of treatment effects, a robust experimental design aims to keep all salient factors constant except the variable (or treatment) of interest. Any changes measured in the simulation can be assigned to a single introduced treatment (achieved by keeping all other factors constant). To account for the complexity of all potential solutions and the potential interaction of treatments, a standard is employed as a control treatment. Third, the treatment is able to be expressed as a formal hypothesis, in this case the null hypothesis.

To clarify the experimental logic, Section 4.2 describes the relationship between the market impediment, the subsequent research question, and the relationship of treatments to potential market impediment solutions identified in the main body of the report.

4.1 The simulated catchment

Previous research underpinning the SWAGMAN model has established and enumerated the relationship between an established and proposed crop mix, water application, groundwater depth and soil type and subsequent management with farm income and recharge volumes spatially located to specific landscape positions in the CIA (Khan *et al.* 2003). The influence on recharge and salinity of land management and crop management has been estimated for 12 spatially dispersed farms in the central management irrigation area (Robinson *et al.*, 2005).⁶ Differentiated estimates of recharge and farm income have been provided for the 12 farms as a function of varying crop mix and management. A set of farm enterprises have been selected that represent the main relationships between landscape positions, farm management regimes, farm income and groundwater recharge. The gross margins and water use for the crop management options provided to participants are detailed in Table 3.

Table 3: Gross margins and water use of crops used in the CIA

| Crop | Price (\$/tonne) | Yield (tonnes/ha) | Variable costs (LESS water costs) (\$/ha) | Water use (Mls/ha) | Water costs (\$/tonne) | Total variable costs (\$/tonne) | Gross Margin (GM) (\$/tonne) | GM (less water cost) (\$/tonne) | GM/ML (\$/ML) |
|-----------------|---------------------|----------------------|----------------------------------------------------|-----------------------|------------------------------|------------------------------------------|---------------------------------------|------------------------------------------|------------------|
| rice | 207 | 9.5 | 730 | 12 | 202 | 932 | 1034 | 1237 | 86 |
| maize | 180 | 10 | 838 | 8.5 | 143 | 981 | 819 | 962 | 96 |
| soybean | 389 | 2.8 | 427 | 8 | 135 | 562 | 527 | 662 | 66 |
| sorghum | 135 | 6.5 | 521 | 7 | 118 | 639 | 238 | 357 | 34 |
| lucerne hay | 150 | 15 | 1259 | 12 | 202 | 1461 | 789 | 991 | 66 |
| wheat | 130 | 5 | 379 | 2.5 | 42 | 421 | 229 | 271 | 92 |
| barley - malt | 140 | 4 | 335 | 2.2 | 37 | 372 | 188 | 225 | 85 |
| barley - feed | 105 | 4.5 | 333 | 2.2 | 37 | 370 | 102 | 140 | 47 |
| canola | 318 | 2.7 | 555 | 3 | 51 | 606 | 253 | 304 | 84 |
| fababean | 220 | 4 | 625 | 3.5 | 59 | 684 | 196 | 255 | 56 |
| lucerne pasture | 30 | 26 | 191 | 10 | 169 | 360 | 420 | 589 | 42 |
| summer pasture | 30 | 30 | 223 | 12 | 202 | 425 | 475 | 677 | 40 |
| winter pasture | 30 | 12 | 89 | 3 | 51 | 140 | 220 | 271 | 73 |
| dryland pasture | 30 | 2 | 0 | 0 | 0 | 0 | 60 | 60 | 0 |
| dryland wheat | 130 | 2.5 | 240 | 0 | 0 | 240 | 85 | 85 | 0 |

Source: from the SWAGMAN model, Khan *et al.* (2003)

The simulated catchment is comprised of a total of 12 farms located in the central irrigation area of the CIA. The farms represent a synthesis of existing farm management regimes with a farm size ranging from 200 ha to 335 ha. Throughout the experimental sessions, each participant, randomly assigned to a single farm, will choose from five possible farm management options, associated with specified recharge and income levels.

The five decision choices for each landscape position are in accord with those outlined in Table 4. For the planned experiments, each experimental session will involve approximately 10 independent, replicate periods of annual management decisions, market trading and a forum for discussion.

⁶ Two adjusted duplicates are used from the 10 farms in Robinson *et al.*, 2005.

Table 4 Income, crop mix and recharge of 12 farms in the experimental setting

| Farm | Farm Crop Mix | Water Table rise (m) | Surplus water (MLs) | GM (\$) | recharge (MLs) | Crop Type (ha) | | | | | | | | TOTAL (ha) | Total water use (MLs) | | |
|------|------------------|----------------------------|---------------------------|---------|-------------------|----------------|-------|----------------|---------|-------|--------|------------------|--------------------|---------------|--------------------------|--------|------|
| | | | | | | rice | maize | lucerne hay | lucerne | wheat | canola | dryland wheat | dryland pasture | | | fallow | |
| 1 | 1 | max | | 106417 | 200 | 69 | 22 | | | 56 | | 45 | 9 | 22 | 224 | 1158 | |
| | 2 | 0.3 | | 104442 | 150 | 64 | 22 | 17 | | | | 45 | 53 | 22 | 224 | 1162 | |
| | 3 | 0 | | 100532 | 63 | 40 | 22 | 22 | | | 93 | 24 | | 22 | 224 | 1172 | |
| | 4 | -0.1 | | 98382 | 34 | 33 | 22 | 22 | | | 112 | 12 | | | 22 | 224 | 1171 |
| | 5 | -0.25 | | 95041 | 0 | 26 | 22 | 22 | 10 | | 112 | 9 | | | 22 | 224 | 1078 |
| 2 | 1 | max | | 103965 | 228 | 69 | 20 | 3 | | 48 | | 40 | | 20 | 200 | 1154 | |
| | 2 | 0.4 | 0 | 101180 | 160 | 56 | 20 | 13 | | 66 | 0 | 25 | | 20 | 200 | 1163 | |
| | 3 | 0.2 | 33 | 95333 | 104 | 57 | | 11 | | 52 | 60 | | | 20 | 200 | 1126 | |
| | 4 | 0 | 223 | 86041 | 44 | 39 | | 10 | | 71 | 60 | | | 20 | 200 | 946 | |
| | 5 | -0.15 | 366 | 79071 | 0 | 25 | | 10 | | 85 | 60 | | | 20 | 200 | 813 | |
| 3 | 1 | max | | 106706 | 180 | 69 | 22 | | | 59 | | 45 | 6 | 22 | 223 | 1163 | |
| | 2 | 0 | | 106363 | 170 | 69 | 22 | 4 | | 39 | | 45 | 22 | 22 | 223 | 1161 | |
| | 3 | -0.3 | | 104321 | 111.5 | 62 | 22 | 19 | | | | 45 | 52 | 22 | 222 | 1159 | |
| | 4 | -0.5 | | 102584 | 62 | 50 | 22 | 22 | | 46 | | 45 | 15 | 22 | 222 | 1166 | |
| | 5 | -0.758 | | 98751 | 0 | 46 | 8 | 22 | | 112 | | 12 | | 23 | 223 | 1164 | |
| 4 | 1 | max | | 105687 | 246 | 69 | 22 | | | 57 | | 44 | 5 | 22 | 219 | 1158 | |
| | 2 | 0.2 | | 104165 | 201 | 66 | 22 | 15 | | | | 44 | 49 | 22 | 218 | 1159 | |
| | 3 | 0 | | 102562 | 155 | 58 | 22 | 22 | | | 7 | 44 | 43 | 22 | 218 | 1165 | |
| | 4 | -0.325 | | 96292 | 56 | 35 | 16 | 22 | 2 | 56 | 66 | | | 22 | 219 | 1158 | |
| | 5 | -0.472 | 101 | 90073 | 0 | 57 | 22 | 21 | | 20 | | 44 | 32 | 22 | 218 | 1173 | |
| 5 | 1 | 0 | | 119547 | 227 | 69 | 34 | | | 46 | | 67 | 87 | 33 | 336 | 1232 | |
| | 2 | -0.2 | | 117472 | 166 | 63 | 34 | 16 | | | | 67 | 122 | 33 | 335 | 1237 | |
| | 3 | -0.3 | | 116206 | 132 | 57 | 34 | 22 | | | | 67 | 122 | 33 | 335 | 1237 | |
| | 4 | -0.5 | | 112048 | 31 | 25 | 34 | 19 | | 167 | 7 | 50 | 0 | 33 | 335 | 1256 | |
| | 5 | -0.571 | | 109714 | 0 | 15 | 34 | 18 | | 167 | 53 | 15 | | 33 | 335 | 1262 | |
| 6 | 1 | max | | 105396 | 220 | 69 | 22 | 9 | | 15 | | 44 | 37 | 22 | 218 | 1161 | |
| | 2 | 0.2 | | 100901 | 148 | 61 | 11 | 13 | | 67 | | 44 | | 22 | 218 | 1149 | |
| | 3 | 0 | | 95038 | 97 | 56 | | 11 | | 99 | 26 | 4 | | 22 | 218 | 1130 | |
| | 4 | -0.2 | 152 | 86605 | 38.5 | 39 | | 9 | | 82 | 66 | | | 22 | 218 | 979 | |
| | 5 | -0.4 | 274 | 80811 | 0 | 28 | | 9 | | 94 | 66 | | | 22 | 219 | 877 | |

