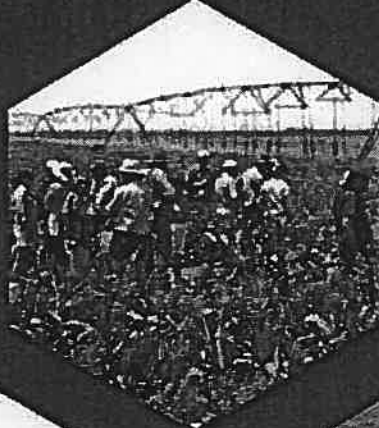


Knowledge Management in Cotton & Grain Irrigation



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and Cotton CRC National Extension Network

November 2004



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Publication details

Callan V, Christiansen I and Harris G (2004) Knowledge Management in Cotton and Grain Irrigation. Australian Cotton CRC Occasional Publication. www.cotton.crc.org.au

Published by

Australian Cotton Cooperative Research Centre

Australian Cotton Research Institute

Locked Bag 59

Narrabri NSW 2390

Phone: 02 6799 1509

Fax: 02 6793 1171

Website: www.cotton.crc.org.au

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***“If you want one year’s prosperity, grow grain.
If you want ten years’ prosperity, grow trees.
If you want one hundred years’ prosperity, grow people”
Chinese Proverb***

Acknowledgements

Particular thanks are due to the irrigators, consultants and other industry participants who contributed their time to participate in interviews or workshops for this project.

The assistance of members of the cotton extension network, along with extension and supply chain managers from grains and horticulture in conducting interviews was invaluable to this project.

This research has been funded by the National Program for Sustainable Irrigation, the Australian Cotton Cooperative Research Centre and the Cotton Research and Development Corporation.

The project steering committee (Di Bentley, Dick Browne, Murray Chapman, Matthew Durack, Merv Jessen, Jim Moore, Eddie Parr and Peter Weal) provided great insights and guidance throughout the project and developed the future directions. We greatly appreciated their input.

Acronyms used

ACGRA	Australian Cotton Growers Research Association
BMP	Best Management Practices program
CCA	Cotton Consultants Australia
Cotton CRC	Australian Cotton Cooperative Research Centre
CRC IF	Cooperative Research Centre for Irrigation Futures
CRDC	Cotton Research and Development Corporation
DPI&F	Department of Primary Industries and Fisheries, Queensland
GRDC	Grains Research and Development Corporation
IAA	Irrigation Association of Australia
IDO	Cotton Industry Development Officer
IPM	Integrated Pest Management
NPSI	National Program for Sustainable Irrigation
NSW DPI	Department of Primary Industries, New South Wales
UQ	The University of Queensland
RD&E	Research, Development and Extension
RWUEI	Rural Water Use Efficiency Initiative
TRC	Technology Resource Centre (Cotton CRC)
UNE	The University of New England
WUE	Water Use Efficiency

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The wise see knowledge and action as one"

Bhagavad-Gita

EXECUTIVE SUMMARY

Knowledge is fundamental to improving the competitiveness, responsiveness and levels of innovation that we see in industries. This research project aimed to determine how information and knowledge about water management and water use efficiency is being used and managed in irrigated cotton and grains and the key factors influencing decision making. To do this, 90 interviews of growers of cotton and grains, consultants, extension workers, government researcher officers, and irrigation equipment suppliers were conducted and a stakeholder workshop held to integrate and progress the findings.

Key issues affecting water management

The project found that four issues in particular were currently impacting on water management:

1. The availability, continued security and cost of water;
2. Economic returns per mega litre;
3. Water quality;
4. Water scheduling.

Growers of cotton and grains accepted that water would be a more restricted resource for them in the future. Crop consultants believed that water management had now emerged as a major focus in their work with growers. Giving advice to growers about water use and efficiency will be an increasingly large part of consultants' work with growers.

Cropping Systems

The majority of growers interviewed produced cotton and grains and some also had other crops or livestock. Most were clearly transferring the knowledge used in their cotton crop to managing other crops. A few of the growers interviewed irrigated only grain crops. There were generally strong similarities between all of these growers as well as a few clear differences.

Growers made decisions about which crop to grow primarily on the basis of the returns per megalitre. Cotton was currently the most profitable irrigated crop for most growers interviewed. However, they indicated that each season they weighed up the benefits and value of other crops and would readily shift to another if it were more profitable.

Information, knowledge and knowledge sharing

All groups believed that the cotton industry was responsive to change, willing to continually learn, and that growers, consultants and extension officers were very willing to share information and knowledge. There was considerable information that was available to cotton growers and consultants. A major concern, however, among growers and consultants, was the need for the information to have been tested and applied to determine its relevance and applicability to specific regions.

Major sources of information

Cotton growers were accessing a large number of people and resources in making decisions about water management. The major "people" sources were:

- consultants
- researchers
- other growers
- own experience.

The major "resources" they talked about were:

- trial data
- field days
- *Cotton Tales*
- grower experiences
- case studies.

Growers preferred personal contact to gain information about water management. Growers accessed this range of people and resources over a number of seasons in thinking through major changes to water use and management. Consultants were the major source of information, and provided a close working relationship that could also bring into the growers' decision-making a variety of other information from research, trials and the consultant's experiences with other farmers in their region.

Grain-only irrigators were similar in terms of the people, resources and activities that influenced their decisions. The main difference was that these growers didn't have a regular consultant, relying more on their own, extensive experience, family, farm staff and water regulators for information. Grain only irrigators didn't express as great or as urgent a need for more information about irrigation as did cotton growers. They were less aware of what information and resources were available to them and what was available was seen to be 'a bit hit and miss'. Field days were less frequent though they would like to see more.

Consultants generally sourced information in very similar ways to how growers did, but were able to make more use of accessing information from other consultants, especially those in their own companies. In addition, they made more explicit attempts to directly resource research and the views of researchers.

What influences decisions?

The **water reform** process is playing a major role in shaping the context within which growers and consultants are making their current and future decisions about irrigated crops. Growers report that they are realistic and expect some form of cutbacks in water availability. However, they would like to see some reduction in the current levels of uncertainty about water security.

Own experience was a prime factor in decision-making and most growers and consultants actively tried out new ideas. This has contributed to incremental improvements in water management. It was felt by some extension staff that many of the gains that could be made through incremental change had already been achieved (eg furrow optimisation). Significant future improvements may require substantial changes (eg systems change) that cannot be easily learnt through on-farm experimentation by growers.

The **driving forces** for positive actions to improve water efficiency are:

- evidence from in-house and outside trials,
- cut backs in water availability,
- the introduction of soil water monitoring devices,
- the continued need to gain maximum financial returns per mega litre of water, and
- access to knowledgeable and supportive consultants and agronomists.

New ideas in water management have been looked at for some time but it was not until forces like those above had emerged, as well as the recent drought, that growers began to re-think their attitudes about water management practices.

The barriers for growers to changing water management practices are:

- the lack of practical evidence that the changes will actually work on their farms, and
- the financial and labour costs of introducing new technologies and farming practices.

Role of public and private service providers

Growers and consultants had similar perceptions, but with some differences in their emphasis. Growers described the public providers' (research and extension) role as being about identifying growers' needs, and to get research completed and communicated back to growers to address their needs about irrigated crops and related issues. Consultants spoke more about the role being limited to having research commissioned and communicated back to the industry, with the implication that the consultant's role was more about identifying growers' needs than it was for the public provider. Consultants believed that they played a more hands-on role or day-to-day role in working with the grower to decide and to implement the crop and water management strategies for the season. At the same time, growers expected to see a cooperative relationship between consultants and extension. In general, growers and consultants felt that there was a lot of cooperation though the sharing of materials and knowledge between research and extension providers and consultants.

Research, development and extension needs

Growers, consultants and suppliers identified a long list of issues that they felt required more in-depth research. Common to their lists were water scheduling, production and efficiency figures for different irrigation systems, salinity management, loss of water research and waterlogging.

Interim Recommendations from the Research

Given this understanding of knowledge management, we put forward for consideration the following recommendations:

1. **Ensure that information about water management is available through a variety of avenues.** Develop and support a package of a range of information and learning mechanisms to suit the differing needs and interests of stakeholders. This package would include field days, newsletters, information resources, website, trials, computerised decision support models, training courses, for example.
2. **Continue to promote as a major strategy the one-to-one interaction and personal contact between irrigators, consultants, suppliers and extension workers.** Irrigators want practical, matter-of-fact information gained through personal contact. They learn by doing and seeing. The best face-to-face methods to promote access to new information and to promote knowledge sharing are field days, trials and grower groups. Access to the experiences of other irrigators and consultants are especially valued as a part of both of these initiatives.
3. **Undertake and promote regional research.** Irrigators want more information relevant to their particular set of farming conditions (i.e. soil type, location, climate). They want more crop trials, field trials and growers groups in their own districts, and write-ups of local case studies providing practical, accessible information relevant to their particular conditions. Therefore, more effort needs to be taken in research being trialled across different types of districts, and the outcomes of these trials being promoted through field days and short, practical publications like *Cotton Tales*. These need to draw together the water delivery and agronomic aspects of water management.
4. **Provide detailed, practical training in irrigation measurement and management for consultants.** Private consultants need to be better educated about irrigation management. While expert in pest management, many consultants believe that they lack the required levels of irrigation management knowledge to best assist growers. Identified experts (e.g. expert private consultants in whole-of-farm water efficiency management, successful

irrigation farmers from various states and regions) need to be brought into all regions to train private consultants, extension officers and others in the numerous aspects of more effective water and irrigation management.

5. The public sector role and expertise needs to continue to be centred upon providing, in highly accessible formats, the findings of relevant research supplemented with practical examples of the local application of this research. Extension staff are perceived by irrigators, consultants and others as facilitators or “knowledge-brokers” who provide information that demonstrates best practice and technical support. They need to continue to promote this role, including greater efforts to promote information to private consultants who are the key individuals influencing irrigators’ decisions about water management.
6. Research needs to be targeted to meet growers’ needs. It is proposed that a grower review board be established in major regions to identify key areas for research, and secondly, to discuss with researchers at regular forums the practicalities of actually implementing the findings from their research. This body would assure that research that is required for specific regions is undertaken. Also this body needs to work with extension so that research findings are communicated in ways that maximise the likelihood of uptake by growers and consultants in particular. This role may be a local adaptation of the ACGRA function.
7. Given their central role as a key source of information gathering and knowledge generation and sharing, consultants need to be better targeted in extension activities. A cooperative approach to information transfer is the best option, and one that is very possible given the existing positive relations between consultants and extension in most valleys.
8. Continue to send out short, concise, practical information to growers through *Cotton Tales* in particular. Include links to more detailed, useful information. Where possible, *Cotton Tales* should be modified by local extension officers to promote information of the most relevance to their particular region and those growers’ needs. Similar formats would be useful for grain

irrigators, although more work is needed in understanding their needs.

9. More work is needed into identifying potential vehicles for cross-industry cooperation in the area of sharing information and knowledge about water management, including forums devoted to innovative water management strategies, and greater incorporation of lessons from other industries into *Cotton Tales*, COTTONpaks and other information resources given to growers.
10. There needs to be the development of more "one-stop" integrative information tools, such as for example, CD's that combine all of the information from different sources on water management (WATERpak is currently under development); a searchable database of all trials (including trial books); field days that only focus on one or two issues in-depth; and a catalogue of "who is doing what" in research.
11. Continue and increase the offerings of courses such as the Cotton CRC's/UNE's Cotton Production course and the GRDC's/UNE's Sustainable Grain Productions course, and ensure a sufficient focus upon irrigation management.
12. Regularly prepare and place articles about more effective water management for specific regions in *Cotton Tales*, the *Cotton Grower & Graingrower* magazines and *Country Life/The Land* and promote these to growers and consultants as a resource for irrigation information.
13. Identify or appoint extension staff willing and able to develop greater technical and general expertise in water and irrigation management to be available to all key stakeholder groups, and most specifically, growers and consultants.
14. Investigate the potential and scope for an Irrigation Technology Resource Centre, and determine whether this Centre could service all irrigation sectors nationally.

Integration and Planning

Key stakeholders met to consider the recommendations of the research and to progress a way forward. There was great diversity between the different industry sectors in which of these recommendations they considered to be of highest priority. This highlighted the need for any knowledge system for cotton and grain irrigation to incorporate a range of avenues for information and learning. These components can be defined as:

1. Developing grower experience;
2. Upskilling advisors in irrigation management – consultants, irrigation suppliers and extension;
3. Generating and communicating localised data through field trials, action research, field days and case studies;
4. Providing ready access to relevant information;
5. Facilitating collaboration and knowledge sharing across industries and between public and private sectors; and
6. Undertaking research to enhance the irrigation knowledge base.

Recommendations

Based on the discussions with key stakeholders at the workshops and through the steering committee, three recommendations are made:

1) A collaborative irrigation knowledge system be developed that incorporates an integrated package of delivery mechanisms:

- Training – growers, consultants and other advisers.
- Accreditation pathway for consultants in irrigation management.
- Case Studies of grower's efficient practices and improvements.
- Information resources – web and print with well maintained distribution pathways.
- Media and newsletters.
- On-farm trials – facilitate linkages, provide trial protocols and communicate.
- Regional extension activities – groups, field days, information delivery, trials.
- Cross-industry forums and study tours.

