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A Virtual Meeting Space to Support Farmers Learning About Natural Resource Management

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by Zvi Hochman

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Foreword

This publication reports on the development of an approach for supporting farmers learning about Natural Resource Management (NRM) through participation of farmers and scientists in internet enabled *virtual meetings*. To achieve this, the project drew on the theory and practice of *action research* to develop an effective approach for *facilitation* of internet based interactions involving stakeholders with potentially conflicting views concerning natural resource management.

The project employed situated-simulation for providing farmers, advisers and other stakeholders with opportunities to investigate natural resource management issues with emphasis on *discovery learning* about the impacts of farming practices on dryland salinity.

This project was funded from RIRDC Core Funds which are provided by the Australian Government.

This report, an addition to RIRDC's diverse range of over 1500 research publications, forms part of our Human Capital, Communications and Information Systems R&D program, which aims to enhance human capital and facilitate innovation in rural industries and communities.

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Peter O'Brien
Managing Director
Rural Industries Research and Development Corporation

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Abbreviations

APSIM	Agricultural Production Systems sIMulator
APSRU	Agricultural Production Systems Research Unit
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EC	Electrical Conductivity (an index of soil salinity)
ESP	Exchangeable Sodium Percentage (an index of soil sodicity)
GM	Gross Margin
GRDC	Grains Research and Development Corporation
FARMSCAPE	Farmers' Advisers' Researchers' Monitoring Simulation Communication and Performance Evaluation.
ICT	Information and Communication Technologies
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ILS	Internet Locator Server
ITU	International Telecommunication Union (standards for voice, video and data communications)
LAN	Local Area Network
MCU	Multipoint Control Unit
MMG	Moonie Management Group
NAP	National Action Plan for Salinity
NHT2	National Heritage Trust stage 2
NRM	Natural Resource Management
QDNRM&E	Queensland Department of Natural Resources and Mines
RIRDC	Rural Industries Research and Development Corporation
RTC	Rural Transaction Centre

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Executive Summary

Background

Building farmers' capacity for sustainable management of natural resources (*e.g.* reducing deep drainage to reduce salinity hazard) is different to helping farmers adopt new innovations for greater productivity. This is largely because (i) market forces do not drive such change since adoption does not result in competitive advantage, (ii) the results of management change are not readily visible, and (iii) adoption requires complex knowledge transformations.

Discovery learning is a methodology for providing farmers with an opportunity to participate in observation, discussion, and experimentation that allow them to learn and to draw their own conclusions about natural resource management (NRM). This project set out to investigate the promise of discovery learning for scientists to help farmers achieve the knowledge transformations necessary for management change.

Aims

The number and geographical location of scientists who can support farmers' learning about NRM is incompatible with the formation of a decentralised network of scientists and farmers throughout the areas where NRM issues need to be addressed. An objective of this project is to investigate the possibility of overcoming this 'tyranny of distance' by using internet based technologies to create a virtual meeting space where scientists can engage farmers in discovery learning without the need to travel to a face to face meeting. The challenge to technologists and facilitators is to create a meeting environment wherein technology does not prevent effective communication.

The trigger for this work was an online meeting in which scientists learned that farmers who were prepared to take action to modify their crop management practice on the basis of learning supported by monitoring and simulation were not prepared to accept the results of simulations which calculated significant deep drainage.

Methods

This project was set up to support farmers' learning about salinity through virtual meetings. Participant evaluation and Video Interaction Analysis were used to analyse the impacts of the project. A virtual meeting held in August 2004 provided farmers with an opportunity to examine the evidence of salt movement that was obtained from field work comparing cropped paddocks with tree and pasture paddocks on participants' farms[1]. Farmers accepted this tangible evidence of salt movement out of the rooting zone of crops but were still left wondering about what they might be able to do about it.

The final virtual meeting held in December 2004 was based on the detailed cropping history provided by one of the farmers. Scientists simulated this cropping history in terms of crop yields but also in terms of visual presentations of what happens to rainfall. This allowed farmers to visualise the impact of climate variability and management on both runoff and deep drainage events. Farmers were able to use their learning from this exercise to design an alternative system. Simulation of the farmers' system showed it to be more productive and less 'leaky' than the historical system.

Results & Implications

This project demonstrated that currently available and affordable internet technologies can be used effectively to support virtual meetings wherein scientists and groups of farmers can engage in a learning partnership. It also showed that by facilitating discovery learning scientists can support the knowledge transformations that are necessary for farmers to deal with dryland salinity.

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[1] The data was from a related GRDC funded Eastern Farming System project titled 'Effect of farming systems on deep drainage in high salinity hazard areas' that was set up to measure salt losses from farmers' paddocks.

1. Introduction

Natural resource management (NRM) is a social issue that has an important scientific dimension. Ultimately, it will be up to the managers of Australia's farms, not its scientists, to manage farm businesses so that they reduce the adverse environmental impact of their economic activity and remain profitable. Developing the capacity of farmers to balance the goals of profitability and sustainability is of enormous economic, environmental and social benefit.

1.1 Dryland Salinity

Primary salinity occurs naturally when salts accumulate in the soil from saline marine sediments, the weathering of rocks, and atmospheric accessions. In a stable system there is equilibrium between inputs and losses of salts within the soil profile resulting in a zone of salt accumulation below the "wetting front" of a soil.

Secondary salinity develops when significant levels of primary salinity are mobilised to other parts of the landscape. It is generally accepted that secondary dryland salinity in Australia is the result of changes in the water balance brought about by replacement of the natural vegetation with agricultural systems which use much less water than the natural vegetation they have replaced. The unused water (runoff and deep drainage below the rooting zone) recharges to groundwater systems. This recharge results in increased mobilization of salt from the soil profile and its movement in the landscape and discharge to the land surface and to streams.

There is sound scientific evidence that all the factors that contribute to salinity hazard exist over large areas of the semi-arid zones of eastern Australia. In landscapes prone to dryland salinity risk, the timeframes and the extent of degradation depend upon the interaction of four key factors:

- *Climate* - the amount of water input to the catchment surface through rainfall. Timing and amount of rain in particular are critical
- *Land use* – this determines soil water status particularly through evapotranspiration and hence the amount of water available in the root zone that can infiltrate to the groundwater system
- S*alt stores* - the amount of salt stored in the catchment and available for mobilisation by groundwater
- *Hydrogeology* - the structural and geomorphic features of the catchment that determine how much groundwater can be stored, how far it will flow, and what will cause it to discharge.

Of the four key factors, the only one that can be managed feasibly is land use. Decisions on appropriate management of dryland salinity require assessments that evaluate the impacts of land use management on the water balance and the effects on groundwater (Webb 2001).

Dryland salinity is difficult to manage because of the lasting nature of the impacts on soil and water resources, and the stability of ecosystems. In common with other land degradation issues it is most widespread in the developed agricultural zones of the southern half of Australia. Many of the remedial or preventative options for managing dryland salinity often result in improvements across the other suite of issues.

Efforts to arrest the spread of salinity have achieved only modest success and evidence suggests that the problem will continue to grow. It poses a great national challenge to sustainability of water supplies, productive land use systems and ecosystem functions. A key factor in this lack of progress is that the knowledge developed to date has lacked actionable relevance to landholders.

As is the case in most Western democracies, Australian governments are reluctant to impose environmental regulations on farmers. Currently the threat of environmental regulation to enforce a solution to the dryland salinity problem is perceived as an unsubtle “stick” by many farmers, while government incentives through NHT2 and NAP programs are designed to encourage farmers to make voluntary changes. These policies will capture the attention of farmers and shift their focus somewhat from their primary ‘pragmatic motive’ of profit making and wealth creation. It is to be expected that farmers will seek to make sense of environmental issues in order to decide what actions they need to take to deal with these threats and incentives and what are the likely consequences of such actions (McCown 2004).

If we expect communities to react constructively and move towards developing new ways of using Australia's landscapes to meet environmental, social and economic objectives, then we need to enable genuine stakeholder participation in generating, using and exchanging knowledge, in decision making, and in resource negotiation. Clearly exploring and co-construction of a mutual understanding of the implication of current farming practices on dryland salinity is a key precondition for co-construction of sustainable NRM outcomes.

One aim of this project is to use the virtual discussion space to bridge the gap between what is known in the world of science and what can be co-constructed by landholders who are interested in taking on-ground action that will result in farming without harm.

1.2 Land Management

Much of what we know about improving the capacity of farm businesses has been learned from helping farmers improve their profitability rather than their sustainability. Interacting with farmers on issues of profitability can be characterised as interactions in a unitary system where the goals of both interacting parties are well aligned. In seeking to address sustainability and natural resource management issues, we need to recognise that we will be facilitating pluralistic interactions where goals of various stakeholders may appear to be at odds.

A previous RIRDC project “FARMSCAPE Online: Interactive internet support for farmers’ situated learning and planning” (Hargreaves and Hochman 2004) successfully demonstrated that the internet can provide an effective medium for farmers, advisers and researchers to interact on issues concerning crop and soil management. Independent evaluation detailed significant shifts in farmer thinking and management practice. Post session evaluations consistently showed a high level of credibility for the realism of simulation of crop yields using the Agricultural Production System SIMulator APSIM (Keating et al. 2002).

While the FARMSCAPE Online project was successful when dealing with farmers on production issues, when scientists presented the same farmers with data showing significant levels of deep drainage (a necessary condition for movement of salt from a paddock) their responses were less positive. Clearly the hard won credibility gained for yield prediction did not translate into credibility in terms of parameters relevant to NRM issues.

The proposed project acknowledges that local knowledge, business ingenuity, farmer experimentation and inventiveness are as important as expert knowledge and the role of specialists such as scientists and farm advisers. Thus, by engaging with landholder groups, stakeholders will be actively and frequently involved in the knowledge construction and learning process. Hard systems tools such as simulation will not be used to design optimal solutions. They will instead be used in a communication matrix that enables stakeholders to gain "virtual experience" of biophysical aspects of the problem within space and time dimensions that make it difficult or impossible to experience in real life except when it is too late to take preventative action.

Current government strategies are for national policy developments to be realised through regional processes to implement desired landscape change. The success of regional implementation of these landscape changes is critically dependent on effective scientific support. This project set out to employ science and simulation tools for evaluating production, social and environmental trade-offs. The aim was to evaluate the suitability of these tools for enhancing the sustainability of regional landscapes via a process-based approach which increases the capacity of rural and regional communities to determine their own future.

1.3 Virtual Meeting Technology

Australian farmers face NRM issues wherever farming is practiced. Scientists, however, are mostly located in capital cities or large regional centres. Distance and cost of travel are major practical barriers to scientists' capacity to engage with landholder groups. The activity reported here was designed to develop new uses of information technology for facilitating internet based simulation-supported discussions that provide opportunities for stakeholders with conflicting goals to participate in facilitated discovery learning. This research aims to build on the positive lessons learned in the FARMSCAPE approach which has had significant impacts in guiding change in farmers' management of crops and soils in Australia (Carberry et al. 2002).

In the previous RIRDC "FARMSCAPE Online" project, virtual meetings between scientists and farmers were held using modems connected to standard rural telephone systems, resulting in low bandwidth, often less than 28kbps. This technology constrained interactions to data sharing supplemented by low quality video. Farmers and scientists could only see each other at very low resolution in a small frame and at shutter speeds in which the video appeared as a sequence of still images. While scientists and farmers found that such video enhanced the social facilitation of meetings, it was very difficult for participants to pick up on non verbal communication during a meeting. This became more important when discussions of NRM issues, with perceived business-threatening regulatory implications, replaced discussions of production issues, primarily concerning new opportunities. Reflection on the meetings suggested to us that a significant improvement in video was likely to be an essential pre-requisite to effective communication between farmers and scientists on these more sensitive issues.

Video conferencing over computer Internet Protocol (IP) networks is cheap at current internet access charges but quality is dramatically reduced at low bandwidth. High quality conferencing requires higher bandwidth, a high quality digital video camera and good quality audio equipment. For multipoint conferences, a costly hardware bridge or Multipoint Control Units (MCU) is required. Recently CSIRO invested $500k in a MCU that allows multi-point video (video at more than 2 sites) with audio and data sharing. The unit provides a multiple bandwidth solution to video conferencing using speeds from 64 kbps to 384 kbps and greater. This is a significant enhancement to our capability. Integrated Services Digital Network (ISDN) video conferencing at speeds of 128 kbps or higher, using a Polycom® ViewStation room video conferencing unit which can support up to four endpoints, offers a third option for virtual meetings. The current project was designed to investigate the feasibility and benefits of the higher quality conferencing options for interactions between farmers and scientists learning about NRM issues.

2. Objectives

- To develop an effective approach for facilitation of internet based interactions involving stakeholders with potentially conflicting views concerning natural resource management by drawing on the theory and practice of action science.
- To evaluate the effectiveness of facilitated discovery learning, using situated-simulation for providing farmers, advisers and other stakeholders with opportunities to investigate natural resource management issues. Specific emphasis will be placed on learning about the impacts of farming practices on dryland salinity.