Table 4 (cont'd)

| Farm | Farm Crop Mix | Water Table rise (m) | Surplus water (MLs) | GM (\$) | recharge (MLs) | Crop Type (ha) | | | | | | | | | TOTAL (ha) | Total water use (MLs) |
|------|---------------|----------------------|---------------------|---------|----------------|----------------|-------|-------------|---------|-------|--------|---------------|-----------------|--------|------------|-----------------------|
| | | | | | | rice | maize | lucerne hay | lucerne | wheat | canola | dryland wheat | dryland pasture | fallow | | |
| 7 | 1 | max | | 106619 | 221 | 69 | 22 | | | 58 | | 45 | 8 | 22 | 225 | 1163 |
| | 2 | 0 | | 103107 | 123 | 55 | 22 | 22 | | 19 | | 45 | 38 | 22 | 224 | 1162 |
| | 3 | -0.2 | | 99874 | 68 | 42 | 22 | 22 | 5 | 65 | | 45 | | 22 | 224 | 1121 |
| | 4 | -0.4 | | 95983 | 24 | 43 | 12 | 22 | 12 | 69 | | 45 | | 22 | 225 | 1055 |
| | 5 | -0.495 | | 92897 | 0 | 46 | | 22 | 15 | 35 | 40 | 44 | | 22 | 224 | 1024 |
| 8 | 1 | max | | 105619 | 229 | 69 | 22 | | | 56 | | 44 | 5 | 22 | 218 | 1155 |
| | 2 | 0.2 | | 104059 | 177 | 66 | 22 | 15 | | | | 44 | 50 | 22 | 219 | 1159 |
| | 3 | 0 | | 102116 | 124 | 55 | 22 | 22 | | 22 | | 44 | 31 | 22 | 218 | 1166 |
| | 4 | -0.2 | | 98931 | 72 | 43 | 22 | 22 | 5 | 60 | | 44 | | 22 | 218 | 1117 |
| | 5 | -0.491 | | 93251 | 0 | 35 | 12 | 22 | 12 | 109 | | 7 | | 22 | 219 | 1059 |
| 9 | 1 | 0.5 | | 105332 | 221 | 69 | 21 | 2 | | 54 | | 42 | | 21 | 209 | 1166 |
| | 2 | 0.15 | | 103852 | 172.8 | 66 | 21 | 16 | | | | 42 | 43 | 21 | 209 | 1163 |
| | 3 | 0 | | 102753 | 141 | 61 | 21 | 21 | | 2 | | 42 | 41 | 21 | 209 | 1168 |
| | 4 | -0.3 | | 99129 | 75.5 | 46 | 21 | 21 | 6 | 52 | | 42 | | 21 | 209 | 1113 |
| | 5 | -0.649 | 25 | 91729 | 0 | 25 | 21 | 21 | 12 | 46 | 63 | | | 21 | 209 | 1035 |
| 10 | 1 | max | | 103751 | 244 | 69 | 21 | | | 49 | | 43 | 11 | 21 | 214 | 1129 |
| | 2 | 0.2 | | 102212 | 192 | 66 | 21 | 14 | | | | 43 | 49 | 21 | 214 | 1139 |
| | 3 | 0 | | 99218 | 131 | 47 | 21 | 14 | | 92 | | 19 | | 21 | 214 | 1141 |
| | 4 | -0.2 | 67 | 92102 | 56 | 48 | | 11 | | 69 | 64 | | | 21 | 213 | 1073 |
| | 5 | -0.381 | 251 | 83143 | 0 | 30 | | 11 | | 88 | 64 | | | 21 | 214 | 904 |
| 11 | 1 | max | | 97758 | 196 | 57 | 32 | | | | | 64 | 134 | 32 | 319 | 956 |
| | 2 | 0 | | 97198 | 180 | 54 | 32 | 3 | | | | 64 | 134 | 32 | 319 | 956 |
| | 3 | -0.2 | | 94881 | 113.5 | 43 | 32 | 15 | | | | 64 | 133 | 32 | 319 | 968 |
| | 4 | -0.4 | | 92564 | 46.5 | 32 | 32 | 26 | | | | 64 | 133 | 32 | 319 | 968 |
| | 5 | -0.532 | | 90740 | 0 | 21 | 32 | 32 | | 28 | | 64 | 110 | 32 | 319 | 978 |
| 12 | 1 | max | | 105687 | 246 | 69 | 22 | | | 57 | | 44 | 5 | 22 | 219 | 1158 |
| | 2 | 0.2 | | 104165 | 201 | 66 | 22 | 15 | | | | 44 | 49 | 22 | 218 | 1159 |
| | 3 | 0 | | 102562 | 155 | 58 | 22 | 22 | | 7 | | 44 | 43 | 22 | 218 | 1165 |
| | 4 | -0.325 | | 96292 | 56 | 35 | 16 | 22 | 2 | 56 | 66 | | | 22 | 219 | 1158 |
| | 5 | -0.472 | 101 | 90073 | 0 | 57 | 22 | 21 | | 20 | | 44 | 32 | 22 | 218 | 1173 |

Using computer terminals, participants are provided with details of their farm's initial recharge allocation (R_a), nominally set as the recharge rate where the water table rise is zero, in addition to farm income and the recharge levels for each decision variable. Recharge information is provided to participants as the number of recharge units rather than by volume (Mls). Participants have access exclusively to their own farm information.

The crop and land management decision variables provided to participants are detailed in

Table 5 and

Table 6. To establish the institutional structure for a potential market in recharge units, a maximum threshold representing the desired stable water table state is required. For the simulation a zero water table rise has been established as the environmental target. Two allocation options have been established. Table 5 represents an initial allocation of recharge units to each farm where the crop mix option leads to a zero water table rise, estimated from the SWAGMAN coefficients. The maximum aggregate recharge of the 12 farms is 2638 recharge units. The crop mix option producing a zero water table rise results in a recharge of 1610 recharge units or 61% of maximum. Table 6 details the crop mix options and characteristics provided to participants if the allocation employed is the 61% of maximum recharge protocol. For example, in Table 6, Farm 1 the maximum recharge is 200 units, the allocation is 122 units (61% of 200).

The tables detail the water table increase arising from the five crop mix options, the incremental change in gross margin and recharge, the marginal value of a recharge unit for each option, and the allocation for each farm.⁷ Incremental changes represent the change in farm income and recharge units when referenced to the initial allocation option. For example, in Table 5, Farm 1, the choice of option 1, requires the player to procure an additional 137 recharge units from market exchange (*viz.* 200 minus the allocation of 63) with a value to that participant for that option of \$43 per unit.

⁷ The allocation and correlated farm incomes for the 61% of maximum recharge allocation protocol has been estimated by regressing the income estimates of the SWAGMAN model against the number of recharge units. The functions for each farm are:

| | |
|---------------------------------------------|------------------|
| Farm 1: $y = -0.1916x^2 + 92.553x + 95298$ | $(R^2 = 0.9967)$ |
| Farm 2: $y = -0.3858x^2 + 200.17x + 78595$ | $(R^2 = 0.9982)$ |
| Farm 3: $y = -0.0765x^2 + 49.863x + 99187$ | $(R^2 = 0.9935)$ |
| Farm 4: $y = -0.2187x^2 + 113.46x + 90541$ | $(R^2 = 0.9951)$ |
| Farm 5: $y = -0.0653x^2 + 56.586x + 109974$ | $(R^2 = 0.9968)$ |
| Farm 6: $y = -0.2935x^2 + 179.23x + 80484$ | $(R^2 = 0.999)$ |
| Farm 7: $y = -0.2453x^2 + 113.47x + 93195$ | $(R^2 = 0.9968)$ |
| Farm 8: $y = -0.1591x^2 + 90.532x + 93214$ | $(R^2 = 0.9996)$ |
| Farm 9: $y = -0.241x^2 + 112.78x + 91924$ | $(R^2 = 0.9977)$ |
| Farm 10: $y = -0.3551x^2 + 169.39x + 83305$ | $(R^2 = 0.9983)$ |
| Farm 11: $y = -0.0106x^2 + 37.536x + 90783$ | $(R^2 = 0.9998)$ |
| Farm 12: $y = -0.2187x^2 + 113.46x + 90541$ | $(R^2 = 0.9951)$ |

Where:

Y = farm income

X = number of recharge units

Table 5 Marginal cost of recharge reduction at zero water table rise allocation

| Farm | Max WT rise (m) | crop mix | GM (\$) | recharge (MIs) | Marginal change in GM (\$) | Marginal change in recharge (MIs) | Marginal cost of recharge reduction (\$) | Zero water table rise allocation (MIs) |
|------|-----------------|----------|-----------|----------------|----------------------------|-----------------------------------|------------------------------------------|----------------------------------------|
| 1 | max | 1 | \$106,417 | 200 | 5885 | 137 | 43 | 63 |
| | 0.3 | 2 | \$104,442 | 150 | 3910 | 87 | 45 | |
| | 0 | 3 | \$100,532 | 63 | 0 | 0 | 0 | |
| | -0.1 | 4 | \$98,382 | 34 | 2150 | 29 | 74 | |
| | -0.25 | 5 | \$95,041 | 0 | 5491 | 63 | 87 | |
| 2 | max | 1 | \$103,965 | 228 | 17924 | 184 | 97 | 44 |
| | 0.4 | 2 | \$101,180 | 160 | 15139 | 116 | 131 | |
| | 0.2 | 3 | \$95,333 | 104 | 9292 | 60 | 155 | |
| | 0 | 4 | \$86,041 | 44 | 0 | 0 | 0 | |
| | -0.15 | 5 | \$79,071 | 0 | 6970 | 44 | 158 | |
| 3 | max | 1 | \$106,706 | 180 | 343 | 10 | 34 | 170 |
| | 0 | 2 | \$106,363 | 170 | 0 | 0 | 0 | |
| | -0.3 | 3 | \$104,321 | 112 | 2042 | 58.5 | 35 | |
| | -0.5 | 4 | \$102,584 | 62 | 3779 | 108 | 35 | |
| | -0.758 | 5 | \$98,751 | 0 | 7612 | 170 | 45 | |
| 4 | max | 1 | \$105,687 | 246 | 3125 | 91 | 34 | 155 |
| | 0.2 | 2 | \$104,165 | 201 | 1603 | 46 | 35 | |
| | 0 | 3 | \$102,562 | 155 | 0 | 0 | 0 | |
| | -0.325 | 4 | \$96,292 | 56 | 6270 | 99 | 63 | |
| | -0.472 | 5 | \$90,073 | 0 | 12489 | 155 | 81 | |
| 5 | 0 | 1 | \$119,547 | 227 | 0 | 0 | 0 | 227 |
| | -0.2 | 2 | \$117,472 | 166 | 2075 | 61 | 34 | |
| | -0.3 | 3 | \$116,206 | 132 | 3341 | 95 | 35 | |
| | -0.5 | 4 | \$112,048 | 31 | 7499 | 196 | 38 | |
| | -0.571 | 5 | \$109,714 | 0 | 9833 | 227 | 43 | |
| 6 | max | 1 | \$105,396 | 220 | 10358 | 123 | 84 | 97 |
| | 0.2 | 2 | \$100,901 | 148 | 5863 | 51 | 115 | |
| | 0 | 3 | \$95,038 | 97 | 0 | 0 | 0 | |
| | -0.2 | 4 | \$86,605 | 38.5 | 8433 | 58.5 | 144 | |
| | -0.4 | 5 | \$80,811 | 0 | 14227 | 97 | 147 | |
| 7 | max | 1 | \$106,619 | 221 | 3512 | 98 | 36 | 123 |
| | 0 | 2 | \$103,107 | 123 | 0 | 0 | 0 | |
| | -0.2 | 3 | \$99,874 | 68 | 3233 | 55 | 59 | |
| | -0.4 | 4 | \$95,983 | 24 | 7124 | 99 | 72 | |
| | -0.495 | 5 | \$92,897 | 0 | 10210 | 123 | 83 | |
| 8 | max | 1 | \$105,619 | 229 | 3503 | 105 | 33 | 124 |
| | 0.2 | 2 | \$104,059 | 177 | 1943 | 53 | 37 | |
| | 0 | 3 | \$102,116 | 124 | 0 | 0 | 0 | |
| | -0.2 | 4 | \$98,931 | 72 | 3185 | 52 | 61 | |
| | -0.491 | 5 | \$93,251 | 0 | 8865 | 124 | 71 | |
| 9 | 0.5 | 1 | \$105,332 | 221 | 2579 | 80 | 32 | 141 |
| | 0.15 | 2 | \$103,852 | 173 | 1099 | 31.8 | 35 | |
| | 0 | 3 | \$102,753 | 141 | 0 | 0 | 0 | |
| | -0.3 | 4 | \$99,129 | 76 | 3624 | 65.5 | 55 | |
| | -0.649 | 5 | \$91,729 | 0 | 11024 | 141 | 78 | |
| 10 | max | 1 | \$103,751 | 244 | 4533 | 113 | 40 | 131 |
| | 0.2 | 2 | \$102,212 | 192 | 2994 | 61 | 49 | |
| | 0 | 3 | \$99,218 | 131 | 0 | 0 | 0 | |
| | -0.2 | 4 | \$92,102 | 56 | 7116 | 75 | 95 | |
| | -0.381 | 5 | \$83,143 | 0 | 16075 | 131 | 123 | |
| 11 | max | 1 | \$97,758 | 196 | 560 | 16 | 35 | 180 |
| | 0 | 2 | \$97,198 | 180 | 0 | 0 | 0 | |
| | -0.2 | 3 | \$94,881 | 114 | 2317 | 66.5 | 35 | |
| | -0.4 | 4 | \$92,564 | 47 | 4634 | 133.5 | 35 | |
| | -0.532 | 5 | \$90,740 | 0 | 6458 | 180 | 36 | |
| 12 | max | 1 | \$105,687 | 246 | 3125 | 91 | 34 | 155 |
| | 0.2 | 2 | \$104,165 | 201 | 1603 | 46 | 35 | |
| | 0 | 3 | \$102,562 | 155 | 0 | 0 | 0 | |
| | -0.325 | 4 | \$96,292 | 56 | 6270 | 99 | 63 | |
| | -0.472 | 5 | \$90,073 | 0 | 12489 | 155 | 81 | |

Table 6 Marginal cost of recharge reduction at 61% of maximum recharge allocation

| Farm | Max WT rise (m) | crop mix | GM (\$) | recharge (Mls) | Marginal change in GM (\$) | Marginal change in recharge (Mls) | Marginal cost of recharge reduction (\$) | 61% of max allocation (Mls) | GM of allocation (\$) |
|------|-----------------|----------|-----------|----------------|----------------------------|-----------------------------------|------------------------------------------|-----------------------------|-----------------------|
| 1 | max | 1 | \$106,417 | 200 | 2679 | 78 | 34 | 122 | 103738 |
| | 0.3 | 2 | \$104,442 | 150 | 704 | 28 | 25 | | |
| | 0 | 3 | \$100,532 | 63 | 3206 | 59 | 54 | | |
| | -0.1 | 4 | \$98,382 | 34 | 5356 | 88 | 61 | | |
| | -0.25 | 5 | \$95,041 | 0 | 8697 | 122 | 71 | | |
| 2 | max | 1 | \$103,965 | 228 | 5000 | 89 | 56 | 139 | 98965 |
| | 0.4 | 2 | \$101,180 | 160 | 2215 | 21 | 105 | | |
| | 0.2 | 3 | \$95,333 | 104 | 3632 | 35 | 104 | | |
| | 0 | 4 | \$86,041 | 44 | 12924 | 95 | 136 | | |
| | -0.15 | 5 | \$79,071 | 0 | 19894 | 139 | 143 | | |
| 3 | max | 1 | \$106,706 | 180 | 2440 | 70 | 35 | 110 | 104266 |
| | 0 | 2 | \$106,363 | 170 | 2097 | 60 | 35 | | |
| | -0.3 | 3 | \$104,321 | 112 | 55 | 2 | 36 | | |
| | -0.5 | 4 | \$102,584 | 62 | 1682 | 48 | 35 | | |
| | -0.758 | 5 | \$98,751 | 0 | 5515 | 110 | 50 | | |
| 4 | max | 1 | \$105,687 | 246 | 3389 | 96 | 35 | 150 | 102298 |
| | 0.2 | 2 | \$104,165 | 201 | 1867 | 51 | 37 | | |
| | 0 | 3 | \$102,562 | 155 | 264 | 5 | 53 | | |
| | -0.325 | 4 | \$96,292 | 56 | 6006 | 94 | 64 | | |
| | -0.472 | 5 | \$90,073 | 0 | 12225 | 150 | 82 | | |
| 5 | 0 | 1 | \$119,547 | 227 | 3008 | 89 | 34 | 138 | 116539 |
| | -0.2 | 2 | \$117,472 | 166 | 933 | 28 | 33 | | |
| | -0.3 | 3 | \$116,206 | 132 | 333 | 6 | 56 | | |
| | -0.5 | 4 | \$112,048 | 31 | 4491 | 107 | 42 | | |
| | -0.571 | 5 | \$109,714 | 0 | 6825 | 138 | 49 | | |
| 6 | max | 1 | \$105,396 | 220 | 6165 | 86 | 72 | 134 | 99231 |
| | 0.2 | 2 | \$100,901 | 148 | 1670 | 14 | 119 | | |
| | 0 | 3 | \$95,038 | 97 | 4193 | 37 | 113 | | |
| | -0.2 | 4 | \$86,605 | 38.5 | 12626 | 96 | 132 | | |
| | -0.4 | 5 | \$80,811 | 0 | 18420 | 134 | 137 | | |
| 7 | max | 1 | \$106,619 | 221 | 2576 | 86 | 30 | 135 | 104043 |
| | 0 | 2 | \$103,107 | 123 | 936 | 12 | 78 | | |
| | -0.2 | 3 | \$99,874 | 68 | 4169 | 67 | 62 | | |
| | -0.4 | 4 | \$95,983 | 24 | 8060 | 111 | 73 | | |
| | -0.495 | 5 | \$92,897 | 0 | 11146 | 135 | 83 | | |
| 8 | 0.2 | 1 | \$105,619 | 229 | 2849 | 89 | 32 | 140 | 102770 |
| | 0 | 2 | \$104,059 | 177 | 1289 | 37 | 35 | | |
| | -0.2 | 3 | \$102,116 | 124 | 654 | 16 | 41 | | |
| | -0.2 | 4 | \$98,931 | 72 | 3839 | 68 | 56 | | |
| | -0.491 | 5 | \$93,251 | 0 | 9519 | 140 | 68 | | |
| 9 | 0.5 | 1 | \$105,332 | 221 | 2675 | 86 | 31 | 135 | 102657 |
| | 0.15 | 2 | \$103,852 | 173 | 1195 | 38 | 32 | | |
| | 0 | 3 | \$102,753 | 141 | 96 | 6 | 16 | | |
| | -0.3 | 4 | \$99,129 | 76 | 3528 | 60 | 59 | | |
| | -0.649 | 5 | \$91,729 | 0 | 10928 | 135 | 81 | | |
| 10 | max | 1 | \$103,751 | 244 | 3904 | 107 | 36 | 137 | 99847 |
| | 0.2 | 2 | \$102,212 | 192 | 2365 | 55 | 43 | | |
| | 0 | 3 | \$99,218 | 131 | 629 | 6 | 105 | | |
| | -0.2 | 4 | \$92,102 | 56 | 7745 | 81 | 96 | | |
| | -0.381 | 5 | \$83,143 | 0 | 16704 | 137 | 122 | | |
| 11 | max | 1 | \$97,758 | 196 | 2623 | 76 | 35 | 120 | 95135 |
| | 0 | 2 | \$97,198 | 180 | 2063 | 60 | 34 | | |
| | -0.2 | 3 | \$94,881 | 114 | 254 | 7 | 39 | | |
| | -0.4 | 4 | \$92,564 | 47 | 2571 | 74 | 35 | | |
| | -0.532 | 5 | \$90,740 | 0 | 4395 | 120 | 37 | | |
| 12 | max | 1 | \$105,687 | 246 | 3389 | 96 | 35 | 150 | 102298 |
| | 0.2 | 2 | \$104,165 | 201 | 1867 | 51 | 37 | | |
| | 0 | 3 | \$102,562 | 155 | 264 | 5 | 53 | | |
| | -0.325 | 4 | \$96,292 | 56 | 6006 | 94 | 64 | | |
| | -0.472 | 5 | \$90,073 | 0 | 12225 | 150 | 82 | | |