It is recommended that this be developed as a pilot program for cotton and grain irrigation industries as a collaboration between the cotton, grains and irrigation industries and related research agencies.

2) It is recommended that a series of specific research projects be commissioned to investigate further various key aspects of irrigation management that are identified in this report. These projects respond to the information and knowledge needs of key stakeholder groups. The specific topics are detailed in various sections of this report. In addition, future research might benefit from the use of other research methods to investigate knowledge management and related issues. Again, such methods are identified in the body of this report.

3) Develop strategies to assist irrigators in overcoming the barriers to change that have been identified in this study. This includes utilising novel means to develop grower experience for improvements that require substantive rather than incremental change.



INTRODUCTION

The Australian Cotton Cooperative Research Centre through this knowledge management project aimed to develop a better understanding of the knowledge pathways being used by irrigated cotton and grain growers, consultants and support agencies.

The study focused on how cotton and grain irrigators and their consultants access information about irrigation and generate knowledge to make better irrigation decisions. Driving the project are observations like the following:

"It's important that we understand what triggers or prevents changes in management so we can figure out how to help growers use knowledge more effectively. Understanding this will help the ACGRA to invest well in future research and extension. There is a lot of good research being done here, there and everywhere. It's really important that this information is available to irrigators in a form that they can understand, otherwise we are not getting the most value from research."

Glenn Fresser

Chair, Australian Cotton Growers Research Association

The specific objectives of the current project were to:

- assess existing frameworks and channels being used for the efficient, rapid transfer of new and timely information and knowledge to primary producers, consultants, resellers, extension networks and industry organisations, and through this exercise to develop new tools and strategies for knowledge management;
- understand the factors that are influencing the decisions and use of research and extension information by primary producers, consultants, resellers, extension networks and industry organisations;
- explore how public and private sector information service providers can more effectively partner to achieve enhanced water management outcomes.

The project's primary research questions were:

Q1. How is information about water management and water use efficiency being used and managed by stakeholders?

Q2. How does this use of information compare with the current extension methodologies being used to promote such research and related information, and where there is a mismatch, what needs to be changed?

This report firstly provides a brief overview of what is understood by the terms of knowledge and knowledge management. Next, we briefly review past research that provides important links to the current project.

The current study adopted a qualitative approach to understanding growers' and others' knowledge pathways, using a series of interviews and workshops to gather the major sets of information. The major parts of this report present the findings from our interviews towards addressing the research questions outlined earlier. Much of the methodology used is described in the appendices.

The report put forward a number of draft recommendations from the initial research that were then debated and explored at a forum of key stakeholders to form the recommendations for progressing irrigation knowledge management in irrigated cotton and grains.

Knowledge management

Knowledge is essential to the survival and success of any industry. The management of knowledge has many dimensions, including how to create, store and share knowledge. Most industry sectors today highlight that people need to think beyond just managing knowledge, and to think more about its creation, sharing and application. The current project shares this aspiration, in that we are examining how knowledge is shared, and ultimately used by growers and consultants in particular to make better decisions about water management with cotton and grain crops.

Also it is increasingly accepted that knowledge work does not happen by itself. It is a cooperative activity. Everyone needs to be given clear responsibility to ensure that when important knowledge, research, discoveries or innovations are found, that they are delivered, shared, integrated and used where it matters most (see Callan, 2003; Rylatt, 2000). As a result, a focus upon knowledge management leads naturally to a focus upon the importance of relationships and networks that allow new information and knowledge to be successfully shared.

There are numerous definitions of knowledge management and no single definition is widely accepted. However, there is strong agreement on its major elements. Knowledge management:

- is the creation of communal value from intangible assets (Svieby, 1986);

- involves not only the creation but also the distribution and use of knowledge, and in doing so, this knowledge is turned into value for those in the industry (Davenport and Prusak, 1998);
- is a process through which industries leverage their institutional or collective knowledge to improve their competitive stance, responsiveness and innovation (Hall, 2003; Koenig, 2002);
- allows industries to drive out costs from business and production processes, and to improve speed, quality and efficiency.

Knowledge is very difficult to quantify, unlike other assets such as buildings, land or farm equipment. Knowledge assets are mostly intangible. Knowledge about irrigation management, for example, will very much rely on interactions and relationships between people. As a result, often the major challenge with knowledge management in any industry is ensuring that key people and groups are in communication with other key people and groups, both within and beyond the industry so that opportunities for knowledge generation and transfer are available.

Changing attitudes, individual differences and personality

A focus of this report is upon how we change attitudes and how people prefer to receive new information that might challenge existing beliefs about water management. There is considerable social-psychological research on each of these topics that informs the current analysis of cotton and irrigated growers' attitudes to water management.

Summarising very briefly what past research reveals (see Callan et al., 1991), we know that:

- attitudes influence our behaviours. Social scientists talk about the belief-attitude-behaviour relationship. To change any attitude, we need to work at a number of levels. We need to alter the learned beliefs that the person has based upon existing information and their past experiences (i.e. introduce growers to new information that challenges their existing beliefs about what makes for efficient water management practices). Next, we need to recognise that changing attitudes is also about making people re-assess the positive and negative outcomes they feel from holding certain beliefs (e.g. changing from a negative feeling about water management ("it is too hard", "it will not improve our productivity") to a positive feeling ("it will save me money which will make me happy"));

- we know that long-lasting attitude change is based on people seeing benefits from engaging in the new behaviours (e.g. more efficient water management practices results in higher levels of productivity and lower costs), and in being praised, talked positively about or rewarded by significant others in their environment for these new behaviours. Behaviours that are positively rewarded (by praise, recognition, financial benefits) are the behaviours that will be repeated in the future;
- attitude change takes time. It occurs when people begin to acknowledge that new information or experiences that they are gaining is actually inconsistent with their existing beliefs, practices or behaviours. This “cognitive dissonance” is uncomfortable psychologically for most people. They resolve this sense of dissonance by changing their attitudes to make their beliefs, emotions and behaviours relating to an issue consistent again;
- to change attitudes, we need to recognise that there are strong individual differences in people. Each of us has preferences in how we like to access new information. The most successful communication strategies that alter beliefs use a variety of communication channels to get new information to people that might challenge their existing beliefs, and in turn, might alter their attitudes and behaviour. In addition, using various channels of communication or information-giving recognises differences in people’s learning styles and how personality differences affect how we prefer to access information from our environment (e.g. introverts tend to prefer reflective more solitary learning, while extraverts want to engage in contact with others).

In a rural context, Cary, Webb and Barr (2002) studied the capacity of Australian agricultural and pastoral landholders to change to more sustainable practices. They identified that landholders’ capacity to implement these practices varies with largely with their situation, individual circumstances and the suitability and perceived value of the practices. They suggest that, because landholders aim to reduce the risk of adopting new practices, those practices which are observable, triable and less complex are more readily adopted. They also found that pro-environmental values and attitudes “have a relatively minor influence on the adoption of sustainable practices”, with financial capacity being a more important influence.

Cary *et al* (2002) highlighted the need for increased R&D effort to identify and develop locally applicable sustainable practices and to promote these only within the areas where they had been proven. They believe that

practices that offer 'soon' and 'certain' outcomes will be more rapidly adopted.

Previous research about water management attitudes and behaviours

A number of previous studies provided important background information for the present project. In particular, these reports highlight the range of resources used by irrigation farmers to make their decisions; the growing importance to growers and others of more efficient water use in irrigation; and the preferred methods of receiving information.

The findings from those projects are now summarised:

- in a report on changes in attitudes to integrated pest management, Coutts, Christiansen and the Cotton Extension Network (2001) found that decision-making about integrated pest management was moving towards a partnership between the grower and the consultant. Most growers rely heavily on their consultant for information to make their decisions, but at the same time, many growers were actively querying and discussing consultants' recommendations. Growers were using this process to set up the type of pest management practices they wanted.
- Bell and Harris (2001) in a report on the Rural Water Use Efficiency Initiative found that efficiency of water use in irrigation is a major issue among growers in the 5 regions surveyed. In achieving efficient water use in irrigation, important factors were, in this order, irrigation management, cost, soil management, and environmental factors. To improve water efficiency on farms, growers have altered their irrigation systems, redeveloped farm storages, engaged in irrigation system improvement and irrigation management and scheduling. Drip irrigation was mentioned most often in terms of a change in irrigation system. Land levelling was seen as a major way to improve water efficiency as part of irrigation system improvement. In looking to the future, growers reported that they intend to implement the installation of sub-surface drip irrigation, greater use of irrigation scheduling tools (e.g. self-moisture monitoring equipment), deepening of on-farm storages, and laser levelling of irrigation fields.
- Christiansen and her associates (2002) found that 90 percent of cotton industry participants surveyed had a copy of at least one of the resources provided by the Cotton CRC and the CRDC. The highest

rate of take-up of resources was by agronomists. The most frequently used resources were *Cotton Tales*, newsletters, the insecticide resistance management strategy, the pest management guide, IPM guidelines, information updates and the insect pocket guide. The most frequently used resources were also judged to be the most useful. The most preferred methods for accessing information about cotton production were from an agronomist, *Cotton Tales* newsletters and the COTTONpaks.

- Harris (2003) reported at the 2003 Farm Systems Forum that there is significant scope to improve further the overall performance of irrigation within the cotton industry. He has calculated that the overall whole farm irrigation efficiency averages 60 percent, with large variation between farms.
- Another report from the 2003 Cotton CRC/CRDC Farming Systems Forum notes that there is recognition of a wide scope for improvement in terms of a range of irrigation efficiencies in the industry. There is a need for better measurement and quantification to determine where the losses occur (Johnson et al., 2003). It is reported that growers and others would like to see a Water Use Efficiency program similar to the Integrated Pest Management program, operated by IDOs in the first place, and then a grower could choose to employ a consultant or not. The better management of water storages was important, as well as improved knowledge about how to reduce evaporation.
- In a survey of participants at the 2003 Farming Systems Forum, Dugdale and her associates (2003) reported on the research and extension needs in several areas of irrigation management. Their survey revealed that most growers and researchers were in agreement that water that could be saved most readily on a farm by reducing evaporation and leakages from storages and channels. In addition, there was agreement amongst both groups on the need for tools to monitor and assess on-farm water use efficiency and to schedule irrigations. Growers estimated their water use efficiency ranged from 50 to 70 percent. Under specific research topics, the report identified the need for better understanding of the best way to reduce evaporation; realistic and practical tax incentives for channel improvements by growers; research into benefits of lasering, slopes and run length; deep drainage, salts and water table impacts; sub-surface drip and issues of uniformity and germination; research into alternative row irrigation and most efficient use of systems; and

comparisons of continuous monitoring versus scheduling. In terms of extension, the report identified feasibility studies and working with growers to get good data that can be used to support policy decisions; define a protocol for use when measuring efficiencies, and simple technology to easily measure water in and out of channels on a continuous basis; extension of ideas on how to optimise irrigation layout; case studies in irrigation management; extension of suitable soil types for drip and awareness that is not the only efficient irrigation option; and publications about what tools are available, the value and accuracy and where and when to use them.

- Ian Plowman (DPI&F/UQ) and his colleagues (2004) are currently investigating innovation across six primary industries, of which cotton is one. This interview and survey study has looked at what makes various industries innovative. Plowman asked various members of the industries about the quality of resources and services available; how well each industry is being promoted; the depth of specialisation in terms of the willingness of people to upgrade their knowledge and skills; the availability of experts for advice; attitudes to change; willingness of the industry to exchange information with outsiders; and evidence of innovation in the industry in recent times. In summary, this study found that the cotton industry currently is a highly innovative industry that readily shares knowledge. He implied that some of this may be due to the first generation nature of the industry. He warns that as the industry matures, it is at risk of declining innovation and lower levels of knowledge sharing, indicating a need for a knowledge system that recognises these risks and includes strategies to maintain innovation.

In addition, a number of other industries have completed research into growers' perceptions and needs that is relevant to knowledge management in irrigation. For instance, Dignam (2003) in a needs survey of wine grape growers, found that better water management was among the key changes needed. Many of these wine grape growers expected the future to be tougher than it had been over the last decade. To grow and prosper, growers needed to improve grape quality, water management, and operational and production efficiency. Like cotton growers, wine grape growers used many sources of information. However, growers liked especially to learn and gain information through personal contact. Some 84 percent reported that they had implemented changes as a direct result of information received over the past five years.

Another report on behalf of NSW Agriculture has described irrigation habits and knowledge about irrigation (see Marston and others, 1998). About a quarter felt that nothing would make them change. For the majority, however, greater profits and higher costs of water were the major factors that irrigators said would encourage them to change their irrigation behaviour. The major barrier to change was the economic cost. Asked about preferred ways to receive new information and to improve communication, field days were very frequently mentioned. Another preferred way to acquire information about a new irrigation method was by a visit from a retailer, supplier or expert. Finally, any new information needed to be practical and straight-to-the-point.

Current extension models in the cotton industry

Overview

The Australian Cotton CRC's National Extension Network includes Industry Development Officers (IDO), District Agronomists and specialist staff in the areas of Water Use Efficiency, Irrigation, Integrated Pest Management (IPM), Spray Application Technology, Education, Evaluation and extension approaches. They are located in every major cotton-growing region. They provide a close link between industry and research. In addition, Cotton Australia's grower services managers drive the implementation of Best Management Practices (BMP).