3. Methodology

Capacity building for sustainable management of natural resources is particularly challenging. Knowledge required for understanding sustainability includes masses of detail concerning many particular issues, which require separate analysis and management. Nothing can be managed in a convenient isolation, issues are mutually implicated, problems extend across many scale levels of space and time, and uncertainties and value-loadings of all sorts and all degrees of severity affect data and theories alike. This complexity presents challenges to scientists, policy makers and landholders. Much recent experience indicates that a knowledge construction paradigm is more appropriate for practice transformation than the traditional technology transfer (Roling and Jiggins 1998).

The key aspect of this paradigm is that most knowledge that is meaningful for practice comes about from what is often called 'discovery learning' (Veenman *et al.* 2002). It is not the product of *teaching* but rather of ongoing individual experience and social interaction that produces change in farmers' beliefs, values, and intentions. But discovery learning can be facilitated and scientists have an important role to play. But what is proposed here is neither 'merely' extension nor facilitation but co-operative discovery learning.

Current research based strategies for sustainable agriculture include (a) designing more ecologically-sound farm management practices, (b) highlighting problems and advocating solutions to generate public pressure on farmers and governments, and (c) providing analyses for government policy formulation. This project adds a new strategy: scientists with their tools engaging farmers in activities in which new knowledge is constructed that stimulates and enables farming to be conducted differently. This strategy presumes that:

- (a) Changes in agricultural production systems hinge on changes in farmers' beliefs, values and intentions;
- (b) Family farm managers have a high degree of freedom of choice and power to change their farming strategies; and
- (c) Farmer behaviour is influenced by their membership in overlapping communities including communities of practice, communities of knowledge and communities of interest.

Much of what scientists know about sustainable ecosystems is not 'actionable' – it can't be confidently formulated as prescription for local action. Further research is needed to develop a methodology whereby systems research takes place in the management action situation and in the process of facilitating change. Such research will be informed by the work of Chris Argyris and Action Science on facilitating communities of inquiry in communities of practice (Argyris et al. 1985) and by Roling and Jiggins' (1998) methodology for facilitating farmer discovery learning.

The level of farmer participation and leadership in the design, conduct, interpretation and communication of research projects and in the conduct of research within the context of real-life farms was integral to the success of the FARMSCAPE Online and other FARMSCAPE projects (Hochman et al., 2000; 2002; Carberry et al., 2002). In action research terminology (e.g. Greenwood and Levin 1998, p. 191) earlier FARMSCAPE projects adopted a theory of action that may be classified as Model O(pposite)-1 (*Opposite* to the underlying Model 1 where one person or group have unilateral control over others). This kind of theory of action gives rise to a learning system that corrects errors that do not threaten the group's underlying norms (e.g. focus on productivity). In Model O-1 the focus is on broad participation, and win-win approaches. This approach enabled the FARMSCAPE team to collaborate with farmers and their advisers in addressing problem issues such as dealing with climatic risk.

The question addressed by this project was whether "action research" can be relevant in the broader domain of systems issues where the issues at stake are more contentious (pluralist) and the biophysical systems more complex (Jackson 2000). This type of problem appears to be better suited to Model II theories of action. In Model II there are "minimally defensive interpersonal and group relationships, high freedom of choice and high risk taking". According to action research theory the result of a group of individuals acting in Model II is a community of inquiry in which issues of conflict can be opened up and learning can occur (Argyris *et al.* 1985, p. 102).

The methodological framework that underpinned this project was based on participants' co-construction of new understandings of balancing production and environmental risks via simulation-aided active dialogues. Central to this is the use of the APSIM simulator by scientists to provide virtual worlds (Schon 1983, p157) to enable participants to gain 'experience' that would otherwise be inaccessible due to impracticalities associated with testing alternative management options through real-life experiences. The Internet provided the opportunity to overcome the "tyranny of distance" by replacing face to face meetings with virtual meetings. Project participants who were located at different sites can share data and video images in real-time.

In practice this research involved a number of cycles each building on the insights gained in the previous cycle:

1. Scientists join local landholder groups ('communities of practice') in discussions of strategy for achieving more sustainable farming practice.
2. Meetings are primarily online using advanced virtual meeting technology.
3. Networks of 'communities of inquiry' in which CSIRO and other invited scientists facilitate learning in an inquiry process that might include:

   - discussion of the socio-political 'landscape' of agricultural sustainability; airing of participants' views
   - farmers' sharing of experiences, their perspective of problems, and their own 'theories of action'
   - scientists' explication of aspects of problems and risks
   - scientist-facilitated exploration of likely effects of ecologically-sound management options on (a) production and returns and (b) states of problematic environmental factors - both aided by simulation and other tools, case histories, and participants' experiences.

Evaluation

In addition to adaptive change made in response to lessons learned from each engagement event, new knowledge accumulated from each learning cycle is captured through a participative evaluation process in order to:

- document changes in views, intended actions, and actual management
- document new insights to farming in these contexts
- evaluate evolving methodology and make changes to improve it
- redesign and implement a new discovery learning cycle.

The philosophy of project evaluation is based on the notions of individual construction of knowledge from experience and of actions changing as a consequence of new knowledge. The methodology is rooted in the learning cycle of Action Research, i.e. *plan, act, observe, reflect*. Evaluation can be viewed as a formalisation of observation and reflection concerning two inter-related phenomena. First, researchers' own project process and methodology development (process evaluation); second, the evolution in farmer participants' planning and acting in their own learning and farming (impact evaluation). Participatory evaluation was a formal component of virtual meetings. As part of each meeting scientists and farmers discussed issues that we raised at these meetings in order to provide data for (a) process evaluation for immediate feedback as to how the project operates; and (b) a longitudinal picture of changes over time in the participant's views and behaviour.

Video Interaction Analysis

Electronic audiovisual recording of meetings from both farmer and scientist nodes provides an extraordinarily rich record of not only what was said, but the context in which it was said and the body language of conversantes. Video Interaction Analysis depends on the repeated viewing of the original data to examine the dynamics of the work setting and the complexity of the interaction (Jordan and Henderson 1995).

4. Methods

The program was manifest in practice as described below:

1. *Negotiate Participation of Moonie Management Group (MMG) in the Project.* The research team approached the group to participate in the project. It was agreed that the emphasis of meetings will be on continued dialogue and investigation of the drainage and salinity issues that were canvassed in the earlier “FARMSCAPE Online” project. Permission to produce electronic audiovisual recordings of meetings was sought and agreement reached on issues of confidentiality and use of photographic and video material.
2. *Negotiate use of Moonie Rural Transaction Centre (RTC) as the MMG’s node for holding virtual meetings.* The MMG was keen to support the new RTC being built in a central and convenient location for their members. The research team negotiated that the project would provide any additional equipment required by the group for the purposes of holding virtual meetings. The Moonie RTC agreed that the group could use the facilities at a mutually convenient time. Facilities included the use of a meeting room and the centre’s computer, Internet, and telephony facilities.
3. *Invite ‘interested observers’*. An integral part of this activity was to extend invitations to other researchers and interested stakeholders to observe the online workshops and to provide the research team with feedback in terms of process, content, and their perception of farmer involvement.
4. *Trials in commercial crops* negotiated between farmer members of the group and the project team and conducted jointly according to the capacities of each party to contribute.
5. *Provide training to farmers, scientists and Information and Communication Technologies (ICT) support staff* in setting up and use of the technology required for conducting virtual meetings.
6. *Hold a virtual meeting online* to present and discuss research results and their implications for NRM issues.
7. *Reflect on Virtual meeting* to evaluate what worked well and what needs to be improved. Revise protocols and plan for next the meeting.
8. *Negotiate contents of the next meeting* and organise a meaningful scientific input to the meeting by gathering appropriate data, inviting topic experts etc.
9. *Create a virtual learning environment in a virtual meeting* by using APSIM to simulate the implications of management practices on NRM. This can be achieved by encouraging farmers to ask “what-if” questions and by responding immediately to these questions with virtual experiments (simulations) to stimulate farmers and scientist’s thinking together about options for “farming without harming”.
10. Researchers document *changes in views, intended actions, and actual management*.
11. Researchers *document new insights* into farming within these contexts.
12. *Evaluate the research practices* outlined above and make changes to improve it.
13. Loop to step 1 for subsequent rounds of virtual meetings.

4.1 Virtual Meetings

Ideally “virtual meetings” consist of individuals or groups physically located at a distance from each other communicating as if in a face to face meeting using audiovisual media. In the current research project two groups of people located more than 200km apart held meetings that were supported at each meeting “node” by electronic media via the Internet. Electronic media consisted of real time video images of the people and objects at each meeting node and data shared via Microsoft NetMeeting® software using its ‘application sharing’ functionality. Although NetMeeting supports audio and video in addition to application sharing when bandwidth is ample, band width limitations in this case restricted NetMeeting to application sharing. In the first meeting audio communication was over existing phone lines using a hands-free telephone at each node. In the second meeting audio communication was via the Polycom® room videoconferencing unit. Data shared were typically text, graphs and other images embedded in Microsoft PowerPoint®, and graphic outputs of APSIM simulations presented via Microsoft Excel®. Data and video were viewed on computer monitors, television monitors, and images projected via data projectors onto screens. Application sharing allows a number of users to see the contents of one or more participant's screens. Users can share any open application on their PC individually, or in any combination.

Users can connect using the Internet two or more NetMeeting® endpoints (N.B. while the physical locations of groups participating in a virtual meeting are referred to as *nodes*, the internet connections at these nodes are referred to as the meeting's *endpoints*) by one of three methods: i) Internet Locator Server (ILS); ii) direct IP connect, or; iii) a Multipoint Control Unit (MCU). We started this research using an ILS. This proved intuitive as users full text names are displayed on a central list, viewable by all participants. However use of an ILS is dependent upon the service being reliable and available on an ongoing basis. The Direct IP connection became the dominant mode requiring only that two or more NetMeeting endpoints be connected directly to each other, using the host PC's IP address, which is easily obtainable within NetMeeting®. Prior to the commencement of the project we had only run limited trials of NetMeeting® together with MCU's; largely due to the fact that MCU's had just recently become affordable and reliable. The project was set up to further investigate the use of a MCU and of a Polycom® room videoconferencing unit for interactions between farmers, scientists and other stakeholders.

NetMeeting's® video and audio functions were limited to point-to-point meetings (*i.e.* only two participants). Application sharing and whiteboard functionality were available in both point-point and multi-point (*i.e.* multiple endpoints all sending and receiving) configurations.

Microsoft NetMeeting® is distributed without charge by Microsoft from their website (www.microsoft.com/netmeeting). It is pre-installed on Windows 2000/XP and may be downloaded for Windows 95/98/NT. NetMeeting® operates on the International Telecommunications Union (ITU) standards of H.323 for voice and video communication, and T.120 for data sharing. This makes NetMeeting® interoperable with a range of other clients and additionally with MCU's for conferences with multipoint audio, data sharing and video.

4.1.1 Technical preparation for virtual meeting on 24 August 2004

Meeting Requirements
This meeting was designed to accommodate farmer participants at the Moonie RTC and researchers at the Agricultural Production Systems Research Unit (APSRU) media studio in Toowoomba and an observer in CSIRO Melbourne. The meeting agenda included introduction of participants followed by a number of presentations and discussions. Some presentations were to be hosted from Toowoomba and some from Moonie.

All participants needed to be able to view shared data (PowerPoint® presentations) and have a continuous audio link. It was considered desirable to maintain a video link between Toowoomba and Moonie for the duration of the meeting. It was also necessary to have an audio and video recording from both meeting nodes for subsequent video interaction analysis.

Technical Setup – Toowoomba Node
The APSRU media studio consists of a purpose built meeting room and an adjoining control room. These rooms were set up as described below:

- audio was communicated by a table Polycom® SoundStation microphone/speaker (conference phone) placed on the desk close to the presenters' table and connected to telephone line via a conference call to Moonie and Melbourne
- a Laptop computer (Windows XP operating system) with NetMeeting installed was placed on the desk close to the presenter's chair and connected to the CSIRO Local Area Network (LAN)
- video link between Moonie and Toowoomba used NetMeeting and Logitech webcam (placed at the far end of the presenters' table to capture a wide view of the presenters and other participants assembled at the media studio) via the laptop computer
- NetMeeting software was used for data sharing

- a PC in the control room received data shared from the laptop in the presentation room and projected it onto one of the two screens on the media room wall
- video received by laptop via NetMeeting from Moonie was projected onto the second screen on the media room wall using the Windows XP split screen facility
- the Toowoomba node of the meeting was recorded with a Canon Video camera at the front wall and a table microphone placed at the presenters table.
- an Apple Macintosh computer in the control room was used to capture this video and audio to disk at 1GB/hour
- a second phone in the control room was available for out of meeting contact.