After entering the chosen management option, participant screens are updated with the option specific income, the marginal value of recharge units and the required recharge balance for the selected option.

Farm income is derived from the SWAGMAN estimates of crop mixes. Recharge balance (R_b) is calculated as the initial recharge allocation less the amount needed for the farm management option the participant selects. R_b can represent a surplus or deficit of recharge units depending on the farm allocation and management option selected. For example if $R_a = 100$, $R_{\text{option 1}} = 200$; $R_b = -100$. If $R_a = 100$, $R_{\text{option 5}} = 0$, $R_b = 100$. Option one has a 100 recharge unit shortfall, requiring purchase in a recharge market; option five has a surplus of 100 units, facilitating a selling option in the market.

Marginal value (MV) for each option is calculated as the marginal cost of recharge abatement for the option compared to the allocation. The marginal cost of abatement is calculated as the difference in income between that of the zero recharge option and the selected management option, divided by the cumulative difference in recharge between the zero recharge and the selected management options.

Players voluntarily enter the market to meet recharge shortfalls and sell surplus recharge units. Market trading options are contingent on player behaviour and conditioned by farm characteristics. Market entrants enter bid quantities (based on R_b) and their market exchange price (based on the marginal value of recharge). Players are prevented from offering surplus recharge units for sale in excess of their calculated R_b . Player payments are calculated as a function of optimum aggregate farm management and trading outcomes, reflecting player capacity to comply with recharge targets, adherence to farm management agreements and trading skill. To ensure salience of player behaviour and response to income variance in the simulated catchment, the player payments are therefore a scaled representation of the income decisions confronting farmers in the CIA.⁸

Optimal incomes are calculated as the crop option that maximises income based on the estimated equilibrium price for the allocation protocol. For example, in the zero water table rise allocation, the farm income is maximised for Farm 1, at a recharge unit value of \$43, with a market price of \$38:

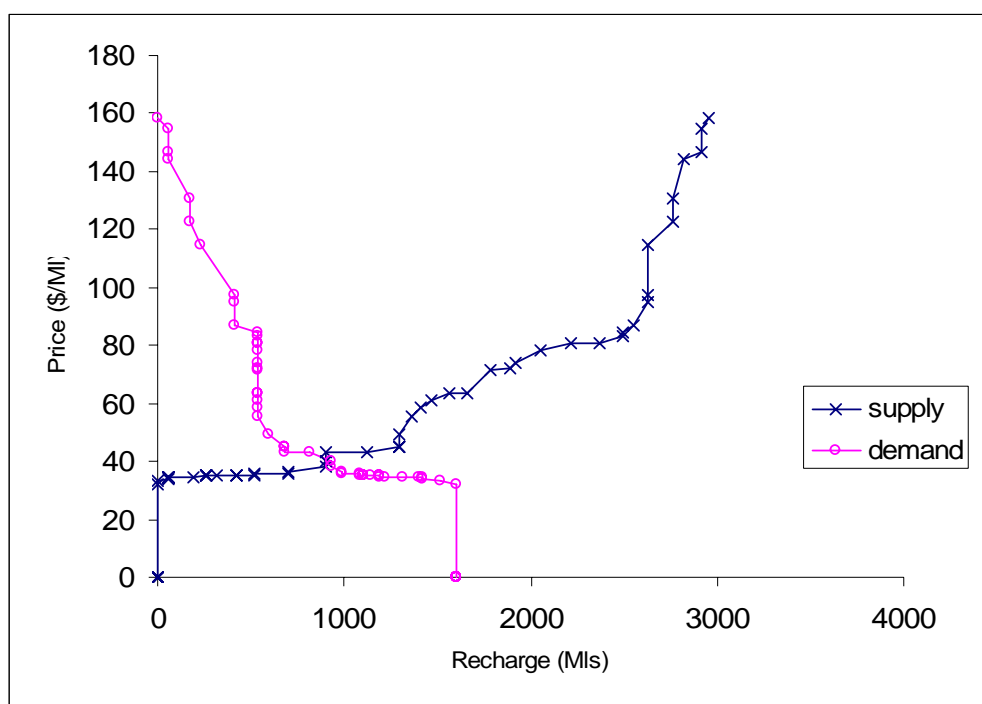
Option 1: requires the purchase of 137 units (200 minus the allocation of 63) @ \$38 or \$5206, leaving a net income of \$101,211 (\$106,417 minus \$5206). A player receives \$1.50 for the period by choosing option 1 and is successful in the market, contingent on a market price of \$38.

The experiments deploy a uniform price, closed call auction structure, providing historical market bidding information, whilst assuring the anonymity of bidders thus preventing potential trader collusion. In a closed call market potential buyers submit sealed bids to buy and potential sellers submit sealed offers to sell. The market is ‘‘called’’ and trades are executed by a clearing-house, in this case the recharge

⁸ A \$10 attendance payment, player payments are calibrated using a single variable OLS regression, relating a \$1.50 per period for achieving the derived optimum farm income and \$0.40 for static decisions (*viz.* a zero water table rise income choice).

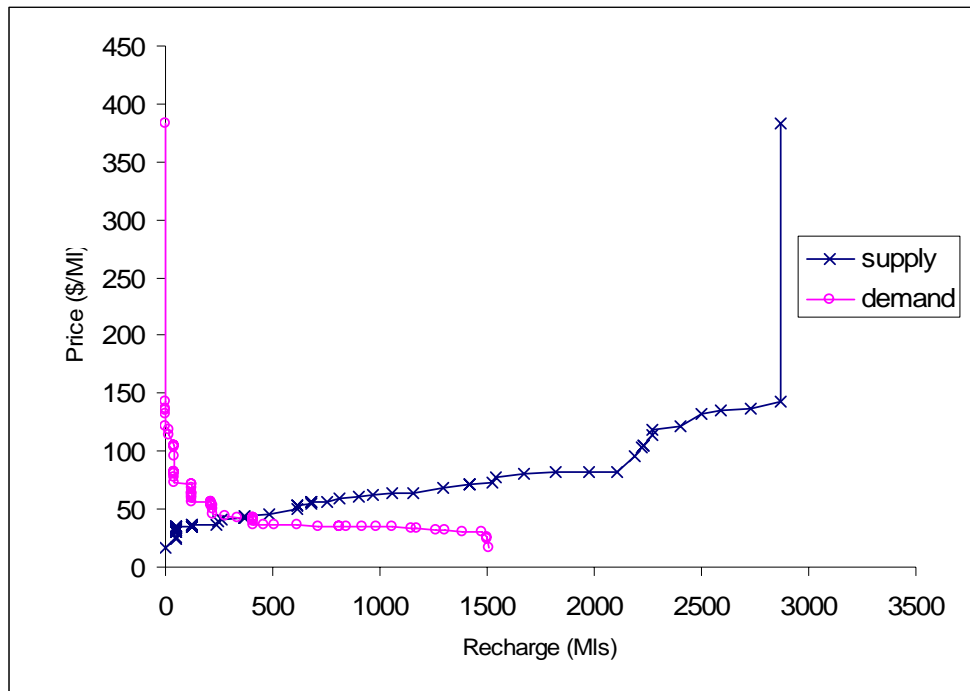
managing authority, at a competitive equilibrium price. The authority notifies successful traders and releases the market price and volume traded information only. The estimated optimal market outcomes for the two allocation procedures are illustrated in Figure 1 (Zero water table rise allocation, equilibrium price of \$38) and Figure 2 (61% of maximum recharge allocation, equilibrium price of \$35). For reference purposes, the marginal costs and benefits and estimated optimal market outcomes of choosing single incremental crop mix choices referenced to the maximum farm income of option 1 are illustrated in Figure 3. That is the marginal change in recharge unit value when choosing option 2 from option 1, option 3 from option 2 and so on.