The cotton extension model used by the Industry Development Officers includes a range of approaches such as information transfer; trials and demonstrations; groups; benchmarking; and education. Through each of these is threaded evaluation to ensure that activities are reaching the mark and achieving positive outcomes for industry. Close industry engagement is a core mode of operation. Industry reference groups in each valley and for specific programs provide growers and consultants with the opportunity to set priorities for the extension program.

Trials, demonstrations, groups, benchmarking, education and extension focus teams.

One of the key drivers for establishing the IDO positions was the need for on-farm, regional trials. Trials are utilised for ground-truthing and gathering local data, building confidence in recommendations or techniques, benchmarking and for developing technologies. Groups such as area wide management groups have rapidly gained momentum across the cotton

industry as growers look to each other for support in implementing complex systems. These groups are most effective when driven by growers, with the extension team providing support and coordination.

Benchmarking through physical trials or desktop data interrogation allow growers to view themselves on a continuum amongst their peers. Benchmarking also allows the extension network to focus efforts on elements that show the greatest variability between farms. The *Cotton Production Course* offered by the Australian Cotton CRC / UNE provides scientific and practical skills that promote sustainable and profitable cotton production. Its main purpose is to build technical capacity in the industry service sectors and it also attracts some growers. An *IPM Short Course* has been specifically designed for cotton growers. It comprises practical and theory session to give hands-on experience and knowledge about Integrated Pest Management. It is available for small, interactive groups in all regions on demand. A *Waterwise* course offered by NSW DPI focuses on the basics of irrigation management.

In addition to their local role, each member of the extension network contributes to a national extension effort through one of the Insects, Farming Systems, Environment, Diseases and Weeds or Water focus teams. These teams work closely with researchers and their ACGRA members to ensure that consistent messages are extended across the industry with minimal duplication of effort. They aim to take a strategic approach to developing and integrating information and extension methods for industry wide issues and to partner closely with the related research programs.

Sources of communication

Relevant, timely information is communicated to industry through a range of sources. The COTTONpaks: ENTOPak, SPRAYpak, MACHINEpak, SOILpak, NUTRIpak, WEEDpak and IDM guidelines are a compendium of relevant information on their specific issue for the cotton industry.

In addition, other channels of extension involve:

1. **Newsletters**, includes regional fax-out or email newsletters such as Cotton Tales and WaterWorks provide timely, concise, locally relevant information.
2. **Field Days and Farm Walks** are a widely used forum for observing the results of trials, hearing from researchers and promoting discussion between industry participants.
3. **Workshops** on specific issues such as spray application technology allow the issue to be discussed and demonstrated in greater detail.

4. **Collation, distribution and interpretation of regional data** such as pheromone trap results for timely use through the season.
5. **Web**, the Cotton CRC website hosts a wide range of information resources and tools. Forums and chat rooms are under development. www.cotton.crc.org.au
6. **Computerised Decision Support Tools**, in particular CottonLOGIC have been developed to aid the accessibility of research information and to make it more readily usable. Further tools such as the OZCOT crop simulation model, a water use efficiency calculator and HydroLOGIC, a decision support for irrigation management are under trial.
7. **Cotton CRC's Technology Resource Centre** acts as a central point for the development and distribution of information resources, maintains industry distribution lists and develops the CRC website.
8. Through **links with research**, the extension team provide a channel to enhance two-way communication between research and industry and between different regions of the industry.

METHOD

A total of 90 people were interviewed either face-to-face or by telephone for this project: 39 cotton and grain growers; 4 grain irrigators; 30 consultants and irrigation suppliers/designers; 10 members of the cotton extension network; and 7 members of government research bodies. The study focussed on cotton and grain irrigators in cotton regions – most irrigators in these regions grew both cotton and grains whilst a few grew grain but no cotton. As a result, the study focuses primarily on the mixed cotton and grain systems. Appendix A presents more details on the methods used to design the interview schedules, and to prepare interviewers. Appendix B presents copies of the various interview schedules. Appendix C provides a list of participants (i.e. consultants, resellers, extension officers, other industry figures) in the study, but does not list growers' names.

FINDINGS

Key issues affecting water management

It is important to understand the context at the time these interviews took place. Growers were in a period of prolonged drought. As a result, there was no doubt among those interviewed that water had become a more restricted resource than it had been in the past. A number of growers have quite large parcels of land developed for crops, but they did not have the water to allow them to use that land effectively. In the last few years as well, growers and consultants acknowledged that public opinion had focussed more upon the use and abuse of water, and irrigators, in particular cotton irrigators had been targeted as poor water managers. This public perception was important to many growers, and many mentioned that irrigators had to start to change their behaviours to avoid continued negative publicity for the industry.

Overall, farmers had taken fewer risks with their crops in 2003 compared to 2002. Queensland and many NSW regions had been in a long drought. Most regions had not been able to plant full areas of cotton due to a lack of water. Of those who had planted cotton without sufficient irrigation water and did not get enough rain, several had either ploughed out the area or double or single-skipped. In some regions, irrigated wheat had provided a reasonable income.

While there was a considerable range of issues cited by those interviewed, the key issues impacting on water management were:

1. the availability, continued security and cost of water
2. returns per mega litre to determine what is the best crop type to maximise profitability on the farms
3. water quality including the need for more information about issues such as the long term benefits and costs of using saline or bore water
4. water scheduling.

Irrigators, consultants and resellers highlighted these major issues. For each of these major issues, there was a strong emphasis upon the need for more information about each issue at a local level. A number of other issues related to water management were also frequently mentioned in their interviews. These issues included (in no particular order of priority):

- variations in climate and rainfall, and how these influenced decisions on irrigation management and crop type

- public attitudes about irrigators, and water conservation
- the use of cheaper ways to monitor more areas on farms using probes
- the need to better understand and manage waterlogging
- the relationship between soil types and irrigation choices
- more understanding of deep drainage
- ways to increase capacity to store water
- ways to minimise labour requirements around the most appropriate choice of irrigation method
- the management of losses due to deep percolation
- improved tail water reticulation
- managing irrigation and soil erosion problems
- alternative crops to cotton given changes in water availability and its cost.

Consultants believed that water has now emerged as the new area of focus for them. As one reported:

"With Bollgard® II we'll spend less time chasing bugs and more time working with water and nutrition management."

In addition, many consultants believed that they were less expert in giving advice about water than they were in other areas of crop and pest management. A large number of consultants wanted to develop their knowledge and expertise in water management. This was a major theme in our discussions with most consultants. Most felt that water and nutrition advice would become a key part of their consulting service, they also believed that there will be much more work for specialist consultants in the future. Most of their current advice about water management was related to the use of Diviners and neutron probes; advice about water scheduling; design of systems and equipment supply; dealing with distribution losses; and in general discussions with growers about ways to maximise returns per mega litre given the costs and availability of water. The vast majority of consultants believed that advice to growers on irrigation will be an increasing part of their consulting services.



Launch of WATERpak – a guide for irrigation management in cotton.

Growers' and consultants' attitudes about change

There is a lot written in other contexts about the need for people to be "change-ready" if they are going to respond to new opportunities for innovation. It is argued that without this attitude, levels of innovation will be low, and the death of organisations and industries is more likely.

There were some growers who were clearly very resistant to any change. They were highly cautious and conservative decision-makers, and were very reluctant to alter any practices that were giving them acceptable returns per mega litre. Unfortunately, those returns were based on continued assumptions about continued good availability of water. Even a severe drought had not altered their thinking, and in the longer term, they will lag well behind others in changing their water management practices.

At the same time, they were clearly the minority. The vast majority of growers we interviewed were "change-ready", being open to new ideas but this did not imply that change was quick. Rather, they were open-minded, and they were building a case for change by accumulating over time new information from a wide variety of people and resources. Growers were definitely not flighty or in panic about potential changes to water availability. However, more correctly, they were growing in concern and were getting somewhat anxious about the lack of information in more recent times, especially about continued water security.

Consultants believed they were more open to change than were growers, especially as openness and constant challenging of their own ideas kept them up-to-date and commercially viable. They talked about the need to be open to new ideas. Idea generation and dissemination was central to their role and professional practice. Many mentioned that they felt that they were very influential in making growers more change-ready, mostly through the quality and length of their working relationship with growers. Some had been consulting to individual growers for a decade or more. As a result of a good track record of successful decision-making about many issues related to crop management in the past (i.e. mostly pest control), they were major sources of influence upon farmers' decision-making now about water management. As one consultant concluded:

"I have been working with some growers for several years, and we get to know each other and the individual concerns of the grower very well. We develop faith in each other, and see how successful we have been in past decisions. Growers are willing to change, but like me, they want to see some practical results before they commit to something that will cost a lot of dollars and time".

Information, knowledge, knowledge sharing and learning in the industry

There was little evidence of any passivity among those interviewed in wanting to seek new information and knowledge. Indeed, the vast majority of growers and consultants were actively seeking information that would lead to improvements especially in the areas highlighted earlier as major concerns; that is, the returns per mega litre, and various aspects of water quality and water scheduling. Many growers were highly active in seeking new information to build their knowledge in these areas, doing their own searches through the web, telephone calls to researchers, consultants and other growers, looking for articles in local newspapers, and by attending farm trials that allowed them to see new initiatives at work, as well as to talk to key players.

Also consultants were very active in seeking new information and in building their knowledge about water. While they made mention of mostly the same sets of resources as growers, they made more use of research publications, discussions with other consultants (often in their own business) and researchers, and comparisons of trial data from within or across farms. As to be expected, they were active seekers of new information as such information gave them a competitive advantage over other consultants, and allowed them to better meet the needs of their grower clients. Also, they were highly aware of changing public attitudes and that if growers did not alter their behaviours, threats could build that might challenge the continued viability of the industry and their role as consultants.

Growers, consultants, suppliers and extension officers rated the industry very positively in terms of its responsiveness to change, risk-taking, willingness to experiment, willingness to continually learn and judged its future to be a healthy one. Across all sectors, there was the general opinion that the cotton industry was an innovative one. The cotton crop could be regarded as a knowledge crop.

"Between us on this farm we read just about everything that's related to the industry, go to events, have trials on-farm and talk with other growers and agronomists. Then we talk about how these ideas fit with our systems and plan what we can do better."

Driving innovation and the sharing of knowledge is the relative youthfulness of the industry, the good financial returns that have encouraged a willingness to share information, and an acceptance that good

information is critical to successful change. The grower culture is clearly one focussed upon innovation and trial-and-error learning. A number of farmers talked of "giving it the acid test", about "getting a real buzz" from on-farm trials, often "pushing the boundaries" by experimenting with different options and how their own trials and small experiments built up their confidence for larger changes.

Most growers were experimenting each season and often paddock by paddock with a variety of infrastructure changes (e.g. pivot/lateral, recycling) and practice changes (eg siphons, double siphons, various sizes, stubble, minimum zero till, rotations, field redesign) that might maximise returns and profitability from irrigated crops. Trialing was central to working out the value and cost of a change. As a grower explained:

"Currently I just cannot justify the expense of putting in drip irrigation or laser levelling. But I might trial it in a few a paddocks once we get past this drought."

There were very positive attitudes about the links between information sharing, knowledge generation, learning and innovation in the cotton industry. Similarly, the horticultural industry was judged as a leader in irrigation management and knowledge sharing by many growers, extension officers and consultants. Growers tended to transfer what was learnt about irrigation from the cotton industry to their grain crops.

Overall, there was a strong consensus that the cotton industry had excelled in getting information out to growers in a timely manner using a wide range of communication channels. However, despite this positive record, there were concerns in several areas:

- There was sometimes too much information and it was often very time-consuming to locate specific information. As two growers commented:

"Really there is plenty of information. I feel that we need more about the application of the information to see if it works. The scientists need to show us in practice some of their findings. I also want better access to information about specific issues, which is often the hardest information to get".

"While there is a lot of information out there, information about irrigation issues is extremely difficult to find. I wouldn't know where to go if I wanted to find something."

- Growers wanted more specialised information brought together into one easily accessible form.

"It would be good to see case studies with the names and addresses of people involved in a COTTONpak on a CD. Good to have all of the research pulled together about important water management issues on one database."

- Growers and consultants felt that a lot of findings from research had not been tested or applied to determine its relevance and applicability to specific regions. Farmers and growers were very "valley centric", and expected either consultants or extension officers in their valleys to select the information that was most useful to their conditions (eg type of soil, crop type, water quality and availability). To them, the best information had been tested out in farm trials that put theory into practice, with case studies of successful implementations, and discussion in growers' groups about what works or does not work for their regions.

"I want to see things actually work. The farm trials are good, and it does show me that these ideas might make a difference to my farm, and my conditions. Because of the expense, and the effort needed to introduce practices, I really do have to weigh up the evidence over a few seasons. And even when we (the consultant and I) decide to move on a change, we will usually go for a trial first."

Own experience and the experience of other growers was a key information source. On-farm trials were central to generating and sharing new information and knowledge, and in producing new learning. On-farm trials were important for building growers' confidence in innovations and new practices. Growers wanted to see new technology working before they used it themselves. Central to these needs was the considerable financial cost and time involved in implementing new information and new technology. Talking about how he combined various sets of information, a grower explained:

"I build up my confidence about the value of changes to how I manage water by talking to my consultant and other farmers. I won't change unless I see it working elsewhere. It also depends on your view of risk. Do you just treat four furrows or double it to do a whole paddock? I need good advice and consultants, using research and other farmers and their experience, guides me a lot."