Technical Setup – Moonie RTC node
The Moonie group gathered in U configuration around a table, facing a projection screen in a meeting room at the Moonie RTC. This room also serves as a community internet kiosk and a clinic for a visiting GP. It was set up as follows:

- audio was through a standard Panasonic phone with hands free capability connected to a telephone line and placed on the table
- a Laptop computer (Windows XP operating system) with NetMeeting installed was connected to the Moonie RTC's LAN which is connected to an ISDN Internet service (nominally 128Kbps) and placed on top of a TV set at the projector screen end of the room and within reach of the scientist who was providing technical support for the meeting
- video link between Moonie and Toowoomba used NetMeeting and Logitech webcam (placed at the screen end of the room to capture a wide view of the Moonie group) via the laptop computer
- data sharing (sharing of PowerPoint presentations) used NetMeeting software
- a data projector was connected to the Laptop and placed on the table to project shared data, using Windows XP split screen facility, onto the projection screen at the far end of the room
- video received from Toowoomba by the laptop via NetMeeting was viewed on the computer monitor
- the Moonie end of the meeting was recorded with a video camera with built in microphone placed near the projector screen

Technical Setup – CSIRO Melbourne node
The meeting was observed by a researcher from the CSIRO ICT Centre in Melbourne. The researcher's interest was in observing people using ICT to work together from a distance. The researcher was set up as follows:

- audio through a standard office phone
- a Laptop computer (Windows XP operating systems) connected to the CSIRO LAN with NetMeeting installed.
- data sharing (sharing of PowerPoint presentations) via NetMeeting software

4.1.2 Technical preparation for virtual meeting on 2 December 2004

Meeting Requirements
As with the August meeting, this meeting was designed to accommodate participants at the three nodes: Moonie RTC, the Toowoomba media studio, and an observer in CSIRO Melbourne. The meeting agenda included introduction of participants followed by a presentation reviewing a farmer's paddock management history from 1994 to 2004, the climatic conditions of that period with a 100 year perspective, and presentation of results of simulations of that paddock's history in terms of crop yields and water usage including drainage and runoff. Provision was made for farmers to lead a discussion session to design an alternative cropping sequence for scientists to simulate and present results back to the farmers. It was important that some frank discussions take place to summarise the impacts on the project on farmers' thinking and likely actions regarding drainage and salinity.

As in the August Meeting all participants needed to be able to view shared data (PowerPoint® presentations, Rainman© output, and simulation results presented as Excel® graphs) and have a continuous audio link. It was considered desirable to maintain a video link between Toowoomba and Moonie for the duration of the meeting. It was also necessary to have an audio and video recording of the meeting from both nodes for subsequent video interaction analysis.

Technical Setup – Toowoomba Node
The APSRU media studio was set up as described below:

- audio and video were captured using a Polycom ViewStation room video conferencing unit connected to a 128kbps ISDN link
- two laptop computers (Windows XP operating systems) with NetMeeting installed were placed on the desk close to the presenters' chairs and connected to the CSIRO LAN
- NetMeeting software was used for data sharing
- a PC in the control room ran NetMeeting and hosted the connections to Moonie, the meeting room Laptops, and the PC in Melbourne
- data shared by laptops was projected onto a screen on the media room wall
- video received from Moonie by the Polycom videoconference unit was projected onto the second screen on the media room wall
- Toowoomba node of the meeting was recorded with a Canon Video camera at the front wall and a table microphone placed at the presenters table
- an Apple Macintosh computer in the control room was used to capture video and Audio to disk at 1GB/hour
- a second phone in the control room was available for out of meeting contact.

Technical Setup – Moonie RTC Node
The Moonie group gathered in U configuration around a table and facing a projection screen in a meeting room at the Moonie RTC. The room was set up as follows:

- audio and video were captured using a Polycom ViewStation room video conferencing unit connected to the Moonie RTC's ISDN line (128Kbps) providing a direct ISDN link instead of an IP network link over the Internet
- video image of the Toowoomba node was displayed on a large TV monitor
- a Laptop computer (Windows XP operating systems) with NetMeeting installed was connected via a modem to the Moonie RTC fax line dialled into an Internet Service Provider (ISP) and placed on the table in the centre of the room
- data shared by laptops via NetMeeting was projected onto a screen at the far end of the room

Technical Setup – CSIRO Melbourne Node

- the meeting was observed by a researcher from CSIRO ICT Centre in Melbourne for the purposes of researching how people work together from a distance. The researcher's setup was the same as in the August meeting.

4.1.3 Affordability of the equipment required to carry out virtual meetings
Three levels of technology were investigated:

1. Point to point NetMeeting with Logitech webcam and hands-free phones.
2. ISDN Video Conference Unit with bridge for multiple (up to 4) video and audio sites, with TV unit, conference phones, and remote control cameras
3. Multipoint, multiple bandwidth conferencing with MCU technology.

The first level of technology using NetMeeting is simple, cheap and readily affordable by any individual who is already connected to the internet. The second level of technology requires an ISDN link using 128 kbps which at the time of writing this report was available to 96% of the Australian population at a fee of about $45.00 per month. Hardware costs are in the range of $8,000 to $13,000.

This technology is affordable for groups or businesses. The third level of technology using the MCU is only affordable for larger institutions and businesses.

4.2 Video Interaction Analysis

Data were collected from each virtual meeting by video recording the interactions at both the farmer and scientist nodes. These tapes were logged which involved the recording of 'timecode' data with notes describing the video and audio content in tabular form. A subset was then selected from this log that comprised 'video segments of particular interest'. Video data was analysed as a rich source of evidence for "what happened" at these meetings.

Exit surveys were designed for each virtual meeting and participants were asked to complete them towards the end of the meetings. After individual responses were recorded the facilitator initiated a discussion with the farmers to encourage their open reflection on the meeting. After the conclusion of each meeting, scientists also participated in an open discussion to reflect on the social and technical dimensions of the meeting.

An analysis framework was used to *filter* data from all sources into four categories used to structure discussion.

1. *Farmer understanding of system function:* what did farmers learn about the 'science' of their farming system?
2. *Mutual understanding:* was there a 'meeting of minds' between participants?
3. *Effective interaction*: what was the experience of interacting via the Internet?
4. *Evidence of impact:* what was the consequence of these virtual meetings?

5. Results and Discussion

In describing the results of this project it is not possible to fully separate the contents of the interaction between scientists and farmers from the mode of engagement. However, in the interest of clarity, results are presented first in terms of the contents and then in terms of the effectiveness of virtual meetings.

5.1 Supporting Farmers' Learning about NRM

There were three meetings held between the research team and farmer members of the MMG: a preliminary face to face meeting held on the 27th of November 2003; a virtual (Internet) meeting to present and discuss results of field research held on 26th August 2004; and a virtual meeting held on the 2nd December 2004 to discuss, with the aid of simulation, the production, drainage and runoff of a specific paddock in the past 10 years. The background, content and learning derived from each of these meetings are described below.

5.1.1 Negotiations between scientists and farmers – November 2003

The first meeting was a face to face meeting held on the 27th of November 2003. Scientists travelled to meet of the MMG at the home one of the group's members. The meeting was called to discuss the group's commitment to a project centred on NRM issues. The research team re-presented the results of simulations discussed at an online meeting 2 years earlier (Figure 1).

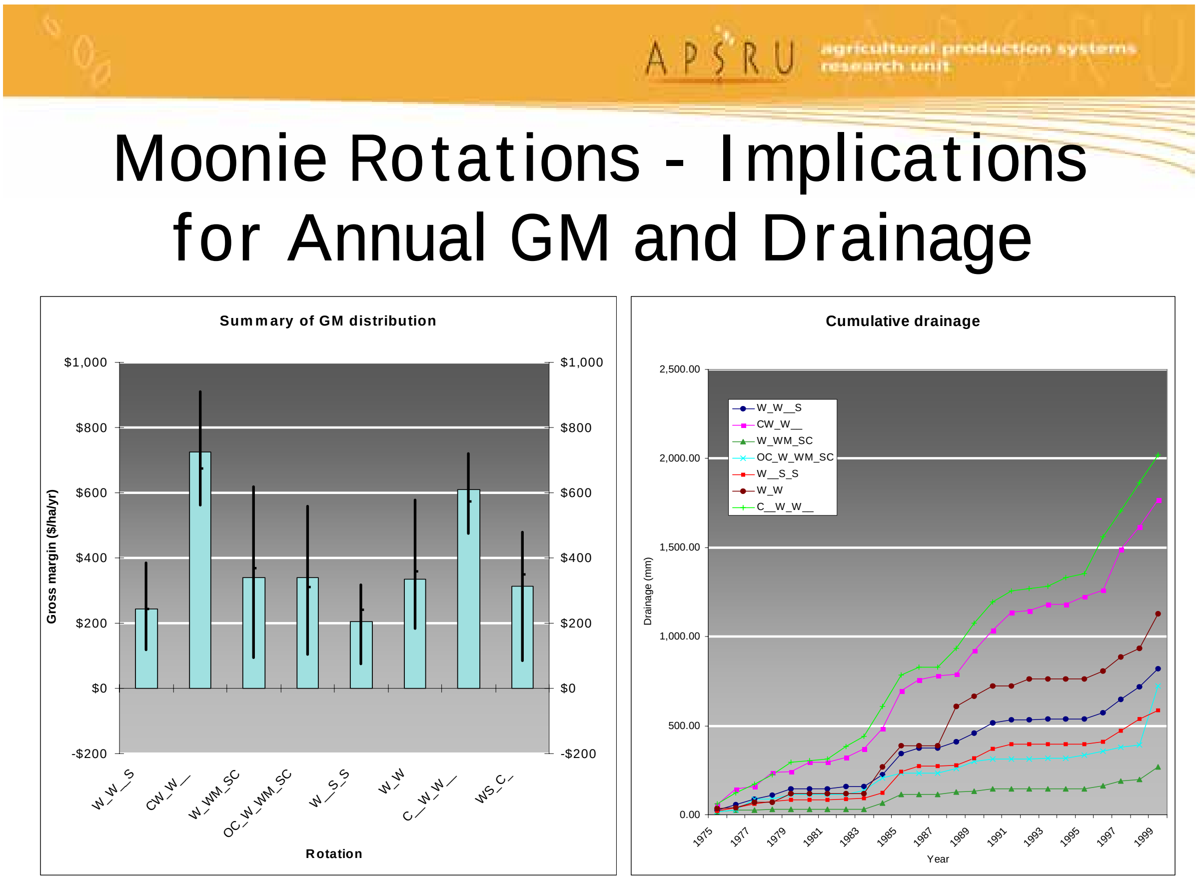


Figure 1: Simulated Gross Margins and Drainage outcomes of seven Moonie crop rotations projected over a 25 year period (1975-2000).

Video segments showing the group's sceptical response to these simulations (generated with the APSIM model) was played back to the farmers. In the video a telling farmer's response to figure 1 was: "This is a model Zvi and we don't really know whether that drainage figure is right or not…I'm highly suspicious of the drainage figures in our soil because of the bulk densities and the nature of the soil….” However, demonstrating a high level of trust in the research team the same farmer offered: “I’d be interested in how we could do some measurement of both the drainage and the runoff …”. This conversation progressed to a firm offer by the group to use their fields to resolve the drainage and runoff issues through field studies. This offer was accepted by the FARMSCAPE team in collaboration with Queensland Department of Natural Resources Mines and Energy scientists in the context of a parallel GRDC funded Eastern Farming System project titled 'Effect of farming systems on deep drainage in high salinity hazard areas'.

Discussion at the Nov 2003 meeting confirmed that while these farmers were still keen to use APSIM as a learning tool for production issues they remained sceptical about drainage and did not believe that their farming practices had negative off farm salinity impacts. Farmers were also aware of the widely publicised release in July 2002 of a “Salinity Hazard” map (figure 2) and the fact that much of the Moonie catchment was in the red (high hazard) zone. The map was compiled by the Queensland Government’s Department of Natural Resources and Mines as part of the National Action Plan on Salinity and Water Quality to define the potential for salinity on a regional scale. While the map does not necessarily predict where salinity will occur, it was clear that Moonie farmers were concerned about the potential for government to intervene. It was seen by the farmers as an implied threat to their autonomy to determine how they manage their farms.