Figure 1: Optimised trading outcomes in a recharge unit market for a zero allocation protocol



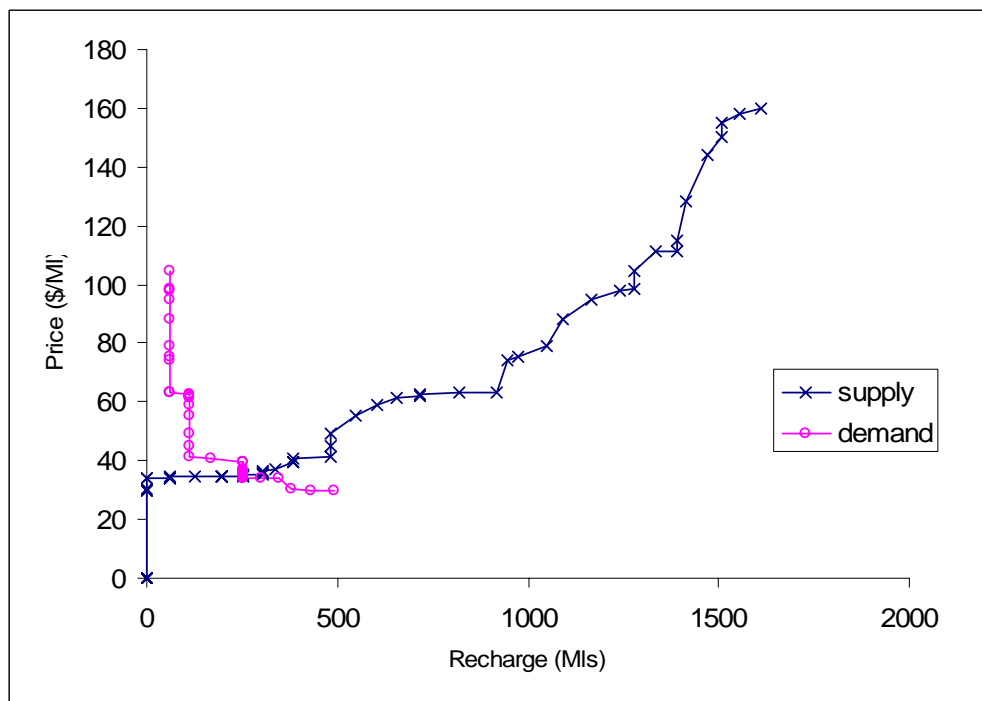
The equilibrium price of the zero allocation market is \$38.

Figure 2: Optimised trading outcomes in a recharge unit market for a 61% of maximum allocation protocol



The equilibrium price of the 61% of maximum recharge allocation is \$35.

Figure 3: Optimised trading outcomes in a recharge unit market for incremental option choices (zero allocation protocol)



Equilibrium price of incremental options is \$35

The experimental trading environment relies on the MWATER software platform developed by Dr. John Tisdell of Griffith University and the CRC for Catchment Hydrology. The experimental economics platform provides an internet based flexible market environment, is capable of various auction structures, institutional rules and penalties, facilitates remote location operation, coupled with high levels of data integrity and security and is designed to be populated with complex biophysical and economic data sets.

Table 7 outlines the proposed experimental design in a more formal mathematical way including:

- the set of experimental metrics;
 - potentially confounding experimental factors;
 - experimental controls and;
 - the null hypotheses to be tested with each proposed experiment.
-

Table 7 Experimental design for potential laboratory based treatments

| Symbols for the metrics of experimental treatments: | Treatments: |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Y_{ti}: income for experimental farm i, for treatment t; $Y_t = \sum Y_{ti}$ aggregate income. R_{ti}: recharge for experimental farm i, for treatment t; $R_t = \sum R_{ti}$ aggregate recharge. P_t: market price for recharge units, for treatment t. Q_t: aggregate number of recharge units traded, for treatment t. YY_t: distribution of individual farm income for experimental farms 1-12, for treatment t.</p> <p>Where: $t =$ treatments (1 – 8); $i =$ experimental farms (1 – 12)</p> | <p>Treatments:</p> <p>Standard treatment equals Treatment 1: Unless otherwise specified, standardised variables are:</p> <ul style="list-style-type: none"> • Recharge entitlements (property rights) are assigned to farmers • Entitlement distribution according to zero water table rise recharge potential; • Uncertain rainfall is normalised : i.e. recharge allocation calculated according to the median rainfall for the CIA; • Participants include farmers; • Individual penalty for recharge non-compliance; • Closed call market <p>Treatment₂: Treatment 1 with forum for communication and social contracts;</p> <p>Treatment 3: Treatment 1, with forum for communication and social contracts minus closed call market;</p> <p>Treatment 4: Treatment 1, recharge entitlements assigned to downstream beneficiaries;</p> <p>Treatment 5: Treatment 1, minus external trader;</p> <p>Treatment 6: Treatment 1 with uncertain rainfall effects included in annual performance measure;</p> <p>Treatment 7: Treatment 1 with recharge entitlements auctioned;</p> <p>Treatment 8: Treatment 1 including a multiple year dynamic mgt option. Includes the banking of credits/debits, period specific mgt. costs and a requirement to clear all accounts at end of multiple year trial (e.g. 5yr period)</p> <p>Treatment 9: Treatment 1 with socialised penalty for non-compliance;</p> <p>Treatment 10: Treatment 8 dynamic mgt option, with amortised management costs.</p> |
| <p>Metrics</p> <p>Y_{ci}: income for experimental farm i, for control₁; $Y_{c1} = \sum Y_{ci}$ aggregate income; R_{ci}: recharge for experimental farm i, for control₁; $R_{c1} = \sum R_{ci}$ aggregate recharge; P_{c1}: market price for recharge units, for control₁; Q_{c1}: aggregate number of recharge units traded, for control₁; YY_{c1}: distribution of individual farm income for experimental farms 1-12, for control₁. Where: $i =$ experimental farms (1 – 12)</p> | |

| MARKET IMPEDIMENT | INTERACTING EXPERIMENTAL FACTORS | FACTORS HELD CONSTANT | TREATMENTS AND FACTORS VARYING FROM STANDARD | NULL HYPOTHESIS |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. COMMON POOL RESOURCE</p> <p>Status Quo: Currently farmers are required to adopt recharge reduction practices Market based instruments or community governance based on social contracts offer alternate solutions to the social dilemma</p> <p>Research Question. Does the introduction of a formal and controlled forum for discussion, leading to a robust voluntary social contract result in reduced recharge, compared to trade in recharge units. Aggregate income, and the distribution of income are additional measures of the economic consequences at the catchment scale, the recharge impact and the equity of redistribution.</p> | <p>a.The method of entitlement allocation b.The negotiating party with assigned rights c.The effect of the risk of uncertain climatic events. d.The effect of thin markets e.Insufficient incentive to comply with recharge targets.</p> | <p>a.Entitlement distribution according to zero WT rise. b.Normalised climate effects c.Participants include farmers and external trader. d.Individual penalty for recharge non-compliance.</p> | <p>Control₁ Input based assessment: <i>Status Quo</i> Treatment₁ Treatment₂ Treatment₃ Rationale: property rights assigned to farmers (Treatment₁) compared with communication + trade (Treatment₂) and communication only Treatment₃</p> | <p>1) $H_0: Y_{c1} = Y_1 = Y_2 = Y_3$, 2) $H_0: R_{c1} = R_1 = R_2 = R_3$, 3) $H_0: P_{c1} = P_1 = P_2 = P_3$, 4) $H_0: Q_{c1} = Q_1 = Q_2 = Q_3$</p> |
| <p>1. PROPERTY RIGHTS</p> <p>Status Quo: Currently farmers are required to adopt recharge reduction practices Recharge entitlements can be assigned to either one of the negotiating parties: either farmers or downstream beneficiaries of recharge reduction.</p> <p>Research Question. Does the assignment of recharge units affect the level of market efficiency, measured as market price and quantity traded? Aggregate income, aggregate recharge and the distribution of income are additional measures of the economic consequences at the catchment scale, the recharge impact and the equity of</p> | <p>a.The method of entitlement allocation b.The effect of the risk of uncertain climatic events. c.The effect of thin markets d.Insufficient incentive to comply with recharge targets. e.Communication</p> | <p>a.Entitlement distribution according to zero WT rise. b.Normalised climate effects c.Participants include farmers and external trader. d.Individual penalty for recharge non-compliance.</p> | <p>Control₁ Input based assessment: risk assigned to Govt <i>Status Quo</i> Treatment₁ Treatment₄ Rationale: property rights assigned to farmers (Treatment₁) compared with property rights assigned to downstream beneficiaries (Treatment</p> | <p>1) $H_0: Y_{c1} = Y_1 = Y_4$, 2) $H_0: R_{c1} = R_1 = R_4$, 3) $H_0: P_{c1} = P_1 = P_4$, 4) $H_0: Q_{c1} = Q_1 = Q_4$</p> |