Another explained:

"I gather as much information as possible before I make a decision. It is one that my son-in-law and I make together. Our challenge is to increase water use efficiency across the farm but in the most economical way. Our decisions usually take two to three years for a major change. We just keep 'looking over the fence' to build our confidence about the right way to go."

Finally, while growers and consultants believed that those in the industry were mostly open to learning and were "change ready", change was adopted as an incremental process due to the considerable financial and logistical costs involved. There is also the political dimension. As one grower explained:

"There are currently problems and politics with water supply. There needs to be an incentive for water use efficiency. Farmers think at present that if they cut their water use by 20 percent then their allocation will be cut by this amount. If water use efficiency is such a government priority, they need to start giving funding and incentives. At present there is no water. Where there is water, my aim is to grow as much cotton as possible to take advantage of the price without being unrealistic or too risky."

How growers, consultants, suppliers and others access information

Table 1 summarises the wide range of people and resources that growers accessed to gain information that was required to make a recent change to some aspect of their water management. Consultants, suppliers and extension workers generated highly similar lists of such people and resources.

Table 1 People and resources accessed by growers (in no order of preference)

People	Resources
Irrigation consultants	Trial data
Crop consultants	Field days
Researchers	Cotton Tales
Extension staff	Experience
Irrigation equipment suppliers	Legislation
Resellers	Case studies
Bankers	Benchmarking information
Other farmers	Magazines (The Land, Cotton Grower Magazine)
Family	Media
Farm workers	Soil characteristics/soil monitoring
Grower groups	COTTONpaks
Water suppliers	World Wide Web
Regulators	Decision support systems
Irrigation officers	Weather bureau
Chemical representatives	Cotton conference
Spray contractors	Formal courses (e.g. Irrigation Association of Australia)
Water suppliers	Knowledge resource directory
	BMP manual

A number of other general observations can be made about this list of people, resources and information nominated by growers, consultants and others:

1. They like a mix of contact.
2. They are especially very positive about contact that is one-on-one.
3. A lot of information was seen to be too general and not tested for the climate, soil type and water quality of specific regions. Again, growers and consultants emphasised the value of greater grower/consultant/extension staff partnerships to conduct farm trials to deal with local concerns. Growers wanted to see more research being funded for their own region. They wanted region-specific trials rather than the research being done on an experimental farm in a region with quite different conditions.

4. Growers are clearly combining various sets of information over periods of 1 to 2 years to make their decisions. One farmer explained his decision-making as follows:

"My decision-making usually takes about a season or two. I let the idea take shape in my mind, and before discussing it with anyone. I look for evidence from local and international research, using magazines, CDs and the internet. I then discuss this idea with my consultant and agronomist to get their feedback. I might also pick up feedback at growers' meetings, but not always."

Another talked about his decisions as follows:

"Our decision-making about planting takes time and preparation. Everything is prepared throughout winter to ensure we could plant everything if water becomes available. Country that came out of fallow was planted solid, and country that had a crop was planted double skip to hedge bets and make the decisions a bit safer. In the end there was no water from the river and we had to rely on bores. This reliance on bore water ultimately limited what we could do."

5. Local papers or cotton-specific media (eg *Cotton Grower* magazine) were seen to be a more significant source of useful information than the larger media (eg *The Land*, newspaper articles). The media and magazines were especially useful to consultants.
6. Many farmers felt that there had been too many courses and too many meetings to transmit information.
7. Growers would come together around tangible reasons (eg field trials, demonstration of a new technology).
8. Many consultants, growers, consultants and extension officers believed that there is a real shortage of experienced irrigation consultants, particularly consultants who can merge the agronomic and engineering aspects of water management.
9. Growers judged resellers as being less useful sources of information than consultants.
10. Consultants were by far the major "people" source of information for growers, and consultants also believed that this was the case.
11. Resources like *Cotton Tales*, *COTTONpaks* and magazines needed to shift their focus more towards water management rather than pest management.
12. While benchmarking was identified as a valued resource, growers felt that appropriate benchmarking was a highly complex and

difficult task that needed to be managed for them by researchers and public providers. Consultants valued benchmarking as an activity more than did growers.

13. Growers called for short, concise information like in the form of dot-points that was relevant to what they needed at the time and that provided links to other information. Growers indicated that links to other information, including websites, could help growers to access and digest the relevant and trustworthy information from all that is available.

In other "mapping exercises" used in the interviews, growers, consultants, extension staff and others talked through the use of these people and resources in more detail. A categorisation of people and resources as "very important", "somewhat important" and "less important" emerged. Based on the various mapping and rating exercises, and group discussion sessions in the data gathering workshop, Table 2 presents a summary of the people and resources that were perceived by growers to be more important in shaping decisions about water management.

Table 2 *Growers' perceptions of key people and resources that influence decisions about water management*

Resource	Most Important	Somewhat Important	Less Important
People	Own experience Researchers Irrigation consultants Other growers Crop consultants Other consultants	Farm staff Bankers Water suppliers Other farmers Family Grower groups Extension staff	Resellers Chemical representatives Spray contractors
Resources	Trial data Field days Cotton Tales Grower experience Case Studies	Benchmarking Legislation Magazines COTTONpaks Soil characteristics Soil monitoring Weather bureau Decision support systems	Media World Wide Web Formal courses Cotton conference Knowledge research directory BMP manual

As Table 2 shows, growers felt that consultants (irrigation, crop, other) were the dominant source of information. Many other growers shared this grower's point-of-view:

"My consultant is a major sounding board. He suggests that I go to field days to see what can be done, and helps me think through the changes. I have irrigation scheduling tools like C-probes to help my day-to-day decisions along with regular visits from my consultant. The consultant works closely with me in planning our crops."

A consultant reported his relationship with his group of growers as follows:

"I have direct day-to-day contact. Because of the water restrictions with growers, we do a review at the start of the season, look at crop types, look at 'what ifs', and I work closely with growers during the season advising on water."

Growers reported that their consultants tended to have long-term relationships with individual growers built upon a deep understanding of the grower's experience, risk profile, soil and water conditions, as well as high levels of trust based on many years of contact and in making good decisions with those farmers. Consultants were a key resource in terms of bringing into the decision-making framework for growers the experiences of other growers in similar regions and conditions with the same issues. At the same time, growers also emphasised how they worked independently, accessing research findings either directly from researchers by email/telephone/reading reports, or through getting the assistance of other consultants and extension officers.

The ratings (see Table 2) again showed the perceived value of trials, field days and case studies as attractive and practical sources of information that shaped grower's water management decisions. Grower experience was a core resource. Field days were a great opportunity for growers to share their experiences, and to hear and most importantly to see what else was possible. There was a clear preference for short (2 hours to half a day), informal field days that focussed on a 1-2 issues in detail and gave an opportunity to look at other growers systems and the application of research. One grower explained the impact of his experiences from a field day as follows:

"Here is an example of how a field day changed my mind. After going to a field day and hearing an irrigation consultant, and seeing results, I made some changes almost straight away. I split a field in half, and compared one siphon and two siphons. The whole farm went to two siphons. An improvement of about a bale to half bale has meant I've stayed with the new system."

As also shown in Table 2, of all of the cotton extension publications available, *Cotton Tales* emerged as possibly the best-known and most respected source of information.

Many farmers mentioned the value of grower groups (see Table 2).

"I see great benefit in getting grower groups together to discuss irrigation methods. We have done this in the past and it has been quite effective. You get a good response from growers because they are the ones who are most interested."

Another reported:

"We are currently doing benchmarking as part of a grower group. It is working quite well. So far 87 paddocks have been benchmarked. Grower groups with more field days, trials and benchmarking linked into them, are a good way to go in getting and applying new information."

There was a lot of comment by growers about the value of the Cotton Conference held every two years, but at the same time some concern about the style of the most recent conference, and its immediate value for growers. A grower explained his concerns:

"The cotton conference has been a great source of information. However, I feel that the conference is drifting from research findings, and a different sort of conference strictly focused on research would be useful."

We also completed the same mapping of major source of influence on decisions with consultants.

Table 3 presents their judgements, which overall:

- were very similar to growers' perceptions, especially concerning the role of one's own experience, field days, trials, and other consultants
- consultants reported a much narrower set of people and resources than did growers
- they highlighted more the value of Cotton Grower magazine, formal seminars, formal courses, attendance at special workshops (e.g. Jim Purcell), publications from research groups, research stations and centres, accessing ideas from their consultants' networks and companies
- mentioned less the role of resources like COTTON Paks, *Cotton Tales*, farm workers, family, and bankers.

- irrigation resellers tended to be quite different in how they sourced information. Generally they tended to be less likely to access the industry specific information sources such as *CottonTales*, COTTONpaks or the Cotton Conference.

In talking to the providers of irrigation equipment, they believed that as cotton has traditionally used surface irrigation, the equipment providers have had less impact upon the decision-making of growers. Irrigation equipment suppliers are not installing the hardware (e.g. centre pivots, spray irrigation) that they do in other industries, and so are not building the close personal relationships and opportunities for knowledge sharing that they have with growers in other industries.

Table 3 *Consultants' perceptions of key people and resources that influence decisions about water management*

Resource	Most Important	Somewhat Important	Less Important
People	Own experience Irrigation consultants Consultants in own business Researchers Growers	Grower groups Extension staff	Resellers Chemical representatives Spray contractors
Resources	Trial data Field days Seminars Publications by research groups Benchmarking Formal courses Grower experience Soil monitoring CottonGrower magazine	Legislation Decision support systems BMP manual In-house company training Weather bureau Case studies One-to-one extension Knowledge research directory	Media World Wide Web Cotton conference Cotton Tales COTTONpaks

Drivers and barriers to change

The water reform process is playing a major role in shaping the context within which growers are making their decisions. Almost all growers said that they had to be realistic, and prepared for some form of cutback. The uncertainty at present surrounds how much will this reduction be in water availability, and if there will be any compensation linked to the cutbacks.

Even in regions where no cutbacks have been announced, growers were uncertain about making any changes to their water management practices, as they feared that any savings in water would be a guide to the future level of cutback that they may incur. Growers were keen to save water, but until their production capacity had some sort of security, they will not spend the money on introducing further water management strategies or technologies.

Growers reported that the driving forces for introducing positive changes that would improve their water efficiency were:

- evidence of the benefits of a new practice, technology or strategy based on the findings or facts from in-house and outside trials and experimentation on their farm or other farms
- cutbacks in water availability
- the drive to continue to gain the best financial return for a farm, and now that pest management was under control, the focus was upon maximising returns through reducing the costs per mega litre of water
- the long-term sustainability of the farm and the soil
- the support, advice and experience of their consultant agronomist
- the need to save labour costs associated with irrigation
- the introduction of neutron probes.

In our interviews, growers mentioned more drivers for change than barriers to change in their water management decisions. The most frequently listed barriers were:

- not having enough practical evidence that the specific change will improve water use efficiency enough to improve the acreage grown
- the capital cost of introducing new technologies such as a change to an overhead or trickle irrigation system. In talking through the outcomes of some trial-and-error learning, a grower concluded:

"If my on-farm trial or another in my area is successful, I will possibly put in a field and then see what the results are. Cash flow finally determines if we implement this on a farm scale."

- being concerned about "change for change sake" or "following the herd", when really what was currently being done on the farm made the most sense given the soil, climate and water availability. A grower commenting on change for change sake responded:

"If it is not going to give me an extra quarter of a bale or more per hectare, I won't bother. You need to show me the evidence that changes will make a real difference."

- unknowns about the best choice of irrigation methods and engineering given the soil type.

Grain irrigators

Cotton growers were making irrigation decisions not only about cotton but also about other crops (e.g. chick pea, wheat, lucerne, sunflowers, sorghum), beef cattle and some horticulture (e.g. olives, oranges). The choice of crop was clearly made on the basis of the best returns per mega litre of applied water. In the cotton growing regions, there were few irrigators who did not include cotton as a part of their farming system. Therefore, our interviews focussed on irrigation knowledge in general, not specifically to cotton or non-cotton crops.

We interviewed four growers who did not grow cotton, but irrigated other crops (i.e. wheat, barley, mungbeans, sorghum) to determine if they had special issues that were different from the issues raised by growers of cotton and grains. In addition, we spoke to a consultant working primarily with wheat crops. Growers reported that the drought had made them intensify production on irrigated country. Water availability has not impacted dramatically upon their farming practices, but with proposed water reforms and the experience of the drought, both were looking at alternatives that will use less water in the future. These strategies included reducing or cutting out summer irrigation, only irrigating winter crops, putting in more bores, looking into alternative irrigation systems to sprays, with related changes in farm equipment to deal with stubble and minimum till. Mentioned more often by grain-only growers as a determining factor for any changes in water management was the markets for the various crops at different times of the year.

While the sample of grain only irrigators is small, at least for this sample there were very strong similarities in the key issues in water management (e.g. costs and continued availability of water), the range of people and resources that influenced decisions about water (e.g. own knowledge, field days, other growers, local agronomists), the barriers to change (e.g. financial costs), and the time frame for key decisions was also over a few seasons. This is consistent with the other growers who indicated that the issues in water management were similar across their whole cotton and grain farming system.