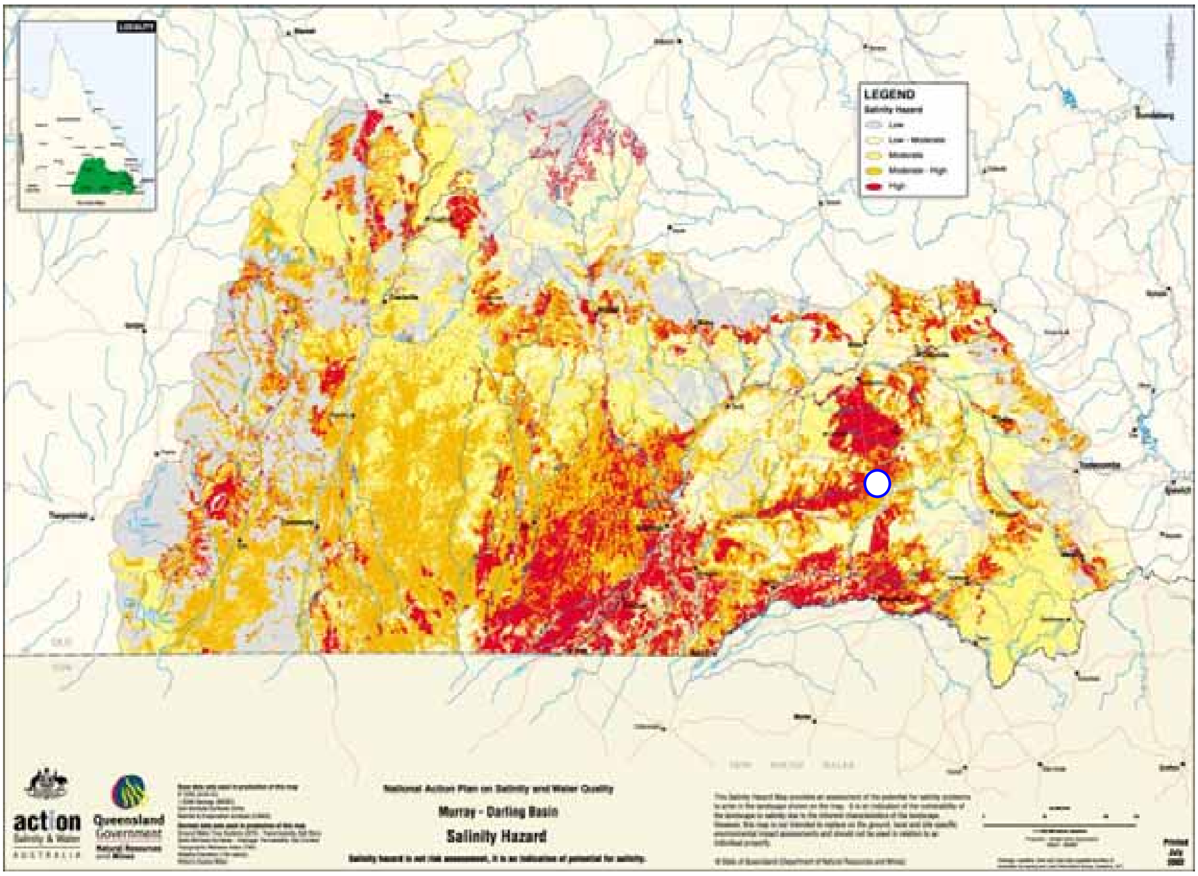


Figure 2: Murray-Darling Basin Salinity Hazard Map for Queensland, with a white circle showing Moonie’s location in the high hazard zone.

Reflection on the earlier meeting suggested to the scientists that the farmers lacked the capacity to respond proactively to the type of information presented in both figures 1 and 2. In response to figure 1 showing that while rotations featuring dryland cotton (with a long fallow built in to ensure full profiles before planting cotton) were the most profitable in terms of mean $/ha/year, these rotations also had the most drainage (mean mm/ha/year draining below the zone which can be accessed by crop roots) one farmer responded that: “I don’t think farmers are pricing in drainage or runoff. It’s more the gross margin in your pocket. So I think that’s why people are moving towards that rotation". He added that "Well it's not an easily measured thing really, the internal drainage and runoff, in terms of dollars."

As a partial response to this confusion the research team presented the data of figure 1 as a trade-off between gross margin and drainage (figure 3). Discussion of figure 3 clarified that the mixed rotation (a four year cycle of: wheat-fallow-wheat-mungbean-fallow-sorgum-chickpea-fallow) was clearly preferred to the wheat-sorghum-sorghum and the wheat-wheat-sorghum rotations as it had both a higher average annual Gross Margin (GM) and less average annual drainage. It was also considered that given the near equality of GM of the mixed rotation and both the Opportunity Cropping rotation (the same rotation as the mixed rotation with mungbean and chickpea crops sown only if sufficient soil moisture was available) and the continuous wheat rotation, the Mixed rotation was preferred to the other two provided that any value could be ascribed to reduced drainage. Similarly, of the two dryland cotton rotations, the three year rotation was preferred to the four year rotation as it had both a higher average annual Gross Margin and a lower average annual drainage. The only meaningful trade off between GM and drainage was between the Mixed Rotation (340$/ha/yr and 11 mm/ha/yr) and the 3 year dryland cotton rotation (650 $/ha/yr and 71 mm/ha/yr). In this trade off 60 mm/ha/yr can be avoided by foregoing 310 $/ha/yr.

There was some discussion about the implications of this trade-off and who should be expected to bear the burden of this trade-off. However, reflection on the level of interest in this information led the research team to conclude that this path should not be pursued while the farmers maintained a high level of scepticism about estimated amounts of drainage and whether their cropping system contributed significantly to the salinity problem.

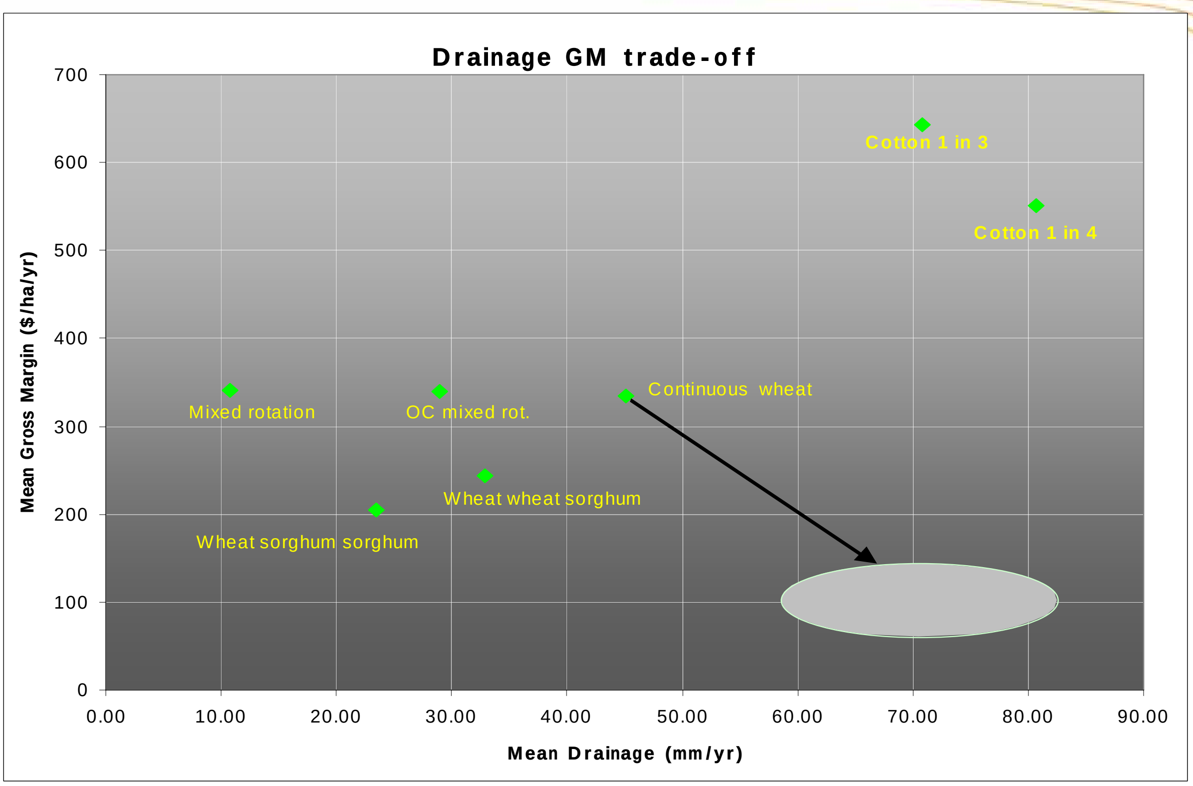


Figure 3. Simulated drainage – Gross Margin trade-off of seven cropping rotations at Moonie.

5.1.2 Virtual Meeting Moonie-Toowoomba-Melbourne 24th August 2004

Farmers and scientists agreed that firm evidence as to whether significant quantities of salt were being leached out of cropped paddocks in Moonie was a high research priority. Scientists negotiated with the MMG to undertake a program to compare the salinity profiles of Remnant Native Forest, pasture, and cropping paddocks on three MMG farms. Because the Moonie soils form gilgai micro topography, sampling at each site was further divided into mounds and depressions. The field work was undertaken in collaboration with the GRDC Eastern Farming Systems project 'Effect of farming systems on deep drainage in high salinity hazard areas'. Farmers helped scientists select the sites and undertook to provide detailed site histories. Scientists used the methods outlined in Tolmie et al. (2003) to determine salt loss and calculate deep drainage. Soil moisture characteristics required for modelling drainage in APSIM were also collected using the methods of Dalgliesh and Foale (1998).

Once the field data were collected and collated a virtual meeting was arranged for scientists to present and discuss the results with the MMG farmers. The meeting took place with participants in the Toowoomba media studio and at the Moonie RTC. Interested observers were located at the Toowoomba media studio and at CSIRO Melbourne.

The meeting commenced with introductory discussions in which farmers confirmed their scepticism about deep drainage. They had seen moisture at depth as a result of participating in the experimental process but they felt they had no reason to believe that their crops could not capture that moisture.

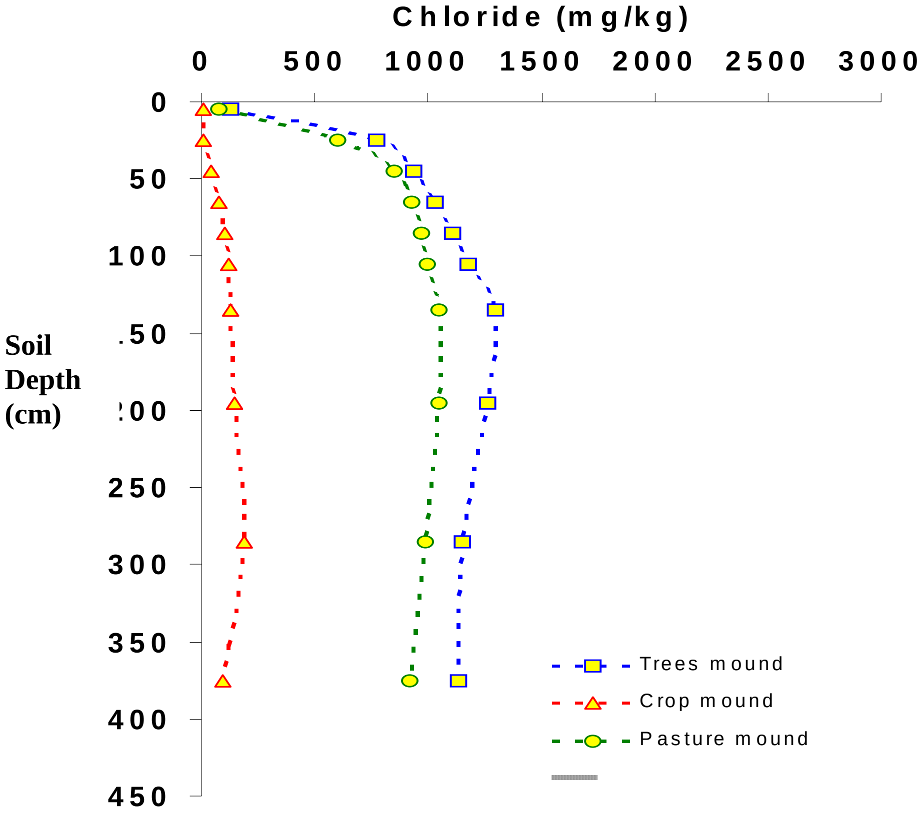


Figure 4. Chloride profiles below three vegetation types on a Moonie farm.

Data presented by researchers provided scientifically compelling evidence (e.g. figure 4) that at the three farms there was less salt (represented by the concentration of chloride) under crops than under pasture and less salt under pasture than under trees. Differences were greater under mounds than under depressions. Calculations showed that under mounds the differences in the amount of salt stored under trees and the amount of salt stored under crops ranged from 6.7 t/ha to 22 t/ha representing losses of from 35% to 92% of the salt load under trees.

Using the chloride mass balance approach a tentative drainage rate was calculated for each treatment. The calculated drainage rate for mounds ranged from 4.9 mm/yr to 13.2 mm/yr since cropping commenced.

As researchers we were aware that even when faced with the same information farmers and scientists may not necessary draw the same conclusions. The following conversation took place at the end of presentation of the abovementioned data:
Facilitator: "have you seen convincing evidence that drainage is occurring in your cropping systems and soils?"
Farmer: "we always thought that the salt level is going down so it's basically confirmed in my mind what I thought was happening"
Facilitator: "are you accepting that the salt level going down is evidence of drainage?
Farmer: "Well I suppose it has to be"
Another Farmer: "It's interesting that one of [names deep rip farmer] because he's deep ripped and he's had probably 28" of rain on it since it was ripped and his salt level dropped dramatically hasn't it? …it's let that flow of water go through a lot quicker."
This comment was followed by a discussion of other factors that might explain why some paddocks had more deep drainage than others including the likely consequences of minimum and zero till and of increased retention of stubble cover on drainage. The facilitator then returned to the original question and asked if any of the farmers had a contrary opinion. A farmer who had not contributed thus far to the conversation answered with a firm "no"!