| redistribution. | | | 4) | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MARKET IMPEDIMENT | INTERACTING EXPERIMENTAL FACTORS | FACTORS HELD CONSTANT | TREATMENTS AND FACTORS VARYING FROM STANDARD | NULL HYPOTHESIS |
| <p>2. THIN MARKETS (insufficient buyers and sellers)</p> <p>Low numbers of recharge traders may result in low trading liquidity, price volatility, and strategic price distortion or permit hoarding.</p> <p>Research Question. Does the introduction of an external trader deepen the market, increasing the volume of trade in recharge units, affecting aggregate income, aggregate recharge, market price and quantity traded and the distribution of farm income?</p> | <p>a. The method of entitlement allocation</p> <p>b. The negotiating party that recharge entitlements are assigned to.</p> <p>c. The effect of the risk of uncertain climatic events.</p> <p>d. Insufficient incentive to comply with recharge targets.</p> <p>e. Communication</p> | <p>a. Entitlement distribution according to zero WT rise.</p> <p>b. Entitlements assigned to farmers.</p> <p>c. Normalised climate effects.</p> <p>d. Penalty for recharge non-compliance.</p> <p>e. No Communication</p> | <p>Control $_2 = \text{Treatment } _1$</p> <p>Treatment $_5$</p> <p>Rationale: The presence of an external trader (Treatment $_1$) compared with no external trader (Treatment $_5$)</p> | <p>1) $H_0: Y_5 = Y_1$,</p> <p>2) $H_0: R_5 = R_1$,</p> <p>3) $H_0: P_5 = P_1$,</p> <p>4) $H_0: Q_5 = Q_1$,</p> <p>5) $H_0: VY_5 = VY_1$</p> |
| <p>3. MISMATCHED CREDIT DEMAND AND SUPPLY</p> <p>Random natural events such as flood or drought can cause systemic under or overachievement of recharge reduction, leading to most participants incurring either excess credits or debits, regardless of land management practices.</p> <p>Research Question. Do uncertain rainfall events influence the level of recharge exchange, affecting aggregate</p> | <p>a. The method of entitlement allocation</p> <p>b. .</p> <p>c. Insufficient incentive to comply with recharge targets.</p> <p>d. The effect of</p> | <p>a. Entitlement distribution according to zero WT rise.</p> <p>b. Entitlements assigned to farmers</p> <p>c. Penalty for recharge non-compliance.</p> <p>d. Participants include farmers and external trader.</p> <p>e. No Communication</p> | <p>Control $_1$ (<i>status quo</i>)</p> <p>Control $_2 = \text{Treatment } _1$</p> <p>Treatment $_6$</p> <p>Rationale – Govt assumes management of rainfall uncertainty and farmers assume farm management risk</p> | <p>1) $H_0: Y_{c1} = Y_6 = Y_1$,</p> <p>2) $H_0: R_{c1} = R_6 = R_1$,</p> <p>3) $H_0: P_{c1} = P_6 = P_1$,</p> <p>4) $H_0: Q_{c1} = Q_6 = Q_1$,</p> <p>5) $H_0: VY_{c1} = VY_6 =$</p> |

| | | | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| income, aggregate recharge, market price, quantity traded and the distribution of farm income? | thin markets e.Communication | | (normalised rainfall Treatment₁) compared with farmers managing both risk of uncertain rainfall and management (Treatment₆). I.e treatment isolates random impacts of rainfall on performance. | VY1 |
| MARKET IMPEDIMENT | INTERACTING EXPERIMENTAL FACTORS | FACTORS HELD CONSTANT | TREATMENTS AND FACTORS VARYING FROM STANDARD | NULL HYPOTHESIS |
| <p>4. METHOD OF ENTITLEMENT DISTRIBUTION AMONG FARMERS</p> <p>If the distributional changes arising from the initial allocation of recharge entitlements are perceived as inequitable program participation could decline.</p> <p>Research Question. Does the allocation of recharge entitlements to farmers influence the level of recharge exchange, affecting aggregate income, aggregate recharge, market price, quantity traded and the distribution of farm income?</p> | <p>a.The negotiating party that recharge entitlements are assigned to.</p> <p>b.Insufficient incentive to comply with recharge targets.</p> <p>c.The effect of the risk of uncertain climatic events.</p> <p>d.The effect of thin markets.</p> <p>e.Communication</p> | <p>a.Entitlements assigned to farmers.</p> <p>b.Penalty for recharge non-compliance.</p> <p>c.Normalised climate effects.</p> <p>d.Participants include farmers and external trader.</p> <p>e. No communication</p> | <p>Control₂ = Treatment₁ Treatment₇</p> <p>Rationale: The efficiency outcome of recharge entitlements auction (Treatment₇) equals the free allocation and market redistribution (Treatment₁).</p> | <p>1) H₀: Y7 = Y1,</p> <p>2) H₀: R7 = R1</p> <p>3) H₀: P7 = P1,</p> <p>4) H₀: Q7 = Q1</p> <p>5) H₀: VY7 = VY1</p> |
| <p>5. RISK ASSIGNMENT</p> <p>There are two elements to risk for the pilot. a) risk associated with random, exogenous events such as rainfall variability, b) risk of on-farm performance of management options in</p> | <p>a.The method of entitlement allocation.</p> <p>b.The negotiating</p> | <p>a.Entitlement distribution according to zero WT rise.</p> <p>b.Entitlements assigned to farmers.</p> <p>c.Penalty for recharge non-compliance.</p> | <p>Control₁ : (status quo) Control₂ = Treatment₁ :</p> | <p>1) H₀: Yc1 = Y6 = Y1 = Y8,</p> <p>2) H₀: Rc1 = R6 = R1</p> |

| <p>achieving recharge reduction.</p> <p>Research Question. Do different methods to reassign the uncertainties of rainfall from farmers to the State, affect aggregate income, aggregate recharge, market price, quantity traded and the distribution of farm income?</p> | <p>party to whom recharge entitlements are assigned.</p> <p>c. Insufficient incentive to comply with recharge targets.</p> <p>d. The effect of thin markets.</p> <p>e. Communication</p> | <p>d. Participants include farmers and external trader.</p> <p>e. No Communication</p> | <p>Treatment 6</p> <p>Treatment 8</p> <p>Rationale – farmers assume both rainfall uncertainty and mgt risk (Treatment 6) compared with a multiple year dynamic mgt option (Treatment 8)</p> <p>Multiple year accounting can allow offsetting the risks of excess demand from some years with risks of excess supply in other years.</p> | <p>= R8,</p> <p>3) H₀: P_{c1} = P₆ = P_{t1} = P_{t8},</p> <p>4) H₀: Q_{c1} = Q₆ = Q₁ = Q₈,</p> <p>5) H₀: VY_{c1} = VY₆ = VY₁ = VY₈</p> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>MARKET IMPEDIMENT</p> | <p>INTERACTING EXPERIMENTAL FACTORS</p> | <p>FACTORS HELD CONSTANT</p> | <p>TREATMENTS AND FACTORS VARYING FROM STANDARD</p> | <p>NULL HYPOTHESIS</p> |
| <p>6. INSUFFICIENT DIFFERENCE IN RECHARGE REDUCTION COSTS</p> <p>A reduced incentive to trade results in thin markets</p> | | | <p>No treatment: rely on social contracts</p> | |
| <p>7. INSUFFICIENT INCENTIVE TO COMPLY WITH RECHARGE TARGETS</p> <p>Research Question. Does the introduction of a penalty for individual non-compliance with recharge targets influence the level of recharge exchange, affecting aggregate income, aggregate recharge, market price, quantity traded and the distribution of farm income?</p> | <p>a. The method of entitlement allocation.</p> <p>b. The negotiating party to whom recharge entitlements are assigned.</p> <p>c. The effect of the risk of uncertain climatic events.</p> | <p>a. Entitlement distribution according to zero WT rise.</p> <p>b. Entitlements assigned to farmers.</p> <p>c. Normalised climate effects.</p> <p>d. Participants include farmers and external trader.</p> | <p>Control 2 = Treatment 1:</p> <p>Treatment 7</p> <p>Rationale: Individual penalty for non-compliance with recharge targets (Treatment 1) compared with socialised penalty (Treatment 9) and no penalty (Treatment 7).</p> | <p>1) H₀: Y₇ = Y₁ = Y₉,</p> <p>2) H₀: R₇ = R₁ = R₉</p> <p>3) H₀: P₇ = P₁ = P₉,</p> <p>4) H₀: Q₇ = Q₁ = Q₉</p> <p>5) H₀: VY₇ = VY₁ = VY₉</p> |

| | | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <p>d.The effect of thin markets. e.Communication</p> | | | |
| <p>8. CAPITAL CONSTRAINT Farm management data indicates capital constraints may limit management options that increase farm income and reduce recharge.</p> | <p>a.The method of entitlement allocation. b.The negotiating party to whom recharge entitlements are assigned. c.The effect of the risk of uncertain climatic events. d.The effect of thin markets. e.Communication</p> | <p>a.Entitlement distribution according to Zero WT rise. b.Entitlements assigned to farmers. c.Normalised climate effects. d.Participants include farmers and external trader. e.No Communication</p> | <p>Control₃ = Treatment₈: Treatment₈ Treatment₁₀ Rationale: dynamic mgt option with period specific establishment, and management costs (Treatment₁₀) compared dynamic mgt option, amortised management costs (Treatment₈).</p> | <p>1) H₀: Y₈ = Y₁₀, 2) H₀: R₈ = R₁₀ 3) H₀: P₈ = P₁₀, 4) H₀: Q₈ = Q₁₀ 5) H₀: VY₈ = VY₁₀</p> |

5 Outcomes of the Yanco Field demonstration

The experimental simulation and recharge credit trading environment was field demonstrated at Yanco Agricultural College, Yanco, on the 3rd August 2004.