Notable differences were that the grain only farmers could not afford a regular consultant; they seemed to have increased reliance upon the knowledge of family, farm staff and water regulators about water and suitable crops; overall information that was available was described as "a little hit and miss in terms of quality and availability"; growers were just moving into soil monitoring instruments; somewhat less understanding than cotton growers of what is available to assist them in terms of available information and resources; less frequency of field days than it seems for cotton crops; and evidence of somewhat less urgency and concern about the quantity of information that they need as their experience with their crops was so extensive, and the crops were less troubled by pests than cotton. In terms of improvements to getting access to information, growers wanted more access to publications and short (i.e. 2-3 hours only) field days.

A consultant who advised growers on their peanut crops commented that the grower transferred the knowledge gained from the cotton industry about irrigation to the management of his peanut crops.

Role of public and private sector service providers

First it is important to note that in discussing the public-private relationship, many growers explained that a "sea change" was quietly occurring. A third player had now joined the public and private providers in generating and sharing information and knowledge. This third player was the grower.

A grower commented:

"I see that extension staff in particular are now looking to the grower for answers. Through the innovations and ideas we are trying, growers know more about these issues than many researchers and extension people. We are now becoming much better in collecting information as well as data for our own farms, and extension can make good use of this."

In addition, as a consultant explained it:

"As consultants, we find that growers are getting more sophisticated with water scheduling, C-probes and continuous recording of soil moisture. Consultants need to keep pace with growers who will lead the way now as they get their own data rather than us. Our task is now to problem-solve and brainstorm with them on the alternatives they might consider to maximise dollar returns per hectare."

Another sea change is that on the larger farms there is a clear trend towards building an internal capability in water management among those on the

farm. They are focusing upon building their skills and knowledge internally by employing two to three agronomists at each farm, and funding their professional development through the cotton production course, and consultants' seminars. Some large farms are holding in-house seminars to promote and to grow this knowledge about crop and irrigation management internally among their own staff. These farms are contributing to the greater knowledge base through commercial scale trials and economic analysis of changes.

The vast majority of growers and consultants believed that the public providers' role was about identifying growers' needs, and getting research completed and then communicated back to them to address those needs. The private consultant played the key "hands-on" role in working with the grower to decide and implement the crop and water management strategies for the season.

Overall, growers, consultants and extension officers considered that the current model of roles and duties was working well. A consultant put it like this:

"I see the public/industry extension role to be about getting data out and communicating this out to all of us. The private role is to get these messages out to the growers through one-on-one contact. The challenge is that we need to be more confident about the usefulness of the outcomes from research to be convinced that we can use it."

Growers identified field days as an excellent forum that could showcase the cooperation between public and private providers. The more successful field days already had shown the value to farmers of the two groups working together to plan the purpose, location, timing and speakers for the field days.

Another opportunity for cooperation was in the organisation of benchmarking. Working together, it was felt that public and private providers could drive more opportunities for benchmarking that combined public funds and private sponsorship, with grower groups being central to these benchmarking partnerships. As one consultant commented:

"We need to work together by doing field trials on farms, like case studies and benchmarking. By working together, consultants have all of the information, and can exchange with extension staff to write it up and put it out there."

Another consultant remarked:

"An enthusiastic extension officer is a very important bridge in this industry".

Regional (and linked to this, historical) factors seem to have influenced the levels of public-private provider partnering in some regions. Generally, there is considerably more change in the extension staff in a valley than changes to the consulting staff. If an extension officer has developed good working relationships with local consultants, relationships generally have continued despite regular changes in extension staff. However, the increased movement and turnover of extension staff in more recent times was making it difficult for co-operative relationships to be maintained, according to many consultants.

Possibly as a result of this increased movement of extension staff, a few consultants were critical of industry extension. Although a minority in holding these views, it is important to report their concerns. One of the more vocal among them complained:

"Overall, the extension system in the cotton industry in my view is almost non-existent in my region. IPM methods have clearly been adopted more in Queensland than NSW, so therefore the system is not working. Private consulting is now the paramount source of information for growers. Extension officers are not around long enough for you to build good working relationships."

New and emerging issues were seen to benefit from extension work in developing local understanding, undertaking trials and benchmarking, and communication of findings to raise awareness on an issue. Once "the ball gets rolling" then it was considered that consultants would provide the services and day-to-day support needed for growers to manage it. Depending on the issue, this may take a year or two of extension input to develop the understanding and the capacity in the local industry. The focus of extension tended to be more about the bigger issues facing the industry. As one extension officer put it:

"Extension tends to work on the issue until it gets its own legs and then we move on to another issue. We tend to focus upon the bigger picture rather than the nitty gritty that consultants work with. Once an issue gets its own steam than we are able to cut back and move onto other issues, and other information as it becomes available"

Finally, both growers and consultants saw the public provider as a potential source for funds that will bring financial benefits to the industry. A grower reported:

"I see the Government's role being about offering incentives for improved irrigation efficiencies".

Role of the irrigation industry

A number of consultants and irrigations suppliers talked about the gradual growth of an irrigation industry that will in time be available to better serve the needs for information and knowledge of irrigated cotton and grain growers. They emphasised, as did many others we interviewed, that more expertise was needed in understanding how to reduce losses due to inefficient water management practices. People with more expertise in the engineering and equipment side of irrigation had a greater role to play in identifying and working through ways to more efficiently manage the system. This role included using engineering knowledge to improve existing systems, the better engineering design of new systems, the impact of practices like increased flow rates, methods to reduce evaporation, efforts to reduce seepage, improved ring tank storage, furrow design and other developments.

Those interviewed, however, were concerned that universities were only now beginning to consider programs that will produce the numbers and types of irrigation engineers that are currently required by the irrigated cotton, grain and other industries. On a more positive note, recent developments in vocational education and training now mean that Certificate and Diploma qualifications are available in irrigation, as well as a training package and the recognition of prior learning, that will promote more traineeships and apprenticeships in irrigation. The graduates will be able to bring their new expertise to the industry either as irrigation suppliers or as irrigation managers on farms.

Research, development and extension needs of growers and consultants

In our interviews, growers identified the following issues for future research and extension:

- irrigating hard-setting soils
- water scheduling
- application efficiencies
- waterlogging and siphon times
- deep drainage losses
- siphon sizes and flow rates in compacted areas
- the costs of putting in trickle and drip systems, including installation, pump, filters, flexibility of the systems
- more research into salinity
- management of tail water – many growers are waiting for more information about this to emerge from the Water Use Efficiency Initiative project, and feel this dissemination has been very slow
- loss of water through open channels (calculations of amounts and management strategies)
- research into water storage, under and above ground.

Consultants provided the following list of issues, which was similar in many areas:

- water scheduling
- results from trials using the SIRMOD system
- cost effective drip irrigation and how to make it work financially for crops like cotton
- production and efficiency figures for different irrigation systems
- results on rotations of cotton with other crops
- what crops to move to after cotton if water prices keep going up
- return on investment research
- better information and understanding about deep drainage
- salinity management
- more reports that integrate and adopt a more holistic approach, showing the inter-relationship between crop, water and management
- loss of water in channel losses, dam losses, and application efficiency
- irrigation choices and soil types
- shallow watering in furrow systems
- waterlogging and siphon times
- more case studies on change from furrow systems to pressurised systems

- the trend towards linear moves
- overhead irrigation for broad acre cropping.

Consultants gave examples of gaps that they felt existed in research that needed to be undertaken (e.g. irrigation under different conditions, soil types, drainage rates; water holding capacity, effects of compaction, irrigation internal stretches). A number of consultants also commented upon what they felt were delays in distributing the findings from the research (e.g. findings from RWUE initiative).

Many of these issues targeted for future research or as issues are highly interrelated, and growers and consultants did describe such issues as being influenced by each other. For instance, a consultant explained his needs as follows:

“As a consultant, there is a range of matters that I and others need to know more about. It is all inter-related. I’d like to see more research into Bollgard®II needs for irrigation. I need to better understand how to make head ditches more efficient, along similar lines to research done on storages. More field days are required on how to measure water. A lot of people will be surprised at how much water they are using. Research into soil types and implications for irrigation is needed. Different irrigation systems and different soil types is a big issue for my work. The pros and cons of different moisture monitoring equipment is another topic. And more irrigation training for consultants as they move more into water as part of their services.”

Education and training in water management

There was interest in practical, advanced level training in how to measure irrigation system efficiencies and how to manage these. Accreditation was not considered necessary for training, unless this was to become a government requirement for irrigators in the future. Across all the groups we interviewed, there was a strong emphasis on the need for courses to be practical, short, going deeply into an issue (rather than covering a lot of issues more generally), being linked into a farm trial or actual piece of research that could be seen, and in which there was a good mix of different types of people and interests (e.g. growers, consultants, extension, re-sellers, researchers). The list of issues raised earlier is clearly a guide to what such courses might be about.

Irrigation equipment suppliers

Four interviews were also completed with irrigation equipment suppliers. As a part of their sales service, they advise growers on irrigation design work and equipment supply. Advice on irrigation management is seen as part of their service to growers. They recognised the challenge of keeping up with technological changes, and the need for continued staff training. The top water management issues were similar to those identified by growers and consultants: availability of water; efficiency of water use; quality of water; salinity management more specifically; and the best crops for the type and availability of water.

Asked about the major influences upon the decisions that growers make about water management, suppliers mentioned the same individuals and resources, as did other groups. However, possibly as to be expected, water suppliers, re-sellers, equipment suppliers were placed in the "inner circle" of agents that most influence growers, while these three groups were not seen by growers or consultants to be as centrally important.

Suppliers believed that they could easily access information about water management from many sources. In particular, they had networks of suppliers through to advisers that could provide them with the information they required. At the same time, there did not seem to be the same depth of understanding about the people and resources actually available to provide information about water management that we found among growers and consultants, in particular.

These suppliers wanted to see more irrigation research and extension on the availability of water; getting better efficiency (i.e. channel losses, dam losses, application efficiency); waterlogging; efficiency of energy versus application efficiencies especially for smaller growers; the inter-relationships between water, crops and management; lower cost drip systems suitable for cotton; and the returns on investment of highest yielding crops given water availability, cost and quality.

Agency and funding bodies' perspectives

Major water management issues. A number of interviews were also completed with agencies and funding bodies to report their views about water management, as well as where public sector irrigation extension is heading. On the topic of the major water management issues, these groups had highly similar perceptions to other groups that were interviewed. To them the major issues were the continued access to water; including

volumes and when growers will be able to use it; whole-of-farm water use efficiency; water use scheduling; and soil management to maximise use of fallow.

Current and future roles of extension and consulting. Their views about the extension role supported those expressed earlier. Extension is focused upon “public good” and providing a whole-of-industry benefit. Examples given were the greater attention that extension, when compared with consultants, is giving to sustainability, water use efficiency on a catchment basis, and the recognition by extension of the social science issues and community interests that are integral to an understanding of the longer-term future of the irrigated cotton and grain industry.

In particular, government extension provided independent advice typically based upon access to solid research. As one person put it:

“There is a need for growers to have access to people independent of commercial interests, and who are able to adapt information for the regional areas. Extension also filters research so that consultants are accessing the best available research evidence”.

It was felt that extension has played a major role in “kicking-off” water management efficiency as a major issue among growers, and that consultants followed once they realised that improved water efficiency had been recognised by growers as the next big issue to manage more successfully to gain further improvements in production. Water management has now moved from being seen as “extension business” to being perceived as “the farmer’s business”.

In looking at the future of extension and water management, agency and research respondents talked about “almost going the full circle”. Once extension provided most of the technical skilling. Next, consultants took on this role as extension moved more into information and research dissemination, using adult education principles and skills to get the right information to the right people. In the future, it is felt that effective extension will be a mix of sound technical skills and knowledge, together with facilitation and adult learning skills. Their focus is not on the day-to-day of farm management but on capacity building. As one senior officer summarised:

“The current and future role is about capacity building. We deal with people and need to show demonstrated people and communication skills. But also we need to gain client respect by having technical understanding, not about the finer arts of irrigation design but by promoting the benefits of adopting

the more holistic picture about sustainable production systems that will be essential now and in the future”.

The consultants' role is seen to be focused “upon things”, the “private good” and the technical side of farming, and less so about “people, community, and systems”. Extension and consultants currently were seen to strongly complement each other in the roles they played. These complementary roles were seen to be at their best in trials, field days and related hands-on activities that brought together practice and research.

It is predicted that the consultant's role will be increasingly specialised. To a lesser extent, this was also predicted for extension with water specialists being developed for some regions. Specialisation that offered growth in technical knowledge was seen to offer young extension officers improved career opportunities that may keep them in extension longer and make them less likely to move to private sector interests. Specialisation was being driven by the need for more in-depth understanding and improved practices in irrigation system design, detailed design issues, how to best re-work existing systems, and in getting the efficiency right within the production system.

Factors that influence growers' water management attitudes. A number of key issues emerged here. First, many growers “did not know what they did not know” until their current practices were challenged by the right combination of new information and new practices. Egos can be big in this industry. Many growers believed that they had little to learn, as they had concluded that they had already highly efficient irrigation systems. As one person put it:

“The big challenge was that many growers already believed that they were efficient”.

However, recent advances in the science of water measurement (e.g. with better measurement of losses through seepage, ring tank storage, evaporation in channels, applications to fields) had surprised many growers in terms of how much improvement was still possible in their systems. Managing crops with the limited water available during the recent drought has also clearly challenged perceptions about irrigation management and waterlogging as some crops, managed with limited water, yielded very well.