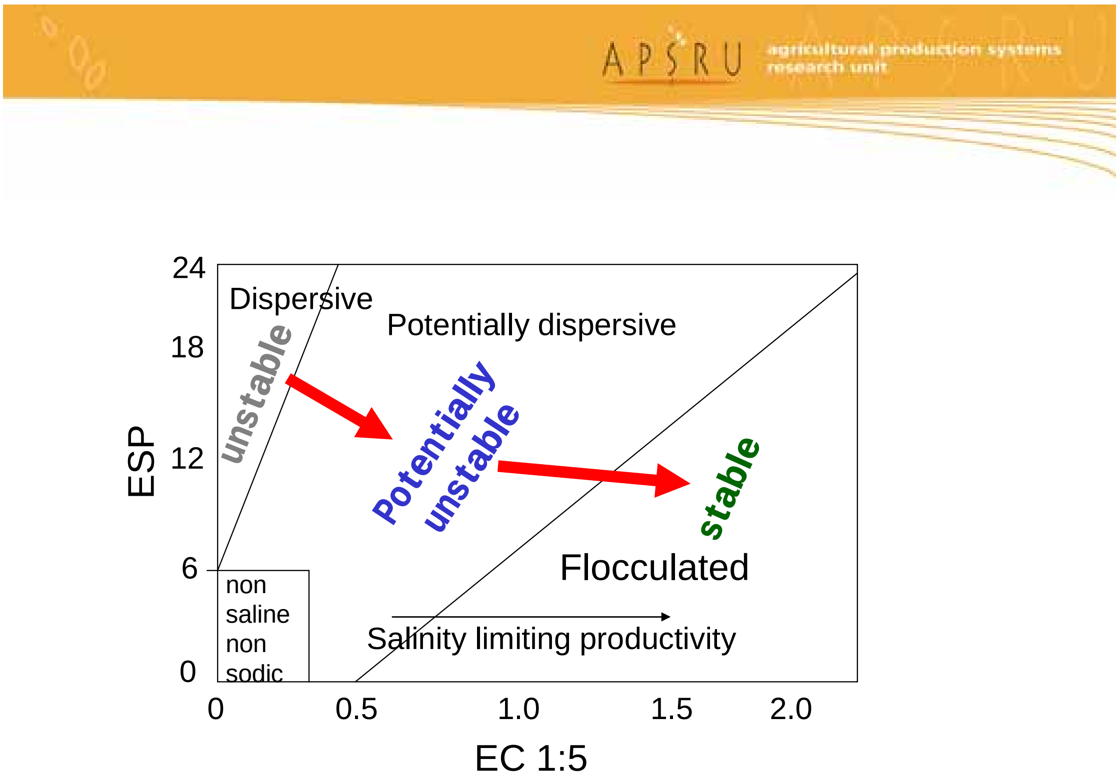
At that point farmers were facing up to a production-NRM trade-off. Salt moving out of their crops' root zone may have negative implications downstream but it may have positive implication for their own production potential. The following conversation sheds some light on this dilemma:
Facilitator: "The fact that you are losing salt from your own soil, is that a good thing or a bad thing?"
Farmer: "If we can grow a better crop it's a good thing! ….Well I suppose the concern is what is happening to it? Where is it going? What's the final result?
Another farmer interrupts: "We'd like to know where it stops so we need test holes that we can check every few years and see whether the [salt] concentration goes up."

However, there is some doubt that low salt concentration is always beneficial in these highly sodic soils where salt can mitigate the tendency for sodicity to cause soil particles to disperse and for soils to set hard upon drying. Figure 5 was presented at the meeting along with Exchangeable Sodium Percentage (ESP) and soil Electrical Conductivity (EC) profiles of all sites. A farmer picked up of the significance of figure 5 and asked the scientists where the three soils fit on the EC versus ESP graph with respect to the potential for soils to become dispersive. On inspection of the relevant graphs it was found that one of the soils is currently in the dispersive range while the other two would become dispersive if the EC level would drop much further. An interesting observation was that the farmer with the soil that was in the dispersive range was the one who had recently deep ripped his crop paddock; most probably in response to the soils hard setting properties!

Scientist to farmers: "Was the negative impact of leaching salts on soil stability news to you?" Four farmers responded that it was.

The **farmer** with the worst affected soil said (half joking): "that's why I put this 'for sale' sign up."
The **facilitator** enquired about the tension created by scientists concentrating on NRM issues when farmers' natural emphasis is on production: "Do you see it as two sides of the same coin or do you think we are pushing you to an area that you are not comfortable with?"
Farmer: "We are not very comfortable but it's probably a good way to go."
Another Farmer: "Well I don't see a problem, these paddocks are physically producing a product, they are not under performing, so you are highlighting a problem before it's actually eventuated which is good."

First Farmer: "The biggest problem is that we can't see things that happen beneath the soil [surface] and we need to have you people to be able to virtually let us know what is happening so that problems that do eventuate, we can start to get to them before they become a problem."



Slide from GRDC EFS Monitoring and managing soil water ALM-Wockner et al.

Figure 5. Dispersion as a function of sodicity & salinity

Participant Evaluation:
Five farmers responded to the post meeting questionnaire. The answers provided to questions regarding the contents of the meeting are summarised below:

How strongly do you agree or disagree with these statements?

Today's meeting was	**Strongly Disagree**	**disagree**	**unsure**	**agree**	**strongly agree**
A good use of my time	x	x	x	3	2
Interesting	x	x	x	3	2
Useful for management decisions on my farm	x	x	2	1	2
Supported my own observations	x	x	1	2	2
Of concern for the future of my farm	x	x	1	1	3

Production systems can be managed to minimise adverse impacts on natural resources

x	x	x	5	x

My current farming system is sustainable into the future

x	1	x	4	x

Why is understanding how much drainage occurs under your farming system important to you?

- impact on future farming decisions and impact on other people
- I wish to remain sustainable for future years without an adverse affect on others
- to know what soil contents are moving to, where and how
- change of deep soil analysis has a long term effect on production future.

All respondents found the meeting useful and interesting and all agreed that production systems can be managed to minimise adverse impacts on natural resources. There was however less consensus on the other questions. One farmer was unsure whether the meeting supported his own observations and one farmer was unsure if the meeting was of concern to the future of his farm. One farmer did not agree that his farming system was sustainable into the future. Interestingly two farmers were still unsure about whether the meeting was useful for management decisions on their farms.

Reflection:
The data presented at the meeting provided scientifically sound evidence that cropping had resulted in loss of a significant amount of the salt that was endemic to these soils to a depth of at least 4m. Analysis of mean annual deep drainage, based on the chloride mass balance approach, provided estimates of annual mean deep drainage that were at the low end or less than rates simulated for most cropping systems in Figure 1. The difference between the calculated deep drainage based on field data and the simulation results were not surprising to scientists for three reasons:

1. while the simulations were based on current or future rotations, field based calculations can only reflect past practices
2. the assumptions inherent in the chloride mass balance method, and
3. detailed data on the cropping history of the paddocks had not yet been collected.

In some respects this meeting was similar to a conventional meeting of scientists and farmers in which scientists presented data and used their scientific knowledge to interpret that data for the farmers. There were however some important differences:

- the work originated from the farmers' stated desire to find out whether deep drainage was occurring on their farms
- all the data presented was from land owned by members of the group who also participated in site selection
- calculation of deep drainage from chloride data was only possible with the aid of the farmers' knowledge of site histories
- scientists were not motivated by the search for new biophysical knowledge but rather by the desire to provide farmers with an opportunity to learn about: (1) the impact of their farming system on secondary salinity and (2) to attempt to gain an insight into how such knowledge would influence farmers' thinking about their farming system.

Farmer understanding of system function
Farmers' statements during the meeting and their responses to the post meeting evaluation questions provided clear evidence that a shift had occurred in their understanding of the impact of cropping on deep drainage and on the loss of salt from their cropped paddocks. The farmers also became aware for the first time that in these sodic soils there is a point beyond which further loss of salt may have negative rather than positive impact on their soils' physical properties and that this has already happened at one of the three cropped sites.

Mutual understanding
There was a clear shift in farmers' attitude from one of denial about deep drainage to acceptance that it does happen on their cropped soils and that it is associated with a loss of salt to depth. The farmers also shared scientists' concern that these trends may have implications for sustainability of their farming systems. Both farmers and scientists are uncertain about where in the landscape the salt that has drained out of their soils is likely to show up. Farmers expressed a desire to monitor soil movement in the landscape and expect the scientists to help them do that.

5.1.3 Virtual Meeting Moonie-Toowoomba-Melbourne 2nd December 2004

Background
The significant shift in farmers' understanding of deep drainage and salt loss from their croplands was not directly actionable by farmers. They understood a lot more about what was happening but seemed unsure of how they could do anything about it. The research team thought that this impasse was to be expected as farmers still had little appreciation of the conditions under which deep drainage takes place. To overcome this we negotiated for the farmers to provide a detailed history of their cropping paddocks so that we could dynamically simulate crop growth and a water balance budget.

In any season deep drainage is influenced by weather, land use and management, and the hydrological properties of the soil. Weather determines the amount of water input to the paddock and the potential for evaporative loss. Timing and amount of rain in particular are critical. Land use determines soil water status particularly through evapotranspiration and hence the amount of water available in the root zone that can infiltrate to the groundwater system. Soil properties strongly influence how much rainfall infiltrates into the soil, how much water can be held by the soil before it drains under gravity, and how rapidly water moves through the soil profile. The scientists believed that it was important that simulation of the system realistically reflect these three factors.

Scientific Analysis
Before the meeting scientists completed the soil moisture characterisation of one of the Moonie crop paddocks discussed in the August meeting. The farmer provided scientists with a complete paddock history of the past 11 years. The history included such data as cultivations, crops, varieties, sowing dates, and fertilizers used. A summary of crops and yields is provided in Table 1.

Table 1. A history of crops grown in a Moonie paddock between 1994 and 2004. Shaded areas represent years in which monthly rainfall was in the 9th decile for 12 months.

Year	Crop	Crop Yield (t/ha)
1994	Fallow	-
1995	Sorghum	2.5
1996	Wheat	3.0
1997	Wheat	2.5
1998	Wheat	2.0
1999	Wheat / Lucerne	2.6
2000	Lucerne	-
2001	Lucerne	-
2002	Wheat	1.8
2003	Chickpea	1.2
2004	Wheat	2.3

The daily weather records for the period were obtained from the nearest weather station. Analysis of the weather data, using the Rainman software package, showed that this 10 year period was about 10% wetter than the long term average annual rainfall of 588mm. More significantly, there were three prolonged periods (31 months from June 1995 to December 1997; 17 months from February 1998 to June 1999; and 12 months from February 2003 to January 2004) in which rainfall was in the 9th rainfall decile. These are periods in which the potential for drainage and runoff are high.

These data were used by the scientists to specify an APSIM simulation of the paddock. The simulation was set to start in January 1994 and run uninterrupted to the end of November 2004. Simulated yields were generally in close agreement with recorded paddock yields (figure 6) with the exception of wheat yield in 1998 – a year when widespread flooding, waterlogging and crown root problems meant that virtually all commercial crops in SE Queensland yielded at less that half their potential. Because lucerne was grazed there was no data available for comparison with simulated yields.

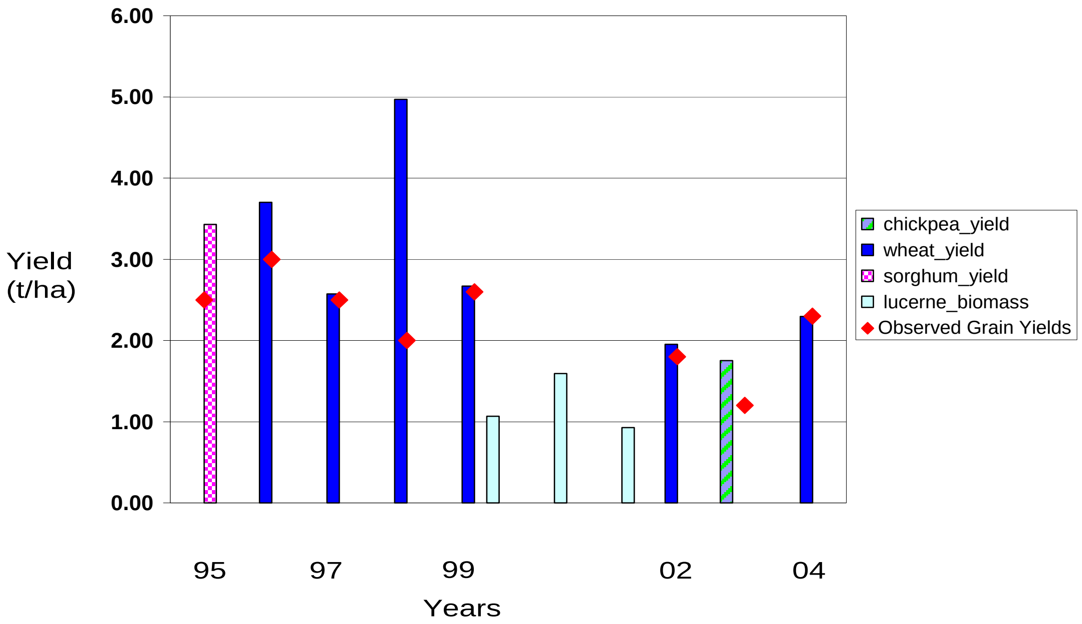


Figure 6. Simulated and Observed yields crops grown in a Moonie paddock between 1994 and 2004.