The field demonstrations were intended to primarily to familiarise irrigators with the inter-dependent nature of excess groundwater recharge, to promote acceptance of the reliability of the SWAGMAN recharge model, and enable irrigators to explore and experiment with recharge market structures and outcomes. The demonstrations play an important role in providing a forum for irrigator discussion, shared innovation, and information about recent developments in recharge management. The informal nature of the field demonstrations did not comply with the experimental design requirements of a controlled setting and precludes the collection of reliable experimental data. That is, to ensure reliable analysis of treatment effects, a robust experimental design aims to keep all salient factors constant except the variable (or treatment) of interest. Performance criteria of the field demonstrations is restricted to qualitative appraisals of the level and willingness of participation, acceptance of recharge markets as a potential recharge solution and suggested strategies and instruments for future recharge management.

Twenty seven attendees participated in the field demonstration: 17 irrigators from the Coleambally district, seven CIA staff and three staff members of CSIRO. Dr John Tisdell of Griffith University and the CRC for Catchment Hydrology and Dr John Ward of CSIRO Land and Water administered and supervised the demonstration.

Twelve computers at Yanco were employed as terminals and rerouted to the Griffith University experimental economics server via the internet. Each terminal screen represented a discrete farm in the central sub-catchment of the CIA, with specific farm income, cropping management and recharge characteristics. The data set is detailed in

Table 5. Recharge trading for the demonstration employed an open call, uniform price market structure, similar to that used by the Goulburn-Broken water exchange. An open call market provided additional bidding information for each market period and a uniform price auction provides opportunities for strategic bidding without the volatility (for novice market participants) of discriminate prices.

The slides in Appendix A were presented to participants reinforcing the shared nature of the recharge problem, the theme of cooperative solutions, the market familiarisation objective, and importantly, the aim of irrigator involvement in developed solutions.

Two recharge trading sessions were held, each session comprising 12 bidding periods, corresponding to annual farm management decisions and ensuing market trading. The experimental instructions are detailed in Appendix B.

5.1 Yanco Demonstration outcomes

Overall the participants were enthusiastic during the recharge trading demonstration, recognising the immediate need for remedial, shared recharge management. Importantly the cohort of irrigators represented those affected by increasing catchment recharge and rising groundwater and those from high recharge areas of the catchment. The demonstration provided a forum for constructive and vigorous discussion of the shared nature of catchment recharge and highlighted the social dilemma facing constituents.

The main points of the Yanco demonstration were:

- The expedient introduction of effective shared, recharge management and catchment wide remedial action was recognised and accepted. The notion of a recharge CAP was generally accepted, in addition to an interest to further explore community based innovations and solutions;
- Opportunities for trade in recharge units were clear;
- Market prices generally reflected modelled outcomes (approximately \$38) although the level of trade was limited (a range of 100-600 units trading). Additionally the income incentive for trading was low, i.e. the proportion of trading income to farm income was very low. Overall the gains from trade in recharge units were low;
- The data for the CIA were refined and re-framed for the laboratory sessions in accord with irrigator comments, with reference to the recharge marginal values reflecting the change in crop mix in reference to the benchmark recharge allocation, not the next highest income option;
- Suggestions of higher penalties for non-compliance. Current experimental penalties reflect a reduction in farm income corresponding to an income level associated with a complied recharge target. The market cost of recharge purchases that partially fulfil targets are also deducted from farm income;
- Widespread consensus for a combined two day SWAGMAN/ Market trading workshop; and
- The reliability of the SWAGMAN model was generally not perceived nor recognised by participating irrigators. Improved recognition and adoption of the model would be enhanced by the combined workshop.

In order to coordinate with farm management schedules, the majority of participants agreed the best time for the workshop was February, 2005.

6 References

- Baumol, W.J. and Oates, W.E. (1988) *The theory of Environmental Policy: Externalities, Public Outlays and the Quality of Life*. 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey.
- Bromley, D. (1991) *Environment and economy: Property rights and public policy*, MA: Blackwell.
- Coase, R. (1960) The problem of social cost. *Journal of Law and Economics*; **3**, pp.144.
- Common, M. (1995) *Sustainability and Policy: limits to economics*, Cambridge: Cambridge University Press.
- Dales, J.H. (1968) *Pollution property and taxes*. Toronto University Press, Toronto.
- Dinar, A. and Howitt, R.E. (1997) Mechanisms for allocation of environmental control cost: empirical tests of acceptability and stability. *Journal of Environmental Management*; **49**, pp.183-203.
- Howe, C. (1996) Water resources planning in a Federation of States: equity versus efficiency. *Natural Resources Journal*; **36**, pp.29-35.
- Khan S., Xevi E., and Meyer W. S. (2003) Salt, Water and Groundwater Management Models to Determine Sustainable Cropping Patterns in Shallow Saline Groundwater Regions – Special Volume of the *Journal of Crop Production* titled *Crop Production in Saline Environments*. 325-340. Co-published simultaneously in *Crop Production in Saline Environments, Global and Integrative Perspectives*, Ed Sham S. Goyal, Surinder K. Sharma and D. Williams, Haworth Press.
- Kampas, A. and White, B. (2003) Selecting permit allocation rules for agricultural pollution control: a bargaining solution. *Ecological Economics*; **47**, pp.135-147.
- Montgomery, W.D. (1972) Markets in licenses and efficient pollution control programs. *Journal of Economic Theory*; **5** (3), pp.395-418.
- Perman, R., Ma, Y., McGilvray, J. and Common, M. (1999) *Natural resource and environmental economics*, UK: Longman.
- Randall, A. (1978) Property institutions and economic behaviour. *Journal of Economic Issues*; **12**, pp.1-21.
- Randall, A. (1987) *Property rights, efficiency and the distribution of income*, New York: Wiley and Sons.
- Robinson, D., Whitten, S., Khan, S., Collins, D., and Ward, J., (2005) Tradeable recharge credits in Coleambally Irrigation Area – Report 2. *Economic impact of tradeable recharge credits and other net recharge abatement policies for the Coleambally Irrigation Area*, pp 1-32.
- Smith, Vernon, (1982) Markets as economizers of information: experimental examination of the Hayek Hypothesis. *Economic Inquiry*; **20** (2) pp.165-179.
-

Stavins, R. (1995) Transaction costs and tradeable permits. *Journal of Environmental Economics and Management*; **29**, pp. 133-148.

Stephan, G. and Muller-Furstenberger, G. (2004) Does distribution matter? Efficiency, equity and flexibility in greenhouse abatement. *Environmental and Resource Economics*; **27**, pp.87-107.

SWAGMAN Farm (online version): www.colyirr.com.au/swagmanfarm/Default.aspx

Syme, G., Nancarrow, B. and McCreddin, J. (1999) Defining the components of fairness in the allocation of water to environmental and human uses. *Journal of Environmental*

Tietenberg, T. (1998) Ethical influences on the evolution of the US tradeable permit approach to air pollution control. *Ecological Economics*; **24**, pp.241-257.

Tisdell, J., Ward, J and Capon, T. (2004) Impact of communication and information on a heterogeneous closed water catchment environment. *Water Resources Research*; **40**, (9) W09S03.

7 Appendix

Appendix A


Slide 1

Tradable recharge credits in
Coleambally Irrigation Area



CSIRO LAND and WATER

Slide 2

 **CSIRO LAND and WATER**
Policy and Economic Research Unit

Simulated groundwater recharge trading
session:
Coleambally Irrigation district

John Ward and John Tisdell

CSIRO LAND and WATER

Slide 3

Our primary focus is improved community outcomes by better management of the aquifer

- Exploring options to overcome increasing salinity and waterlogging in the Coleambally irrigation district
- Shared groundwater resource
- The effects of rising groundwater affects all land managers in the district

CSIRO LAND and WATER

Slide 4

Project overview

How to define, measure and allocate variable irrigator recharge options?

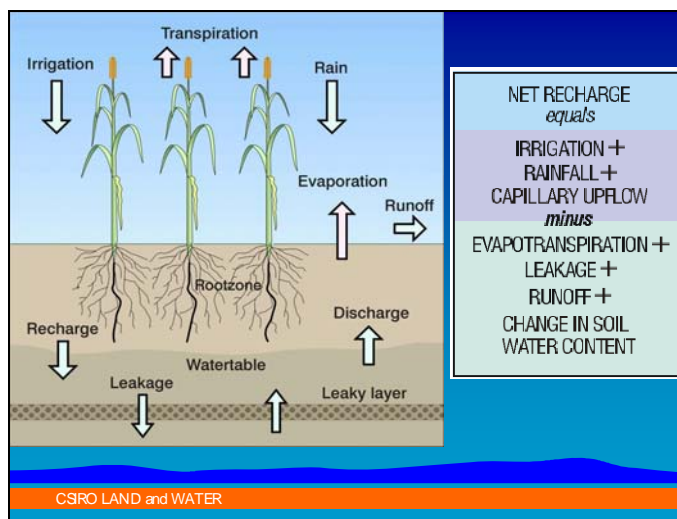
What management options are possible and can be developed?

What trading and compliance considerations can be incorporated?