These respondents from government and research agencies also argued that many growers today feel “embattled by water system reform on the one side, opponents of clearing of natural vegetation on the other, and the victims of changes in commodity prices”. There is strong pressure to change

attitudes and water management practices, and “the smart ones or the top 5 percent are moving quite quickly”. Or as a number of respondents put it:

“A bales-per-megalitre thinking has replaced a bales-per-hectare thinking on farms”.

Another observation among these government agency and research respondents was that the vast majority of growers cannot afford to re-invent their farms. But growers are very willing to use new information and knowledge to continue to improve the returns on capital for each mega litre of water. As one researcher summarised the situation:

“Growers require a number of seasons, and a variety of sources of information and “the pain in the wallet from the previous season” to alter their water management practices”.

A major barrier to change was seen to be a general nervousness among growers as they tried to get an “understanding of what they are changing to, and what it means to them”. To do this, they need time and access to information that they learn to value and trust as it proves to make a difference. Extension was seen to play a very valuable role in supporting growers through this process. The other major barrier was available capital, and returns gained in investing capital into improved water management efficiencies as against other strategies to improve farm production.

It was felt among these government and research respondents that a variety of sources of information were needed to assist growers in their decision-making about water efficiency. Key themes were making messages consistent; available through multiple channels of communication; “gently challenging”; and not making information too hard to access (e.g. avoid complex web searches, having “one-stop” sets of information). The vast majority of those connected with government agencies and research supported the continued use of a variety of information channels. Many believed, however, that growers were “more comfortable” with field days, grower groups meetings, and concise readily useful information like that often presented in *Cotton Tales*. There was very strong praise for the outcomes of the plant production research by the Cotton CRC, but some felt that the Cotton CRC was deficient in providing insightful outcomes regarding water use efficiency strategies.

Government agency staff and researchers were very positive about the impact of initiatives like the Queensland Rural Water Use Efficiency Initiative. It had a lot of local input; challenged existing grower practices; used local extension; and had clear targets to achieve so highlighting its very

practical focus. They welcomed news that additional funding will occur to re-commence the Queensland program. In contrast, respondents from both Queensland and NSW were somewhat more critical of the Waterwise initiative in changing grower practices. Growers had perceived the level of the materials to be below their existing levels of knowledge, covering what they already knew. Once this message was spread around among farmers, the success of the program was limited.

Overall, government and research respondents were critical of the "initiatives funding" approach that was being adopted rather than a focus upon recurrent funding. Initiatives funding paid less attention on how to maintain longer-term support for a water management issue once the funding had ceased. It was believed that Queensland Rural Water Use Efficiency Initiative was very successful, but by the time it had picked up a good level of momentum that may have led to even better outcomes, the funding had ceased. The program did not get private sector buy-in soon enough, which reduced the chances that private consultants would run with the initiatives once funding ceased.

CASE STUDIES

Two case studies were undertaken to illustrate the way in which a large cotton grower and a consulting and re-seller company access and promote information and develop knowledge about water management issues. In preparing both cases, interviews were completed with managers, agronomists and consultants based in both organisations. These case studies have been considered in the overall analysis of findings. They are detailed in Appendix D.



Irrigators Jim Moore (ACGRA), Greg Morris (ACGRA), Chris Joseph (GRDC) and Ben Stephens (ACGRA) work on recommendations at the integration workshop.

FUTURE RESEARCH

Based upon our discussions with growers, consultants, re-sellers and other groups, the following issues emerge as potential areas for future research.

1. A survey of a representative group of stakeholders to determine water management issues and attitudes.

In terms of the current topic of knowledge management, using the findings of this research it is now possible to design survey questionnaires that can be better focused upon the key water management issues facing the key stakeholder groups. A survey using a structured questionnaire can be designed that can more accurately quantify perceptions and levels of agreement/knowledge/importance of several issues, and across different stakeholder types and different regions. A survey of current levels of knowledge and key topics of interest in irrigation and water management also provides a baseline from which to measure and statistically test changes in attitudes over time as extension and related activities continue to raise levels of information and knowledge.

2. More in-depth investigation of selected issues.

Previous sections in this report have identified many water management issues that could be investigated in more depth. A short list of such topics could form the basis of topics to be investigated further through in-depth interviews, focus groups and through the use of other qualitative methods. For instance, such topics might include the use of interviews to gain a deeper understanding of grower's and/or consultants' attitudes about future directions in the industry in terms of water management; recent experiences with innovative attempts to better use water; and how various groups would see themselves responding to a variety of scenarios that describe different changes to the industry, and the availability and cost of water.

3. Case studies of successful innovations in water management

Along similar lines, a series of case studies could be prepared that profile successful innovators in terms of new water management practices. These case studies could be built through the completion of interviews with a variety of people associated with the planning, design and implementations of the innovative water management practice, including growers, consultants of various types, farm workers, extension officers and others who played a role.

4. Action research into the identification of, and solution to, various water management issues

A case study tends to be retrospective in that in reports on what happened, rather than being involved in the actual decision-making in real time that was applied to resolving an issue. More action-oriented research methods also bring together diverse mixes of people to identify and to solve a real problem, usually over a 2-3 month period, with members of the action learning team each playing various roles in researching and investigating the water management issue. There is both individual learning but also team-based learning as the group applies solutions, evaluates their outcomes, engages in reflective enquiry and then introduces other solutions to resolving the issue. The action learning teams should be a mix of grower, consultant and extension participants. Topics that might benefit from the application of action-learning principles and action-learning teams include:

- Having a group identify, plan and implement a field trial or field day, documenting all aspects of the process and outcomes, including the learning, and the communication of findings to other parties;
- Using a team-based approach to identify a set of shared problems facing group members concerning water management, and then planning and implementing a set of solutions to the higher priority problems;
- Using the action learning team to develop a more holistic view of crop and water management.

PERSPECTIVES FROM OTHER INDUSTRIES

The project steering committee requested that some understanding be developed of irrigation knowledge pathways in other industries. For this purpose, people in other industries (e.g. grains, sugar, horticulture) were invited to be participants in the three-day workshop in Moree, and also conducted some of the interviews with cotton growers, consultants and others. In addition, we contacted and invited members of other industries to be involved in interviews, meetings and focus groups. Appendix E provides as summary of the key findings to emerge from a series of meetings and focus groups with members of the sugar and horticultural extension groups. The appendix summarises their perceptions about knowledge and knowledge development, attitudes to change in the industry, innovation and public-private partnerships in extension.

SPECIFIC REQUESTS AND IDEAS

A number of recommendations are provided in this report. In addition, certain issues were also raised more in the style of requests or ideas that needed some attention:

1. provide growers in the Moree region with access to an extension officer with irrigation and water management experience
2. update growers, consultants and others on the outcomes to date from the Rural Water Use Efficiency initiative
3. audit the current systems being used to get extension information out to consultants to improve efficiency and effectiveness of these dissemination channels
4. get a better understanding of what are the causes of some animosity between consultants and public providers in some regions, and work with both groups to identify practical solutions to build more cooperative relationships
5. promote the content and timetable for dissemination of the proposed Water Pak
6. provide more information and explanation about the proposed Rural Water Use Efficiency 2
7. provide wider dissemination of information about opportunities now available for irrigation workers on farms to do traineeships and apprenticeships
8. due to the very frequent mention by growers and consultants of his work, identify an appropriate forum to profile the ideas of Jim Purcell
9. investigate the evidence (for and against) the Mungindi region being perceived by some as a "forgotten valley" in terms of irrigation field days
10. develop an inventory of companies willing to give talks about irrigation methods and management and circulate this inventory to extension offices and consultants.
11. establish grower review boards to discuss with researchers the practical application of research.
12. enhance the linkages between the water/engineering aspects and the agronomic and soils components of irrigation management.

INTERIM RECOMMENDATIONS

Knowledge management is about the provision of the right information to the right people at the right time and so creating a climate for continuous improvement. Also it is about creating the conditions that allow knowledge to flow freely between people. Given this understanding of knowledge management, we put forward for consideration the following recommendations:

1. Ensure that information about water management is available through a variety of avenues. Develop and support a package of a range of information and learning mechanisms to suit the differing needs and interests of stakeholders. This package would include field days, newsletters, information resources, website, trials, computerised decision support models, training courses, for example.
2. Continue to promote as a major strategy the one-to-one interaction and personal contact between irrigators, consultants, suppliers and extension workers. Irrigators want practical, matter-of-fact information gained through personal contact. They learn by doing and seeing. The best face-to-face methods to promote access to new information and to promote knowledge sharing are field days, trials and grower groups. Access to the experiences of other irrigators and consultants are especially valued as a part of both of these initiatives.
3. Irrigators want more information relevant to their particular set of farming conditions (i.e. soil type, location, climate). They want more crop trials, field trials and growers groups in their own districts, and write-ups of local case studies providing practical, accessible information relevant to their particular conditions. Therefore, more effort needs to be taken in research being trialed across different types of districts, and the outcomes of these trials being promoted through field days and short, practical publications like *Cotton Tales*. These need to draw together the water delivery and agronomic aspects of water management.
4. Provide detailed, practical training in irrigation measurement and management for consultants. Private consultants need to be better educated about irrigation management. While expert in pest management, many consultants believe that they lack the required levels of irrigation management knowledge to best assist growers. Identified experts (e.g. expert private consultants in whole-of-farm

water efficiency management, successful irrigation farmers from various states and regions) need to be brought into all regions to train private consultants, extension officers and others in the numerous aspects of more effective water and irrigation management.

5. The public sector role and expertise needs to continue to be centred upon providing, in highly accessible formats, the findings of relevant research supplemented with practical examples of the local application of this research. Extension staff are perceived by irrigators, consultants and others as facilitators or “knowledge-brokers” who provide information that demonstrates best practice and technical support. They need to continue to promote this role, including greater efforts to promote information to private consultants who are the key individuals influencing irrigators’ decisions about water management.
6. Research needs to be targeted to meet growers’ needs. It is proposed that a grower review board be established in major regions to identify key areas for research, and secondly, to discuss with researchers at regular forums the practicalities of actually implementing the findings from their research. This body would assure that research that is required for specific regions is undertaken. Also this body needs to work with extension so that research findings are communicated in ways that maximise the likelihood of uptake by growers and consultants in particular. This role may be a local adaptation of the ACGRA function.
7. Given their central role as a key source of information gathering and knowledge generation and sharing, consultants need to be better targeted in extension activities. A cooperative approach to information transfer is the best option, and one that is very possible given the existing positive relations between consultants and extension in most valleys.
8. Continue to send out short, concise, practical information to growers through *Cotton Tales* in particular. Include links to more detailed, useful information. Where possible, *Cotton Tales* should be modified by local extension officers to promote information of the most relevance to their particular region and those growers’ needs. Similar formats would be useful for grain irrigators, although more work is needed in understanding their needs.

9. More work is needed into identifying potential vehicles for cross-industry cooperation in the area of sharing information and knowledge about water management, including forums devoted to innovative water management strategies, and greater incorporation of lessons from other industries into *Cotton Tales* and information packs given to growers.
10. There needs to be the development of more "one-stop" integrative information tools, such as for example, CD's that combine all of the information from different sources on water management (WATERpak is currently under development); a searchable database of all trials (including trial books); field days that only focus on one or two issues in-depth; and a catalogue of "who is doing what" in research.
11. Continue and increase the offerings of the courses such as the Cotton CRC's/UNE's Cotton Production course and the GRDC's/UNE's Sustainable Grain Productions course, and ensure a sufficient focus upon irrigation management.
12. Regularly prepare and place articles about more effective water management for specific regions in *Cotton Tales*, the *Cotton Grower & Graingrower* magazines and *Country Life/The Land* and promote these to growers and consultants as a resource for irrigation information.
13. Identify or appoint extension staff willing and able to develop greater technical and general expertise in water and irrigation management to be available to all key stakeholder groups, and most specifically, growers and consultants.
14. Investigate the potential and scope for an Irrigation Technology Resource Centre, and determine whether this Centre could service all irrigation sectors nationally.
15. It is recommended that a series of specific research projects be commissioned to investigate further various key aspects of irrigation management that are identified in this report. These projects respond to the information and knowledge needs of key stakeholder groups. The specific topics are detailed in various sections of this report. In addition, future research might benefit from the use of other research methods to investigate knowledge management and related issues. Again, such methods are identified in the body of this report.

INTEGRATION AND ACTION PLANNING

A workshop of key stakeholders (cotton and grain growers, consultants; irrigation suppliers; extension staff, and Research and Development agencies) was held in Moree on 18 March 2004 with the aim of integrating and progressing the research findings to develop a model for knowledge services in cotton and grain irrigation. Participants were actively engaged in reviewing the information from the interviews and progressing the recommendations of the draft report.

Stakeholder perspectives

Representatives of each of the stakeholders set the scene by commenting on the key irrigation knowledge issues from their perspectives.

Grower Representatives (Cotton & Grain) considered:

- Irrigation management research should be disseminated through consultants.
- Research information needs to be drawn together in a concise way.
- The emphasis is on increased returns per mega litre of water.
- Cotton Tales was a good disseminator of information.
- Irrigators are moving to the next stage in irrigation management, and need to maximise returns per mega litre.
- The need to work together across commodities.