In a water balance budget all rainfall must be accounted for. This may be expressed as:

Rainfall = Runoff + Drainage + Evaporation + Transpiration + Change in Soil Water Storage

In APSIM each term of this equation is calculated on a daily basis. For the purposes of the meeting scientists produced a graphic summary of these terms at the end of each fallow period and at each harvest (figure 7). Over this 11 year period APSIM simulated 655mm of drainage or an average of 59.5 mm/ha/yr. Closer inspection of the drainage data reveals that all the deep drainage occurred between 1996 and 1999 with almost half of the total occurring during the summer fallow of 1998/99. That is, during an exceptionally wet year that occurred at the end of a five year period with an average annual rainfall that was 168mm higher than the long term average. As there was no comparably wet period since the commencement of land clearing in the 1960s, the "average" annual deep drainage rate should not be thought of as an average for the whole cropping period; depending on the full cropping history the drainage figure of 655mm may represent as much as 80% of the total deep drainage since trees were cleared.

Scientists were also keen to investigate the possible difference that management can make without radical change such as switching to a permanent perennial pasture or agroforestry system. Lucerne is a deep rooted perennial crop that is often recommended as a solution for deep drainage. A reflection on the role of lucerne in this rotation is that it might have been the right crop at the wrong time. Scientists thought it would be interesting to simulate a "what-if" scenario in which the lucerne phase happened during the wet period of 1995 to 1997 and the stored soil moisture available at the end of the 1998 wheat crop was utilized by double cropping with sorghum.

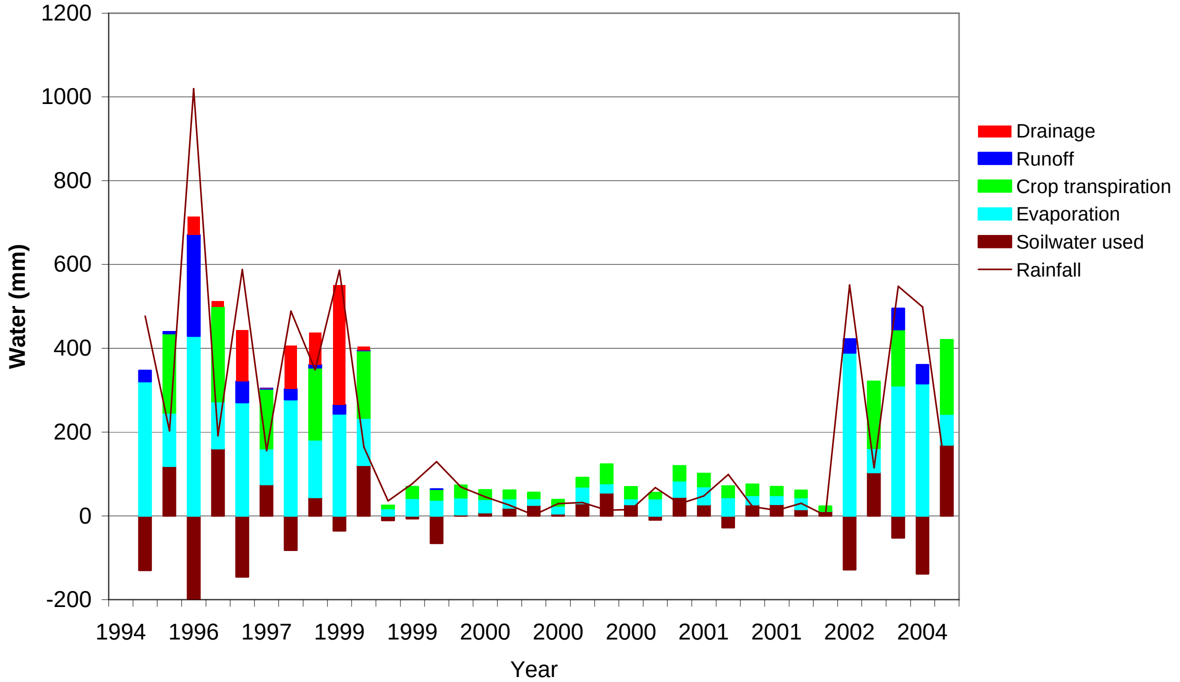


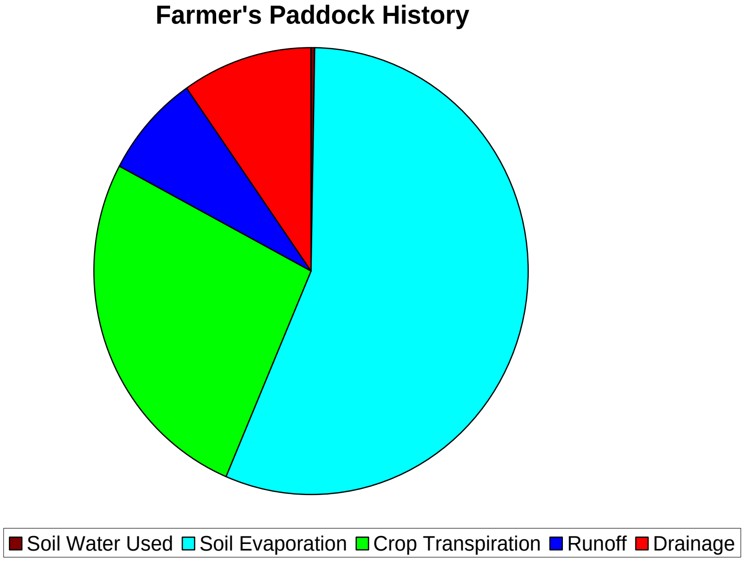
Figure 7. Water budget for each fallow and crop in a Moonie paddock between 1994 and 2004.

The result of the scientists' "what-if" simulation was that deep drainage over the whole period was reduced by about 45% to 365mm. As expected there was no drainage during the lucerne phase with almost all the drainage occurring during 1998, 1999, and 2004. A comparison of the two cropping systems scenarios (figure 8) shows that this significant change in drainage, from 10% to 6% of rainfall, was mainly achieved through a relatively small increase in the amount of water transpired through crops.

Discussion with Farmers
When the scientists completed the presentation of these simulations one farmer responded: "Back in 1994 if I knew then what I know now I would have a totally different outcome to crop results etc. My management would have changed". Another farmer added: "Now when we get into these wet situations we go out and use that moisture. We would have been better off to spray that (1998) wheat crop with Roundup® in September and go in with a Sorghum crop."

These statements led the scientists to challenge the farmers to come up with their own scenario based on their current practice but responding to the conditions of 1994-2004. The farmers asked for a month by month summary of the rainfall record for that period and went about designing their revised cropping sequence:

October 1994	Sorghum
December 1995	Sorghum
June 1996	Chickpea
May 1997	Wheat
May 1998	Chickpea
October 1998	Sorghum
October 1999	Sorghum
May 2001	Wheat
May 2002	Chickpea
May 2003	Wheat
October 2004	Sorghum



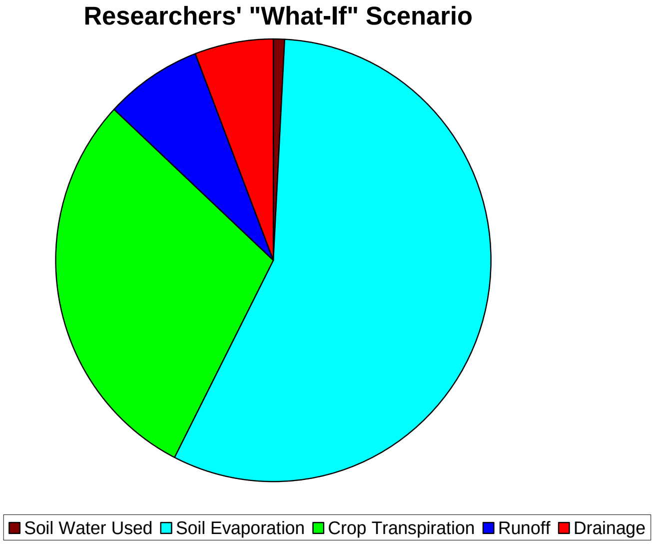


Figure 8. Simulated water utilization of alternative cropping systems.

The farmers’ redesigned cropping program differed from the actual paddock history in a number of respects. The lucerne pasture phase was discarded and replaced by two additional chickpea crops. There was also a marked shift to Sorghum (5 crops instead of one) and away from wheat (3 crops instead of 6). Other changes were that all crops were Zero tilled and higher levels of N fertilizer were used. The simulated deep drainage from this cropping program was 546 mm, not as low as the scientists’ scenario but somewhat lower than the 655 mm calculated for the actual paddock history.

The discussion that followed this activity was started by the scientist summarising his view that the simulations demonstrated that while cropping systems could not avoid deep drainage altogether, the farmers had demonstrated that their systems were moving towards “best practice” through tighter cropping frequency, more summer crops, and double cropping in response to available soil moisture.

Farmer: “Don’t forget the worst case scenario of ’98 which probably won’t repeat itself for quite a few years, so you have to consider that too”.
Another Farmer: “What would be interesting too would be a benchmark comparison in terms of salinity and the environment is what would have happened in those years if there still would have been Brigalow scrub in there”.
Scientist: “We are working to develop that capability in APSIM”
Third Farmer: “I want you to tell us the dollar value of it [Brigalow scrub] when you have it”

It was clear from the discussion that farmers were no longer interested in denying that substantial deep drainage takes place. However, they were concerned to put the period into context and to emphasise that the alternative system of returning to a Brigalow scrub is not a serious option for them. The new focal question concerned the consequences of the drainage. “Don’t we need to know where it [the drainage and salt] goes to? If it moves from the top soil to 4 to 20 meters what damage is that doing to the environment?”

At that point farmers revealed their concern about the way other stakeholders will use this information. An example of this was when a farmer, referring to how variable Gilgai country is with regards to moisture holding properties, said: “First thing NRM guys (reference to QDNRM&E staff) will do is extrapolate your data to a whole catchment scale to come up with a completely wrong figure of the total amount of salt being moved through the profile in the catchment. So it’s far more complicated and we haven’t seen the end of it yet I’m afraid.”

Participant Evaluation
Four farmers responded to the post meeting questionnaire. Only two of these were also present at the August meeting. The answers provided to questions regarding the contents of the meeting are summarised below:

How strongly do you agree or disagree with these statements?

	Strongly Disagree	disagree	unsure	agree	strongly agree
Today's meeting was					
Was a good use of my time	x	x	x	1	3
Has added to my understanding of drainage	x	x	x	3	1
Confirms my own thinking about drainage	x	1	2	1	x
Is of concern for the future of my farm	x	1	x	2	1
Stimulated my thinking about my farming system	x	x	x	3	1
Will change my farm management	x	x	1	3	x
My current farming system is sustainable into the future					
	x	x	x	3	1
Today's APSIM simulations of drainage					
Matched my previous expectations	x	x	x	4	x
Were realistic	x	x	x	4	x
Were relevant to my farm	x	x	x	3	1

All the farmers present at the meeting agreed or strongly agreed that the meeting was a good use of their time, that it added to their understanding of drainage, stimulated their thinking about their farming systems, and that their farming system is sustainable into the future. All the farmers also agreed or strongly agreed that the APSIM simulations of drainage matched their previous expectations, were realistic and were relevant to their farm.

There was however less consensus on some questions. Only one farmer agreed that the meeting confirmed his own thinking about drainage, and one farmer disagreed that the meeting was of concern to the future of his farm. One farmer was unsure if today's meeting would change his farm management.

Open Evaluation
Once farmers completed their evaluation questionnaires, a facilitated session was held to encourage an open discussion on how farmers felt about the meeting.