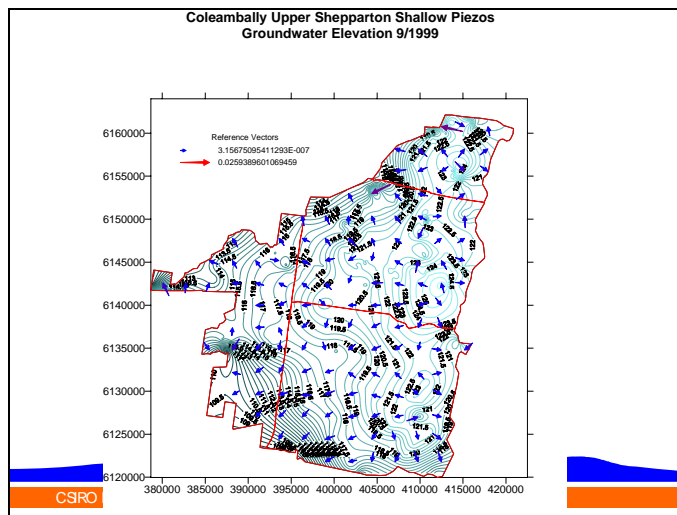
Desire by irrigators and CICL to find more flexible and cost-effective means to achieve recharge management goals

CSRO LAND and WATER

Slide 5



Slide 6



Slide 7

For any management options to be effective the community must be comfortable in engaging and using the scheme

THUS, COLEAMBALLY IRRIGATORS NEED TO BE INVOLVED, AND LISTENED TO, IN THE DEVELOPMENT AND IMPLEMENTATION OF SOLUTIONS

CSIRO LAND and WATER

Slide 8

Purpose of today's workshop:

Using a simulated recharge market we will:

- Familiarise you with a possible recharge market
- Work together to develop trading skills

AND MOST IMPORTANTLY GET YOUR IDEAS ON SOLUTIONS, IMPROVEMENTS AND CHANGES TO THE SCHEME

CSIRO LAND and WATER

Appendix B

Slide 1

What to do:

1. Read through the instructions carefully
2. After you have read through the instructions you will be taken to the experiment screen

Slide 2

Instructions to Participants

When the game opens you will have a farm that has been in the "recharge credit trade program" for a number of years. Your objective is to maximise the income you earn by wisely managing your farm. The instructions are simple and if you follow them carefully and make good decisions you could earn player's income.

Slide 3

Your Recharge allocation & farm plan choices

·When the game begins your "recharge allocation" will appear on the screen. This is the amount of recharge associated with the farm that reduces salinity in downstream rivers.

·You are at the beginning of a new farming season and you can consider whether you'd like to change to a new land management option. There will be a choice of five options. Each has a different level of farm income associated with it that will be shown on your screen.

·Each farm option results in a different amount of recharge. Your computer screen will show this as the number of "recharge units" associated with each decision.

Slide 4

Your Recharge allocation & farm plan choices

You can choose an option plan requiring exactly your recharge allocation, an option requiring more recharge units than your allocation, or an option requiring less recharge units than your allocation.

If you choose an option requiring more recharge units than your allocation you will have to buy additional recharge units to make up the difference.

If you choose an option requiring less recharge units than your allocation you can offer to sell the difference between your allocation the number of units required for the farm option.

Slide 5

Income

In this experiment your farm income will depend on the management option you choose. Some options have higher farm incomes but need additional recharge units. The cost of additional units you purchase will be deducted from your income.

You can also earn additional income by selling recharge units in the market.

$$\text{Net Income} = \text{Farm income} - \text{cost of units bought} + \text{income from selling units}$$

Slide 6

You can choose from five farm management options:

Each option has a different recharge level and farm income.

1. For each option you will be given your farm income, the dollar value of a recharge unit, the total recharge volume produced and the number of units needed to meet the recharge target.
2. The recharge target is calculated as the total units of recharge produced by your crop option minus your allocation.
3. You will be able to buy additional units to meet targets or sell surplus units in the recharge market.

Slide 7

Important

To receive the income for the farm management option you have chosen you must reach the recharge target. The recharge target is the total recharge produced by the farm option minus your allocation. If you do not reach the target, your excess farm recharge will effect other farmers. Your income will be reduced to the management option where the recharge target can be met. You will not be able to trade or be compensated for any surplus units.

Slide 8

For example:

Say you have an allocation of 3 units, where **option3** produces a total of 10 recharge units and an income of \$2 (with a target of $10-2 = 8$) and **option2** has a total of 5 units, an income of \$1 (and a target of $5-2 = 3$).

You choose option 3.

You purchase 7 units in the market. You cannot reach the **option3** target, but can meet **option2**. You receive the option2 income of \$1 and have 4 surplus units. The cost you paid for the surplus units will be deducted from your farm income.

Slide 9

Open call market

The project coordinator will provide you with market information while you are trying to decide on your preferred farm option.

You can check the latest recharge unit market bids of other players, as they are submitted, by left-mouse-clicking on the "**view all bids**" menu option.

You will need to run this procedure each time you check the market bids; the screen information about other players' bids is not updated automatically.

Slide 10

Open call market

In each round of the demonstration, a bidding box will appear. You may only submit one bid, by entering it into the box. You must bid before the market closes and the bidding box disappears (in 90 seconds from opening of bidding).

You can check the bids by left-mouse-clicking on the "view all bids" menu option. for the current trading session you can check bids while the current market is open. You can check on the bids of previous years at any time.

Slide 11

Menu options: FarmMan tab view

Your recharge allocation

Number of recharge units required for management option

Value of a recharge unit

Farm income level

Farm management options

Trading period, recharge information and market outcomes

Slide 12

Procedure

Step 1. Click 'Farm man' on the menu to see your Farm Management options

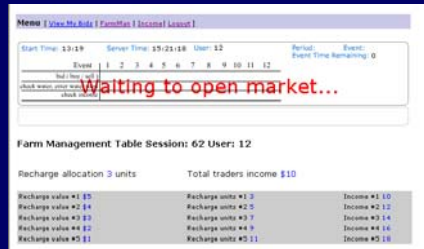
Step 2. Enter the number of the option (1-5) you have chosen in the amount box. Click on submit. A message will inform you that the option has been successfully received. You have 90 seconds to complete this procedure.

Option numbers

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Please Note. Your Farm Management and farm income tables will be updated at the end of the 'Determine Farm option' period. You must Click the 'Farm Man' and 'Income' to view the updated numbers.

Step 4. The "waiting to open market" will scroll across the screen: You will be informed when the recharge market is about to open.



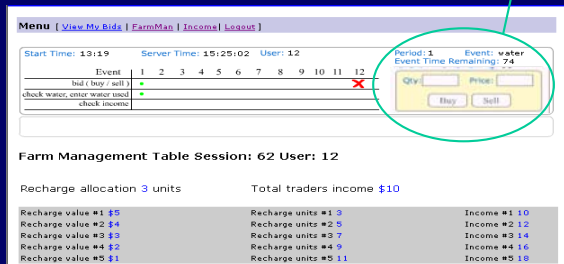
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Step 3

You will have **one** annual opportunity to buy or sell recharge units. After declaring your farm management option, the market session for the current year will be declared open. You will have **90 seconds** to make a bid.

You can view the bids of other players by clicking on the "view all bids" menu button.

The market is open when the bidding box appears as follows:



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Please Note

- You must enter a bid within **90 seconds** if you want to buy or sell recharge units. The timer at the top of the box will show the remaining time.
- You must enter the Qty (quantity) and price, **then** click on either buy or sell to submit your bid. **You cannot place both a buy and sell bid in the same market.**
- If you do not want to buy or sell recharge units do not enter a bid in the table.
- The market is closed when the bidding box is no longer visible.

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Please Note

- When the market has closed all bids will be processed and You will be informed of the market price and volume traded
- You can check your updated farm income and farm management tables by clicking on the menu buttons. You can also check on the bids you have made.
- The farm management option choice and trading procedures will be repeated for each year.

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Click here

Menu [[View My Bids](#) | [FarmMan](#) | [Income](#) | [Logout](#)]

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Farm Management

This table displays information about your farm's Recharge budget and selected farm options.

| Trade period | Decision | Value of recharge \$/ML | Total recharge ML | Recharge target total ML | Recharge target | Qty Sold | Qty bought |
|--------------|----------|-------------------------|-------------------|--------------------------|-----------------|----------|------------|
|--------------|----------|-------------------------|-------------------|--------------------------|-----------------|----------|------------|

Trade period - Years 1-12 for farm management option and recharge trading

Decision - your farm management option for that year

Value of recharge \$/unit - The value of one recharge unit for the selected option

Total recharge - The number of recharge units produced by the selected option

Recharge Target - The total number of recharge units minus your allocation

Market price - The clearance price of recharge trading

Qty sold and Qty bought - The quantity of recharge units traded in the market

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View My bids

If you make a bid the following information will be displayed in this table.

View My Bids (this session) or (by period)

| User | Date / Time | Period | Type | Qty | Price |
|------|-------------|--------|------|-----|-------|
|------|-------------|--------|------|-----|-------|

User - your farm number
Date/time - today's date and time
Period - the year your market bid occurred
Type - either a Buy or Sell bid
Qty - the volume (recharge units) offered for exchange
Price - the dollar value per unit offered for exchange

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View All bids

In the Open Call market you will also be able to view the other farmer's bids to buy and sell recharge as they are entered. Your farm number will not be revealed to other bidders


View All Bids (this session) or (by period)

| User | Date / Time | Period | Sell Qty | Price | Buy Qty | Price |
|------|-------------|--------|----------|-------|---------|-------|
|------|-------------|--------|----------|-------|---------|-------|

User - only your farm number will be shown
Date/time - today's date and time
Period - the year your market bid occurred
Sell/Buy - bids are sorted into type
Qty - the volume (units) offered for exchange
Price - the dollar value per units offered for exchange

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Click here



Menu [[View My Bids](#) | [View All Bids](#) | [Water Usage](#) | [Farm Income](#) | [Logout](#)]

Logout

You must logout using this link when you are told the session is over.

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[CLICK HERE TO START THE EXPERIMENT](#)