Research, Development and Extension Agencies considered that:

- Knowledge management will be critical to the future of the irrigation industry and the CRC Irrigation Futures.
- CRC IF now have a focus upon delivering information to investors.
- Water availability and use is critical to the cotton industry.
- The cotton industry's environmental audit has identified high priority for water issues.
- There were seen to be strong parallels between the stage that knowledge systems for water management issues are at now, and those that existed for IPM some 5 or 6 years ago. The industry's recognition of the need for better research and extension in IPM at that time led to significant development in the knowledge system.
- A need for on the ground extension to move towards water issues.
- The demand by consultants for more irrigation knowledge is prompting the Cotton CRC towards more cooperation with GRDC and CRC IF.

- The Cotton BMP "Land and Water" module would help focus the industry on water issues.
- The cotton industry was seen to be a leader in investment in consultants, and in the levels of public and private sector cooperation.
- Key questions raised by NPSI were:
 - How will industry engage with governments on long term and short term issues?
 - How do we get GRDC to invest in irrigation RD&E given that there is \$350 million of irrigated grain production each year?
 - How do you grow the private sector consulting service as existing consultants get older and leave the industry?
 - What are the mechanisms that support larger organisations sharing their knowledge?

Consultants noted:

- The need for better integration between agronomy and irrigation engineering.
- A need for improved measurement of water use efficiency.
- That we do not know how efficient growers currently are or how good are their systems.
- Consultants are thirsty for knowledge, and continue to respond to growers' needs for them to be expert in irrigation matters, and to be available as sounding boards.

Discussion of the research findings

In response an overview of the key findings of the study, the following questions and observations were made:

- A need to understand 'dripping' away change and transformational change.
- Cotton farmers are seriously looking at alternative systems.
- RWUEI1 achieved change largely through incremental changes, major changes are now needed for significant improvement in WUE.
- Change starts slowly and then picks up momentum.
- Change may be about best using the existing system – first, encourage growers to best utilise what they have got.
- Need to understand what is the real impact of water reforms on change. Real reason for change is a better return on investment. Need to get better measurement happening.
- Must be driven by returns on investment. Some of the WUE information is supposition – need a concrete way to measure returns on investment.

- How much is the process driven by behavioural change (due to water reform) vs. attitudinal change (value of water to broader community).
- Change comes about by adversity.
- We may need a different model for incremental change vs. rapid change in our industry.

Progressing the recommendations

To discuss the major recommendations of the study, workshop participants were grouped based upon their industry sector (e.g. consultants, growers, extension). Each group was asked to select three of the recommendations that they felt were of highest priority and for each of these to discuss their ideas for progressing these recommendations in terms of:

- Practically, how would you see this working or not?
- What and who would help this to happen?
- What are the barriers and risks that need to be overcome?

It was interesting to note that each of the sector groups prioritised different sets of recommendations, as detailed in table 4.

Table 4 *Recommendations selected as priorities by each group (marked by ✓ or highest priority by ✓✓).*

Recommendation	Group						
	Growers 1	Growers 2	Consultants	R&D 1	R&D 2	Extension 1	Extension 2
1. Package of a range of mechanisms						✓	
2. One-to-one interaction and personal contact	✓	✓	✓				
3. Local information	✓		✓			✓✓	✓
4. Detailed, practical training for consultants	✓		✓	✓	✓✓		✓
5. Complementary public and private sectors				✓			
6. Grower review board in regions							
7. Better target consultants in extension activities							
8. Short, concise, practical information		✓✓					
9. Cross-industry co-operation				✓			
10. One-stop integrative tools							
11. Course such as Cotton Production Course		✓					
12. Media articles							
13. Extension staff with technical skills in water	✓						✓
14. Irrigation "Technology Resource Centre"	✓						✓
15. Research into specific aspects of irrigation					✓	✓	✓

Whilst the groups were quite diverse in the priorities that they selected, further exploration identifies many similarities between their detailed suggestions for implementation of the recommendations. The overriding consideration was for a package of information and learning mechanisms that included:

- One-to-one interaction and personal contact;
- Training;
- Information;
- Partnering public and private sector irrigation services; and
- Research.

A package of information and learning mechanisms

The overall feeling of the workshop was that any knowledge system for irrigation would require multiple approaches. This concept was reinforced by the diversity of preferences between the groups (Table 4). The *extension group* felt that such an approach would work "because it has worked in other issues". They felt there was a need for industry wide coordination, focussing on raising awareness of the issues and the information that is currently available about irrigation management. *Research leaders* were interested in engaging manufacturers and resellers to develop appropriate tools. They also queried where resellers might fit into this irrigation and extension model.

Growers saw an opportunity to source funds from catchment authorities for irrigation extension work.

One-to-one interaction and personal contact

Comment was made separately that it would be impossible to fund an intensive, one-to-one extension program. It is interesting to note that the growers and consultants who selected this option considered that this interaction would be between growers, other growers and consultants (not one-on-one extension).

Growers felt that this could be achieved by "growers showing growers and sharing information" and "consultants showing consultants to pass on what individual best growers are doing" and "consultants to disseminate information to other consultants". This they felt could be driven by growers and consultants. Field days and area wide groups were another mechanism. They saw a role for IDOs and irrigation officers in supporting growers to innovate. Growers saw a need for individual industry specialists to teach local consultants and growers. Alternatively, a "one-stop shop" for

dissemination of information. One group felt that this contact is already happening through the Queensland RWUE program.

Growers identified barriers and risks to these mechanisms for one-on-one interaction to include:

- Some growers hadn't felt "enough pain" or could see the return on investment;
- Needs to be an industry wide approach with information sharing across regions;
- Growers being bombarded with non-specific information, not knowing what will really impact on their own farm -> localised knowledge is needed.
- Duplication.
- Cost.

Consultants emphasised the need for one-on-one contact, and networking by consultants was very important. They suggested that the recommendation for one-on-one contact highlights the need for consultants, as providers of this advice. They felt that "Consultants could be facilitators of irrigation knowledge", possibly through the CCA. They felt that all stakeholders needed to be involved, channelling through the consultants. "Empower the consultants with information, contact points, irrigation specialists and resellers."

Consultants wanted better linkages with engineers, consultants and farmers; more research with 2 or 3 growers in each valley; and to develop better networks of consultants with irrigation people. It was felt that researchers found it time consuming to deliver one-on-one. Consultants were also interested in participating in study tours to develop further their understanding.

They emphasised that growers needed to push this. Consultants commented that this would only work if agronomy were linked to irrigation and an understanding of water/plant and soil relationships. Networks were important, as consultants can't be experts in everything. Specifically, they felt it important to improve linkages between irrigation engineers, consultants, soil scientists, growers and extension staff.

Overall the consultants felt that they were a key to bringing the experts to the grower as researchers can't operate one-on-one. Risks identified by the consultants included the potential for different people to give conflicting advice; a lack of networks; aging consultants; and strain on the researchers

through repetition on extension (to consultants, specialists, extension agents). They required more knowledge on soil types

Research agencies were keen to see a business model developed that encourages high quality, professional irrigation measurement and management services. Their goal was for multi-skilled consultants who would work alongside some highly specialised irrigation experts. They also felt that a need existed for a few irrigation engineering specialists in the extension network (focussing on cotton and grains).

Training

Supporting the previous comments about the need for skilled consultants was a strong demand for training courses and other opportunities to build skills in irrigation management, particularly for consultants. As well as training for consultants, it was thought that growers would also benefit from training in irrigation, and that many growers already had more knowledge about irrigation than did their consultants. There was call for training to be considerate of the water reform process.

It was suggested that a short course or a university course be set-up to meet this need. The extension group suggested a modular course so that people could select the relevant components. Several suggested that existing expertise be used to deliver the training:

"Gain the information and resource requirements from those few people currently out there who are doing some innovative work in this area."

Specifically, people were keen to see training that looked at water scheduling for different irrigation systems and measurement of water.

Growers felt that the timing was right to train consultants to provide irrigation services to the industry as many consultants were looking to expand the focus of their businesses (due in part by a concern about the viability of their consulting services once Bollgard®II becomes widely established).

Growers also noted the utility of a short course for growers modelled on the IPM short course. Potential barriers included funding, and that "not all growers have had enough pain to be motivated to do the course".

Research leaders suggested a certification model be developed to accredit consultants' irrigation skills.

A range of existing courses, learning materials, accreditation systems and opportunities were identified, including:

- NSW DPI Waterwise course – short course 4 day
- IAA learning guides - through TAFE people can gain Certificate II, III, IV and V.
- Encouraging undergraduate and postgraduate involvement and education in irrigation.
- Private sector training
- Short courses linked with formal courses.
- Universities to facilitate courses
- A course at AOF level 4 for irrigation

Key players making this training course happen were seen to include: Cotton Consultants Australia, Consultants, CRDC, CRC Irrigation Futures, Cotton CRC, IAA, Cotton Australia, NSW DPI, Universities, TAFE and the Cotton Extension Network. There was suggestion that the training be based from the Cotton CRC's Technology Resource Centre.

Research leaders believed that cotton growers were fairly open to information on how they are performing in water management efficiency. However, they were concerned that many growers focused on short-term issues rather than long-term skilling-up.

Information

The workshop discussions further highlighted the dominant role that experience plays in irrigator's knowledge. Information delivery was very strongly linked with people - such as extension, consultants and other growers.

Growers clearly reinforced their concern about too much information being 'bombarded' on growers – highlighting a need for clear, local summaries of information and local, practical examples. They supported the faxing out of newsletters on research projects and outcomes, but felt that many reports were too long and some researchers were writing too much.

Locally relevant and tested information

This was a theme that came through strongly from the grower, consultant and extension groups at the workshop. The push for local information links strongly with the need to see, experience and trust the ideas and practices. There was seen to be a need to build the expertise and collaboration across all industry sectors in undertaking local trials. Key elements included:

- Collaborative trials and responsibilities.
- New methods for labour intensive trial processes.
- Documentation of on-farm case studies.
- Growers showing growers and consultants showing consultants.
- Industry specialists who can train local growers and consultants.

There was discussion of the need for rigour in the design of on-farm trials and possible mechanisms to achieve this. Some suggested to utilise resources within the local state agencies and also to look at other models such as the Birchip Cropping Group. The *extension* sector felt that extension staff working with the existing model of grower groups could increase the gathering and sharing of local information by:

- Increasing the emphasis on collaborative responsibility;
- Having more staff on the ground in regional areas;
- More collaboration and facilitation of trials in partnership with industry;
- More efficient use of staff;
- More relevant expertise and infrastructure; and
- More resources and more appropriate resource targeting.

Consultants suggested that research be done or extended to a selection of 2 or 3 growers, consultants and resellers in each valley with field days held to reach others.

Information Delivery

Preferred information delivery mechanisms included field days, faxes (eg Cotton Tales) and discussion. The overriding themes for all of these were to be short and relevant with clear take home messages.

Growers commented that 'farmers don't have the time to read a lot of information'. They wanted IDOs together with WUE officer, industry and consultants to provide clear, concise fax information that are easy to read, highlight research projects and outcomes and meet needs. References to further information would help those who needed to follow up details and field days would help to 'wet the appetite'. They wanted this coordinated by the 'industry hierarchy'.

Irrigation Knowledge Centre

Many of the discussions pointed to a need for coordination and ease of access to irrigation information, such as could be achieved through a technology resource centre style model, similar to the Cotton CRC TRC. Generally the name 'irrigation technology resource centre' was disliked and so it is referred to here as an 'irrigation knowledge centre'.

Growers were concerned that a national focus for an irrigation knowledge centre would lack the local focus that they required. They were not interested in anything that would become generalised. They would like to see growers showing grower in locally adapted areas – with a one-stop place for knowledge to help answer questions. Included in the information available they'd like industry information that indicates what other growers are doing (eg case studies).

Extension and R&D groups were keen to develop an irrigation knowledge centre that:

- Could be a virtual centre, not a physical structure;
- Included decision support systems;
- Acted as a knowledge bank with books, case studies training packages, contacts, a database of research and trials completed and in progress, and a repository for all information;
- Was not associated with a specific commodity and provided a focus for linking irrigation industries;
- Acted as a centre of knowledge with people attached to it for advice and resources.

They suggested that this could be delivered through a collaboration of the CRC Irrigation Futures with the Cotton CRCs TRC. They suggested utilising existing industry structures and seeking cross-industry funding and cooperation. In identifying potential barriers in vested industry cooperation, ensuring knowledge is used and access to funds and resources, they suggested to start on small scale such as extensive irrigated field crops and then later to expand to the Northern Murray-Darling Basin.

Partnering Public and Private Sector Irrigation Services

A consensus of the workshop was that "extension" is now a service provided by both the public and the private sectors. There was a clear focus on partnering the public and private roles to effectively deliver the range of services desired by growers. This is clearly reflected in the demand for training consultants and one-on-one services as described already.

To help to develop a public and private sector irrigation knowledge partnership, research leaders considered it necessary to:

- 1) Ensure that governments are aware of the important role of public sector expertise; and
- 2) Develop strategic agreements between industry and government as to who supplies what services.

Research leaders spoke of the complimentary nature of the public and private sector. They considered there to be a need for a small group of experts in this area who need to come from engineering and a practical background as well as more practical training for consultants. They referred to the value of a business model to provide irrigation consultancy business, and more work with Cotton Consultants Australia (CCA), CRCIF, IAA and to be engaged in Cotton Australia policy as well.