Farmer: "If you go back to when we first started this exercise there has been quite a change in our knowledge"
Scientist: "When you say there has been a change in your knowledge, has it come from this interaction or has it come from other sources as well?"
Farmer: "Oh no, I think it all comes from this interaction. That's the only interaction I've got on drainage."
Scientist: "It's just that there is a bit more discussion on this in general circles these days and I thought it might have contributed as well."
Farmer: "Most of it doesn't show a lot of knowledge"
Facilitator: "You've mentioned a change in knowledge over the longer term, what is the essence of it?"
Farmer: "In relation to drainage – I had no idea what the drainage was before we started. It wasn't until we came up with some of the figures in the model (tries to recall figures) and that's when we started to query it. I had no knowledge what the drainage was. I thought it was all going out the top end. I didn't know it was going underneath and now you've quantified it and shown us what is happening. Yeah, I've learned a lot."
Scientist: "what might that do as far as your management goes? Knowing that you are losing a significant amount of rainfall though drainage"
Farmer: "I think it's something that we've got to live with. We've got to change our planting frequencies but that will depend on rainfall frequencies as well. At the same time we need to keep in mind that there are other organizations that are worried about where the water is going and it might affect us politically as time goes on."
Facilitator: "How do the others feel about that?"
Second Farmer: "The big difference between this meeting and the first one we had when you did the model runs you used the 100 years data from a weather station near Moonie and came up with average yields that seemed unattainable, quite a bit higher than what we previously experienced. The feature today was actually validating those yields against [farmers' name] actual data which made it more convincing that the calculations in the model were actually true. So that was the big difference for me today, the validation of the simulated yields and that lent credence to the drainage figures."
Third Farmer: "I'd agree with that…it provided us with information that we can change what we might have had in the back of our minds before. I think when we first started this, going right back, we were principally growing wheat on wheat. What this showed me is that you can vary your model and change according to circumstances, and in fact you need to if you are going to change these salinity issues. We've got to make the best of what we are given. I think it's been fantastic, to me it really set the benchmark. If the model says we can get 6 tons, why can't we get the 6 tons?"
Fourth Farmer: "I think it's very relevant. On our site where I deep ripped, my salt went through much quicker and I'm not sure whether I'm getting ahead by moving the salt down the profile. My yield at the moment is a long way ahead but in the long run I'm not sure. I think what's coming out of this is that we can't rely on a fixed rotation. I think we've got to do it to the actual conditions more."

Farmer understanding of system function
There was clear evidence from farmers' statements during the meeting, from their cropping sequence design session, and from their responses to the post meeting evaluation questions that a shift had occurred in their understanding of how climate and management of cropping sequence interact to modify the impact of cropping on deep drainage.

Discovery Learning
When presented with the contrasting outcomes of the farmer's paddock and the scientist's scenario, farmers were somewhat cynical about scientists using hindsight to halve drainage and improve yields. They also questioned whether lucerne would have survived the extreme rainfall event of the summer of 1996. Nevertheless they did feel that their current more opportunistic approach would

result in greater water use efficiency and less drainage. Scientists saw this as an opportunity to get the farmers actively involved in designing their own solution. In this exercise farmers worked completely independently of the scientists and came up with a cropping sequence that was distinct from both previous scenarios. Scientists were able to use APSIM to simulate the farmers' scenario in a matter of a few minutes giving farmers a very quick feedback on their scenario design. Even without the benefit of a lucerne phase the farmers' scenario achieved a significant reduction in deep drainage compared with the actual paddock scenario. This result indicates that farmers had learned enough about the problem to be able to design an effective management solution.

5.2 Virtual Meeting Technology

Before the first meeting could be held, both the Moonie RTC and the Toowoomba media studio had to be built and the capability of holding meetings according to desired specifications was untested. Pre-meeting tests revealed that our expected capacity to conduct multi-site video conferencing at a bandwidth of 128kbps was not met because a failure in Polycom's personal ViaVideo units' software prevented these units from initiating application sharing with the RadVision MCU. This problem was independently confirmed and was being attended to by the relevant companies. However, without a promised date of resolution for the problem, and given that the project had to be completed in a limited time it was decided to abandon the idea of multi-point video conferencing and concentrate on providing the best possible functionality with available technology. The August and December meetings represent two different options for supporting a virtual meeting and their testing under "real life" conditions of meetings on important NRM issues.

5.2.1 Technical functioning of the virtual meeting held on 24 August 2004

The August meeting was held between 1:30pm and 4:30pm. A full video record of the meeting was captured at both the Toowoomba and Moonie RTC nodes of the Meeting. At the Toowoomba Laboratory (image 1) participating scientists were seated at a desk while observers were seated against the back wall. Technical support was provided from the control room which is to the right of the picture frame. All participants faced the front wall - a purpose built double screen.

Image 1. Wide view of Toowoomba media studio

At the Moonie RTC (image 2) MMG farmers were seated around a table. The phone and data projector were placed on the table. The projector was directed at the projection screen which was at the front of the room. The laptop computer and monitor were also at the front of the room towards the left hand side of the image.

Image 2. Wide view of the MMG in the Moonie Regional Transaction Centre

The meeting functioned sufficiently well to allow for the meaningful interactions described in section 5.1.1 to take place. However, technically there was much room for improvement. A close inspection of the technical problems of the meeting is presented here as background to the reflection and redesign process that preceded the December meeting.

Observation of technical problems

The meeting was interrupted by a series of technical malfunctions that consumed nearly half the meeting time. A list of interruptions and the way in which they were diagnosed and dealt with during the meeting is summarised in table 2. A consequence of these technical problems was that the planned continuous video link was not realised. The compromise of alternating between data sharing during "presentation" and video conferencing during discussion had the consequence of limiting interaction between scientists and farmers during the presentation sessions and making it difficult to refer to the presentation material during the discussion session. Other consequences of disruptions were that they distract participants from the subject matter of the meeting, add to stress levels for presenters, and waste precious time for all participants and observers.

Another disappointing aspect of the technology was the poor audio quality of the standard hands-free phone at the Moonie RTC. The consequences of the less than ideal audio and video links between the scientists and farmers are captured in the video recordings of both nodes of the meeting. Some examples of the miscommunications that resulted are given below to highlight the importance of good audio-visual function for the smooth running of a meeting where sensitive issues are discussed.

The sound quality problem was identified early in the meeting when farmers were making their introductions (images 3 & 4). Increasing the volume did not overcome sound quality problems (crackle and metallic). Video analysis revealed a number of significant miscommunications that took place during the meeting. One example was when the facilitator in Toowoomba was attempting to establish the pre-meeting consensus about the amount of drainage that farmers believed was occurring in their cropping paddocks. This question triggered some good discussion at the Moonie node which was not picked up at the Toowoomba node. The facilitator got the wrong impression that farmers were reluctant to commit themselves to an answer and cut this conversation off prematurely.

Table 2. Sequence of interruptions to August 2004 meeting, their *ad hoc* diagnoses and responses

Interruption	**Immediate Diagnosis**	**Immediate Response**
During the first presentation from Toowoomba. Slides were changing at Melbourne but not at Moonie	Insufficient bandwidth for simultaneous transmission of data and Video	Closed down and Restarted NetMeeting at Moonie and Toowoomba nodes
After restart, Moonie could not get a full view of data slide	Symptom was similar to an unmatched resolution	Alt-Enter pressed to show data full screen
Data from Toowoomba would not transfer to extended screen at Moonie end. Data could only be displayed on the primary (laptop) screen	Not understood. Possibly a "bug" in Windows XP split screen facility	Abandon simultaneous transmission of data and video. Transmission alternated between data sharing for periods of presentation and video for periods of discussion.
Shared data kept freezing at the Moonie node, but not at Melbourne node	Not understood. Tested the possibility that Melbourne link was interfering	Melbourne node exited NetMeeting. This did not remedy the problem.
As Above	NetMeeting bandwidth set too high for Moonie node (i.e. Nominal bandwidth not realised)	NetMeeting bandwidth setting was dropped to 28.8 kbps
When video was re-started Toowoomba could not see Moonie video	NetMeeting bandwidth set too low for video	NetMeeting bandwidth setting was re-set to DSL when sharing video

Another example of miscommunication was observed when after a brief presentation the scientist/facilitator at the Moonie node asked for questions from the farmers. One of the farmers asked a question requesting clarification over the depth of soil sampling, this question was not heard by the scientists at the Toowoomba node who moved on to the next agenda item. Fortunately the scientist at the Moonie node realized this problem and made sure that the question was addressed. A similar incident occurred when a farmer asked about the EC to ESP ratio of the Moonie soils. This crucial question that enabled the scientists to give local relevance to a general principle (see figure 5 above) was missed by the scientists at the Toowoomba node. Once again the scientist at the Moonie node made sure that the question was addressed.

Image 3. Scientist directing video camera at MMG member during introductions.

Image 4. Farmers adjusting speaker phone volume setting

In what turned out to be an interesting adaptation to this suboptimal situation, participants at each node tended to engage in brief periods of communication that were directed only at participants at that node. In Image 5 the Toowoomba facilitator is straining to hear farmers speaking at the Toowoomba node: “Sorry we can’t hear. Whoever is speaking now we can’t hear you.” The farmer’s response: “It’s not for you” was followed by embarrassed laughter.

Image 5. Toowoomba Facilitator attempting to improve audio communication by leaning closer to the speaker and microphone.

Participant Evaluation

Answers provided to questions regarding the effectiveness of the virtual meeting by the five farmers who responded to the post meeting questionnaire are summarised below:

How strongly do you agree or disagree with these statements?

	Strongly Disagree	**disagree**	**unsure**	**agree**	**strongly agree**
Communicating online					
Reduces scientists effectiveness	x	3	1	1	x
Reduces farmers effectiveness	x	3	1	1	x
I would prefer to discuss this type of information:					
In an online meeting	x	1	1	3	x
In a face to face meeting	x	x	1	4	x
In a one to one meeting	x	2	1	2	x

How strongly do you agree or disagree with these statements?

	Strongly Disagree	**disagree**	**unsure**	**agree**	**strongly agree**
This online meeting provided a valuable exchange of views and information between farmers and scientists	x	x	x	4	1

Are there any comments you wish to make about online meetings?

- I think it will work well when all the technologies come through
- audio was not great
- volume up for older farmers!

Given the technical problems that beset the August meeting, it was surprising that a majority of farmers disagreed that communicating online reduced the effectiveness of scientists and farmers. Meeting online was rated as less desirable than meeting face to face but more desirable than meeting one on one for discussion of this type of information. Most significantly, all farmers agreed or strongly agreed that the meeting provided a valuable exchange of views and information between farmers and scientists.

Reflection

On the one hand it was comforting to observe the degree of technical failure that could be tolerated by participants and still have them rate the interaction so highly in terms of the credibility of the information communicated, the quality of information exchange between scientists and farmers, and the impact on farmers' thinking about deep drainage and salinity. On the other hand there was no room for complacency; scientists cannot afford to take for granted that farmers will continue to tolerate so many technical problems indefinitely.

Reflection on the technical failings of the August meeting resulted in a number of lessons that had to be absorbed for future meetings:

- equipment, software and networks are unreliable when used in previously untested combinations - previous successes with simpler configurations in the past cannot be assumed to be repeated in more complex systems
- roles and responsibilities need to be well defined in order to avoid oversight of critical elements: identification, timing, delegation and co-ordination of activities leading up to the start of the meeting - good communication between team members is essential to reduce the surprise element
- more time must be set aside for testing all system configurations. Test completely assembled configurations after the individual components are tested. Carry out a mini dress rehearsal
- carry out a risk/impact analysis and implement/test correctional backup procedures. *e.g.* Impact of extended meeting time, impact of network failure, impact of software failure
- when new elements are introduced, make sure they are properly tested and robust, and participants adequately trained
- while there is still time to modify prepared presentations check that data screens to be shared across the network are not unnecessarily loaded with photographic images that slow down the transmission of data
- adequate backup configurations should be planned and tested beforehand. e.g. if bandwidth appears to be a problem, make sure that the meeting requirements can be met with lower bandwidth settings or using an alternative dialup
- hard copies of presentations must be sent to all meeting nodes before the meeting starts. Sufficient time must be allowed for this
- train support people to operate the diverse range of equipment, to remove reliance on any one person to operate specialised equipment
- when a problem is “fixed” but not properly understood, consider it not fixed until it is understood and the fix is repeatable.

Stepping back to reflect on the lessons captured above leads to the conclusion that simply responding to this list of actions may not overcome the inherent problem that the system is unstable and prone to failure even if all these planning, preparation, and testing steps are taken. This situation is a familiar one in action research praxis where the above list of reactions is labelled as single loop learning. Single loop learning improves participant’s capacity to solve specific problems. However, when such actions only achieve a brief amelioration of the problem without confronting the underlying cause of the problem then the problem is said to have embedded double-loop issues (Argyris et al. 1985, p 87). In this case the double loop insight was that it was necessary to reconsider the team’s preference for IP video conferencing systems. IP conferencing is attractive because it is cheap and offers greater flexibility for use with a wide range of facilities. However, at its current stage of technological development it is unstable. This instability means that any savings in line usage costs are likely to be more than offset by the costs of preparation time and meeting disruptions. The research team decided to trial the more robust dedicated ISDN video conferencing system.