Extension groups felt that more input was needed from local consultants and suppliers in irrigation management. They felt that the industry needed better partnerships between growers, consultants and suppliers.

Public Sector Irrigation Extension

Whilst consultants have long been a part of the cotton knowledge chain, interviews identified a need to better target consultants in extension programs. This may be aided by more clearly defining the public and private sector roles an extension partnership. One grower described the role of the public sector extension programs as being to:

"Work on an issue until it gets its own legs. Once the ball is rolling everything will fall into place and the IDOs can then move onto the next issue and work with that."

During the workshop, one grower group and both extension groups considered the appointment of irrigation extension staff as a key strategy and also considered enablers and barriers to this as detailed in Table 5.

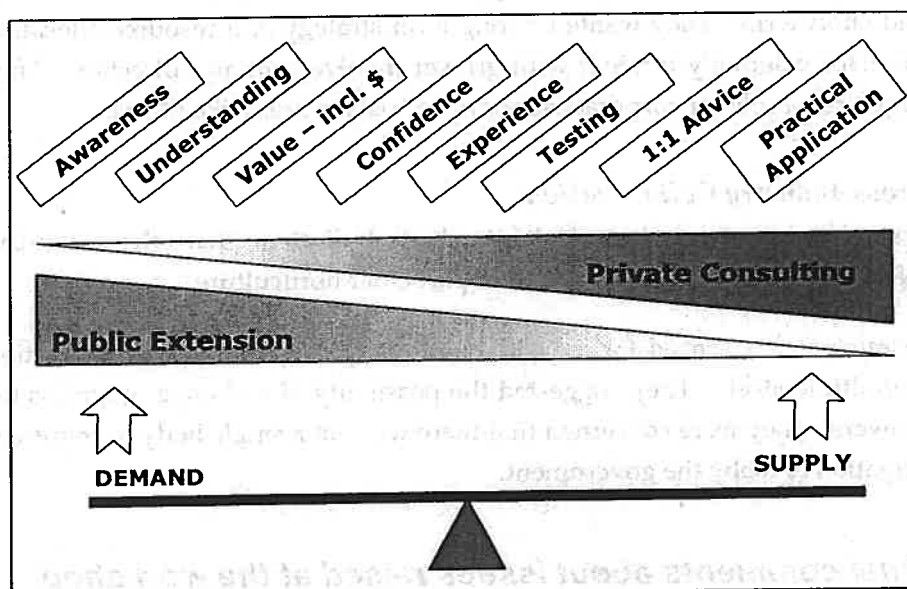
Table 5 *Key considerations in appointing public sector irrigation extension staff identified by growers and extension groups at the integration workshop.*

	Grower perspectives	Extension perspectives
Enablers	<p>Good communication Driven person (enthusiastic/positive) Funding from RDCs, CMAs, Government (based on politics of water reform for all agricultural industries) Need a key researcher, team/issue leader as a one-stop-shop for consultants and IDOs. Must be credible, respected personalities.</p>	<p>More staff needed on the ground. It will work if you can get the staff. Recognition of requirements for irrigation staff. Avenues for developing appropriate staff resources. Is happening now. Long term positions to attract & maintain quality staff. Training – extension staff skilled enough in water to be able to work with farmers. People who are willing and able. Incentives Appoint specialised irrigation extension staff.</p>
Barriers to overcome	<p>Funding Currently there is enough extension but it needs to be better focussed.</p>	<p>Sourcing staff – where? Staff retention Overcoming the perception that irrigation extension is too difficult (daunting for existing extension staff) Career advancement and incentive Recognition of the importance of water work. Dependant on funding and political will. Short term contracts for extension staff – nowhere to go in career. Lack of expertise in existing staff.</p>

Developing the public and private partnership

Further discussion of the public and private sector partnership by the project steering committee identified the need to build for irrigation knowledge service both supply (skilled irrigation consultants) and demand (growers identifying the value in improving their water management sufficiently that they are willing to engage an irrigation consultant). In this way the extension program focuses on raising growers' awareness and perceived value of improving irrigation management practices whilst also building the capacity of the consulting sector to provide detailed management advice. A model of this is depicted in Figure 1.

Figure 1: Partnering public and private knowledge services for irrigation management in the cotton industry.



Research

Both industry experience and scientific research were referred to as means of developing new knowledge about irrigation management. Again there was concern about the difficulties in attracting and retaining key staff to do research in regional areas. One suggestion was for grower groups, rather than agencies, to employ private consultants to conduct trials as has occurred elsewhere in Australia.

Research leaders called for the setting of short- and long-term priorities and targets and queried whether there was a need to set a target water use efficiency. They identified a need for specific research projects to be commissioned to look at irrigation and extension. These research leaders envisaged irrigation research to include crop trials, grower groups, local reporting of trials and case studies of practice. They suggested this would be through the Cotton CRC linking with the CRC Irrigation Futures, NPSI, Universities, state departments and CRDC. They felt that consultants need to be more involved in research than they are at present.

Growers commented that irrigation research trials had been done well in Queensland but were lacking in NSW. They wanted trials that would be easy to implement and for information to be gathered and disseminated to the industry.

Extension suggested that research played a role in filling knowledge gaps as well as in building growers' and consultants' confidence in research. They thought it important to identify appropriate research questions – both long and short term. They wanted a long term strategy and resource allocation (perhaps externally funded) with grower involvement and direction. They suggested a role for corporate support for trials in areas like Moree.

Cross-Industry Collaboration

Several growers and consultants had indicated that they sourced information from other industries, in particular horticulture.

Researchers saw a need for more cross industry cooperation and interaction at multiple levels. They suggested the possibility of exchange programs for growers. They were concerned that there was not a single body to represent irrigation to lobby the government.

Final comments about issues raised at the workshop.

It is important to comment upon two significant issues that emerged during the workshop:

- Incremental *vs* transformational change; and
- Possible changes in level of innovation in the industry over time.

Incremental and Transformational Change

There is a belief that the cotton and irrigated grains industry has dealt with the need to respond to change to its environments mostly through incremental change. This is not unusual, in that most industries respond to the economic, environmental and social drivers for change slowly and preferably by fine-tuning what they do rather than by a transformational radical form of change. Workshop participants recognised this, but now given the belief that water will never again be as plentiful and cheap as it once was, the industry may need to respond to future pressures for change in a much more dramatic fashion.

This transformational change will possibly require a major re-thinking of how the industry has approached water use efficiency. South Australia was raised as an example of this new mind set about water and its use. This State has already set a high standard for its irrigation users with the need for irrigators to not only measure accurately what amounts of water they use, but also it has set a target of 85% water use efficiency. It was felt by some workshop participants that the irrigated cotton and grain industry might be among the next targets for governments increasingly aware of the politics of

water, and the negative attitudes of many communities to the water use habits and practices of cotton growers.

Innovation in the Industry

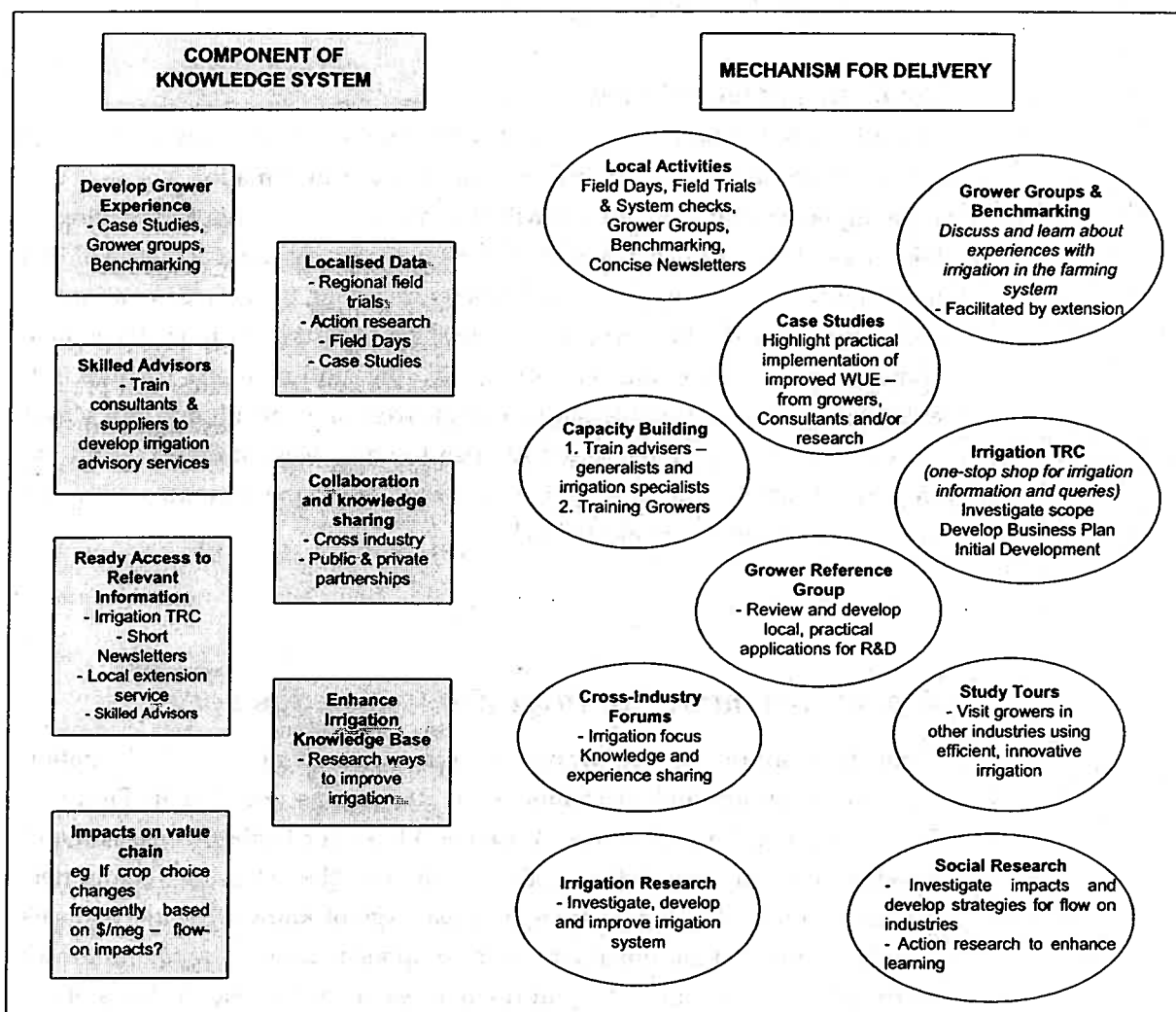
The other observation is a view that, while the cotton industry currently is perceived to be innovative and willing to share information, there was a growing belief that over time it will become less innovative and willing to take risks. Participants believed that there was already some evidence of this in the lower levels of perceived risk tolerance among the new generations of cotton growers. The key issue will be how the industry continues to create a climate for innovation and knowledge sharing, and as many pointed out, extension through its partnerships with growers and consultants will play a critical role in keeping the industry open to new ideas, innovation and the sharing of ideas and new practices either from the practices of more innovative growers or from research.

A potential model for irrigation knowledge services

From this study can be drawn several components of an irrigation knowledge system and mechanisms for delivery as depicted in Figure 2. This hypothetical model has been used as a basis for further discussion and development of research in this area by the steering committee. Collaboration to develop an integrated package of knowledge mechanisms is a key theme that has emerged. Each component adds value to and draws on the other – for example the information resources become the basis of the training program which in turn feeds back with more case examples and learnings.

When looking at it, it appears to be a relatively simple, logical concept to integrate these components. However, it is not unusual for extension programs to be delivered as separate components without the level of integration that would appear to achieve greater efficiency as well as greater simplicity for end users.

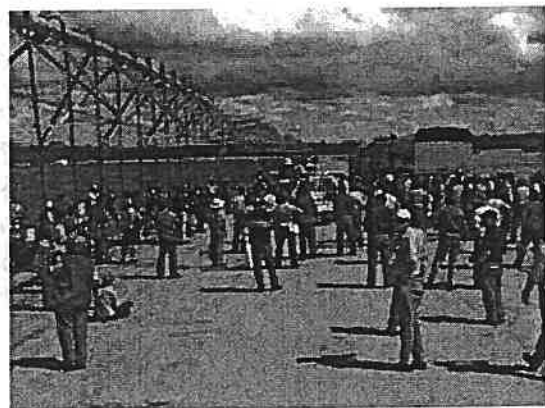
Figure 2: Suggested components and mechanisms in an irrigation knowledge system.



CONCLUSIONS

Knowledge and learning in the cotton industry is diverse and best achieved through a package of mechanisms. The questions relating to irrigation are not unique to cotton and, as many growers readily change between crops, the knowledge systems for irrigation would do well to focus on the irrigation industry. As the demand for irrigation knowledge is escalating, now is a critical time to develop the knowledge system for irrigation.

This study has provided the basis for moving forward with an integrated, collaborative model for irrigation knowledge services in cotton growing regions. The challenge now is to achieve the commitment and funding of all key stakeholders to progress with such an initiative.



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APPENDICES

The following appendices to this report are available at www.cotton.crc.org.au

APPENDIX A Research Methods

APPENDIX B Questionnaires

APPENDIX C Lists Of Persons Consulted

APPENDIX D Case Studies

APPENDIX E Perspectives From Other Industries On Knowledge Management

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