5.2.2 Technical functioning of the virtual meeting held on 2 December 2004

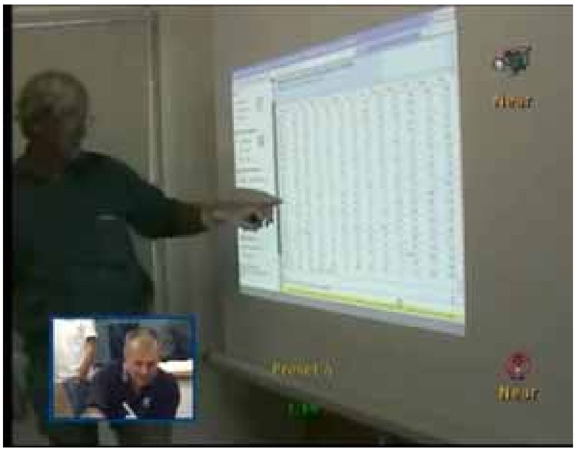
The December meeting was held between 9:30am and 11:50pm. A full video record of the meeting captured both the Toowoomba and Moonie RTC nodes of the Meeting. Participants were positioned at the three nodes (Toowoomba media studio, Moonie RTC, CSIRO Melbourne) much as they were in the previous meeting. A significant role change in the December meeting was that there were no members of the research team present at the Moonie node. A regionally based DPI&F agronomist from the GRDC Eastern Farming Systems project was invited to join the meeting at the Moonie node to play a facilitating role. All technical aspects of the meeting were handled by the Moonie RTC staff and by the farmers themselves.

Both the Toowoomba and Moonie nodes were able to observe shared data and continuous video images and sound of the other node throughout the meeting. Image 7 is a video image of the Moonie node as viewed by scientists at the Toowoomba node. Note that scientists can also see the image (near top left hand corner) of what the Moonie node is looking at. In sharp contrast with the August meeting this meeting was not handicapped by down time. Also, video and audio were of much higher quality and these factors were reflected in the quality of the interactions.

Image 6. Moonie RTC node of December 2004 Meeting

Image 7. Farmers and scientists in animated discussion as captured on the screen at the Toowoomba node.

Using the Polycom ViewStation enabled us to introduce a new technology to the meeting: multiple preset video camera angles. Before the meeting a number of alternative camera settings were preset so that alternative views of each node could be rapidly generated as required during the meeting. Images 8 & 9 provide an example of alternative preset views of the Moonie RTC node. Here farmers were drinking coffee and using Rainman monthly rainfall data while re-designing the cropping sequence for 1994-2004. A scientist at the Toowoomba end recorded details required for simulating the system in APSIM.



Images 8 & 9. Alternative preset video camera angles show different views of the Moonie RTC.

Participant Evaluation
Answers provided to questions regarding the effectiveness of the virtual meeting by the five participants at the Moonie RCT who responded to the post meeting questionnaire are summarised below:

How strongly do you agree or disagree with these statements?

	Strongly Disagree	**disagree**	**unsure**	**agree**	**strongly agree**
Compared to your previous experiences with face-to-face meetings, this online meeting					
Was *less effective* for presentation of research results to us	2	3	x	x	x

How strongly do you agree or disagree with these statements? (Continued)

	Strongly Disagree	**disagree**	**unsure**	**agree**	**strongly agree**
Compared to your previous experiences with face-to-face meetings, this online meeting					
Diminished our ability to communicate with researchers	2	2	1	x	x
Was *less effective* for exchanging ideas between researchers and us	3	2	x	x	x
I am *less inclined* to believe the content of the material presented	3	2	x	x	x

Please rate the following:

	Very good	Good	Unsure	Bad	Very bad
Audio quality	2	3	x	x	x
Video quality	2	3	x	x	x
Application sharing speed (e.g. waiting times for new slides and graphs)	3	2	x	x	x
Readability of graphs and charts	3	2	x	x	x
Arrangement of the room (eg seating arrangements, position of the displays)	3	2	x	x	x
Interactivity of the meeting	3	2	x	x	x

Comments:

- *Amazing – will have wide application to solve the problem of distance of travel for meetings etc.*
- *Very impressed with audio/video quality*
- *Very good*

Please rate the usefulness of the following aspects of the meeting:

	strongly disagree	disagree	unsure	agree	strongly agree
I found that *seeing* the researcher helped my understanding of the contents presented	x	x	x	2	3
The meeting was sufficiently interactive for me (new simulation runs, “what if” questions)	x	x	x	3	2

All respondents either disagreed or strongly disagreed that the December virtual meeting compared unfavourably with face to face meetings in terms of presentation of research results, exchanging ideas with scientists, and their inclination to believe the material presented. Only one respondent was unsure if the virtual meeting diminished farmers’ ability to communicate with scientists. All technical aspects of the meeting; video and audio quality, application sharing speed, readability of graphs and charts, arrangement of the room, and interactivity of the meeting, were rated by all respondents as good or very good. All respondents either agreed or strongly agreed that seeing the researcher helped them understand the content presented and that the meeting was sufficiently interactive. The results recorded here were much more positive that those recorded in the August meeting.

Open Evaluation

In the facilitated evaluation session held after farmers completed their evaluation questionnaires, farmers confirmed the written responses and shed some additional light on them: One farmer said he still prefers face to face meetings but was happy to participate in virtual meetings if that meant that "we can do this regularly and if it's more likely to happen".

The ICT observer from the Melbourne node was concerned that scientists' repeatedly questioning farmers if they are seeing what the scientists are sharing might be disruptive to the flow of the meeting. A farmer responded that: "As we look back at the history of these meetings it's absolutely necessary, but today it [shared data] just appeared, it just came straight up whereas before it was taking 5 minutes and it rolled over and all sorts of things, today it was excellent".

One of the observers summed up the feeling of participants at the Toowoomba node that the experience was "almost like being there". The consensus was that video was much better than before. Yet, as one of the farmers said: "Video was very good - not excellent, but very good".

Reflection:

The main lesson learned was that the ISDN videoconference technology gave reliable connections, good quality video, and good quality audio at both ends. A number of secondary observations of factors that contributed to the smooth technical running of the meeting are worth recording for future reference:

- dress rehearsal was critical
  - it made sure that everything ran together and revealed issues that standalone testing did not show
  - it forced early preparation
  - it forced issues to be addressed prior to the meeting day
  - all elements of the presentation were ready for testing before the meeting day so that all systems could be fired up with a minimum of technical delays and distractions
- technical surprises were avoided by advance briefing of the meeting structure to all participants
- control of camera at both ends using preset positions was very useful
- projecting video and shared data side-by-side worked well at the Toowoomba node
- projecting video to a TV monitor and projecting shared data to a screen worked well at the Moonie node.

Even a very good outcome leaves room for improvement:

- The microphone at the Moonie RTC could have been better located relative to the projector (see image 6) to minimise projector fan noise. This did not show in the dress rehearsal because the projector was not available on the day.
- To check that all participants were viewing the same data screen scientists at the Toowoomba node found it useful to occasionally switch to the preset camera position that allowed them to take a quick look at the data screen at the Moonie RTC node. Having an ongoing view of the data screen may help scientists avoid asking the "are we all looking at the same data" question. It may be worth exploring the benefit of positioning the laptop so that its monitor faces the default camera setting.

6. Conclusions

This research has successfully supported farmers’ learning about deep drainage and dryland salinity through facilitated discovery learning employing participatory field experiments and scenario exploration through simulation. The project was also successful in implementing internet technologies that enable discovery learning to be supported by virtual meetings. Farmers and scientists can use virtual meetings to bridge geographical distance and engage in learning partnerships concerning farmers’ local NRM problems.

6.1 Evidence that the project developed farmers’ capacity to deal with dryland salinity

At the beginning of this project MMG members were sceptical about deep drainage in their soils. They were also concerned that a recently released salinity hazard map may provide a pretext for governments to intervene in the way they manage their farms. Evaluation of this project using participant questionnaires, group reflection, and video interaction analysis provided convincing evidence that MMG members who participated in this discovery learning programme demonstrated significant knowledge transformations regarding secondary salinity and their farming systems:

- denial of deep drainage was abandoned and the group accepted that significant amounts of salt are moving to depths beyond the reach of their crops’ roots
- the farmers accepted that deep drainage does happen in wet years and that this movement of water drives the movement of salt beyond the reach of crop roots
- they were able to link the coincidence of a big rainfall event immediately after deep ripping and its associated impact on hydraulic conductivity with more drainage and significant movement of salt down the soil profile
- the group became aware that in sodic soils there is a point beyond which further loss of salt may adversely impact soil stability and that this point had been reached in a paddock analysed on one of their farms
- the outputs of simulation of an 11 year history of cropping on a MMG farmer’s paddock were accepted by all the farmers at the meeting as realistic and relevant to their farms
- by designing a highly productive yet less ‘leaky’ cropping system farmers demonstrated their understanding and skill in anticipating the complex interactions between their management decisions, variable climate conditions, and deep drainage.

The MMG farmers acknowledged without hesitation that they had learned a lot about deep drainage and dryland salinity and unambiguously attributed their learning exclusively to the interactions described in this report.

6.2 Scientists’ learning about building farmers’ capacity to deal with NRM issues

A shift in emphasis from engaging with farmers on production matters to engaging farmers on NRM issues required scientists to re-think and re-learn what it takes to help farmers learn to deal with NRM issues. From these engagements with the MMG, scientists learned that the success of the learning partnership could be attributed to a number of important factors:

- An existing mutual understanding between the scientists and farmers provided the scientists with some latitude to learn on the job.
- The perceived threat to farmers’ freedom to manage their farms independently of additional government intervention, and the scientists’ demonstrated past commitment to addressing farmers’ issues, created favourable conditions for the MMG to accept the scientists’ invitation to participate in a discovery learning project about salinity issues.
- NRM issues, especially those concerning processes that occur below the soil surface are difficult to make visible to farmers. Yet, farmers are unlikely to own the problem without tangible evidence that a problem exists and that it is relevant to them.

- Simulation proved to be an excellent tool for scientists to help farmers visualise the impact of crops, fallows, and cropping sequence on the partitioning of rainfall between runoff, drainage, evaporation from the soil, transpiration through crops, and change in the amount of moisture stored in the soil.
- Specifying a system simulation to a particular farmer’s soil and to his actual cropping history was a highly successful approach. It resulted in realistic simulation of actual crop yields and this was seen by the farmers as some measure of validation of the simulation as a whole. It also demonstrated the capacity and commitment of the scientists to address the problem in the farmers’ actual situation.
- Once farmers accepted that simulation could be used to provide credible results it became a useful tool for farmers to discover the impacts of management on deep drainage. Farmers accepted the challenge of redesigning their cropping system and the redesigned system was simulated on the spot so that they could get immediate feed back for discussion. This activity was also a useful way of capturing what farmers had learned.

6.3 Learning about virtual meeting technology

Participants in this project had prior experience with virtual meeting technology based on slow internet connections with a focus on data sharing and sporadic low fidelity video connection as described by Hargreaves and Hochman (2004). The virtual meetings that took place in this project were supported by more advanced virtual meeting technologies made increasingly possible by the availability of broadband (128Kbps) connections in rural transaction centres.

All technical aspects of the final virtual meeting; video and audio quality, application sharing speed, readability of graphs and charts, arrangement of the room, and interactivity of the meeting, were favourably rated by participating farmers.

The project provided evidence that farmers’ ability to see the researchers and the smooth technical functioning of virtual meetings helped produce a conducive learning environment. The final virtual meeting achieved a level of interactivity and smooth functionality that compared favourably with face to face meetings in terms of presentation of research results, exchanging ideas, and credibility of the material presented.

Of the three technologies trialled in this project, the ISDN video conferencing technology has proven to be both affordable and cost effective for virtual meetings to discuss NRM issues. Given the demonstrable savings in cost of travel for scientists and the increased availability of scientists for meetings that this technology can deliver, the technology is currently cost effective. The main barrier for getting this technology into widespread use is lack of personnel trained in providing technical support for such meetings.

6.4 Recommendations

While much has been learned in this project some important matters remain unresolved:

- more case studies, using virtual meetings and facilitated discovery learning involving farmers and scientists, are required to confirm and expand on the conclusions of this brief project
- to encourage the routine use of virtual meetings, it may be necessary to develop a national program to demonstrate the technology and to train personnel who could provide technical support for such meetings
- It is true for most catchments, including the Moonie catchment, that it is not known where in the landscape or waterways the salt that has drained below the reach of crop roots is likely to reappear. Both farmers and scientists are keen to learn more about this crucial question. Further research should be directed at developing practical methods for farmer groups to participate in activities that monitor the movement of salt in the landscape.
- In the absence of effective market mechanisms to support farmers in their quest for a more sustainable farming system, we can only expect moderate reductions in deep drainage to result from knowledge transformations alone. Research is required to investigate appropriate policy instruments and institutional support needed to foster sustainable farming.

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