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Context evaluation: a profile of irrigator climate knowledge, needs and practices in the northern Murray–Darling Basin to aid development of climate-based decision support tools and information and dissemination of research

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Abstract. Understanding client needs, knowledge and practices offers a means of ensuring research outputs match intended audience requirements. This paper shows the initial impact of context evaluation on the development of a suite of decision support tools and information to help irrigators better manage their water resources under different climatic conditions. The context evaluation study involved a survey of ~170 irrigators in the northern Murray–Darling Basin in Australia. It sought to clarify how they make cropping area and water management decisions and their levels of understanding and use of climate information. We found irrigators consult widely on cropping decisions and those with large areas commonly apply the Southern Oscillation Index to property decisions. Respondents demonstrated a reasonably good understanding of climate phenomena in an Southern Oscillation Index knowledge test. Two-thirds use seasonal climate outlook information, but only 20% are very confident to apply climate information to decisions. More than half would find a decision support system (comprising tools and information) useful for cropping decisions. Almost 75% would change their crop area, and 43% their crop type, if given advance information about water availability up to 4 months ahead of irrigation season. About 70% have access to a computer and half to the internet, but two-thirds consider their personal computing skill is only nil or basic. Twenty-three percent of respondents expressed interest in working directly with the research team to interact regarding their requirements, indicating the potential for future participative research activities such as collaborative, on-farm research. The context evaluation facilitated formation of a focus group that cooperated to assess research findings and incorporate improvements to the project's set of decision support tools. The evaluation was a new experience for the researchers and, albeit an arms-length consultation process, it has broadened our knowledge about our target audience and their preferred ways to access research findings.

Additional keywords: continuous improvement, cotton growers, ENSO, formative evaluation, streamflow forecasts.

Introduction

Evaluation of Australian agricultural programs

Published evidence of formal evaluation of agricultural research, development and extension programs in Australia is limited. A review of Australian agricultural extension by Dart *et al*. (1998) revealed little evidence of systematic, formal monitoring of programs and projects (Woods *et al*. 1993). Scriven (1975) says evaluation design must sometimes consider issues beyond validity and credibility, such as certification and accountability. Luukkonen-Gronow (1987) suggests evaluations of research fields can demand a new kind of social accountability and responsibility that might not be forthcoming from scientific communities.

Social responsibility and accountability for applied scientists might relate to issues such as: (i) ensuring the intended audience can correctly interpret the message and language; (ii) scientists being available and accessible to aid interpretation and provide input to development of training courses, tools and information; and (iii) scientists developing skills in client consultation and client service, to further enhance their ability to effectively target and disseminate their research findings. Scientists would also have the opportunity to personally interact with users of research, to keep abreast of their information needs and any difficulties being experienced.

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Decision support systems and technology uptake in agriculture

There is little published evidence that agricultural decision makers actually use decision support systems (DSS). Lynch and Gregor (2001) found a considerable quantity of literature indicating farmer adoption of DSS is limited (Cox 1996; Foale *et al*. 1997; Glyde and Vanclay 1996; Greer *et al*. 1994; Hamilton *et al*. 1990; Hilhorst and Manders 1995). A study of 400, mainly dryland, wheat farmers in northern New South Wales found technology uptake low. Respondents generally rejected or had not yet adopted climate forecasts, decision support programs and regular soil tests (Hayman and Alston 1999). What are the reasons for low uptake amongst agricultural producers? What is a successful information system and what is a failure? Can evaluation of a target audience's information needs, knowledge, practices, preferences and skill levels lead to development of better DSS tools, information and uptake that suits end-users?

Over recent years people have studied the reasons for the disappointing uptake of decision support systems and identified several key design problems. Issues range from a limited understanding of user needs, to design of information which may only suit a small proportion of the target audience. Information needs of agricultural audiences are likely to be diverse and factors impacting on uptake, many. For example, farm size, location, enterprise type, social or demographic group, existing communication and advisory networks, education and training, attitude to risk and attitude to innovation may all influence the uptake and perceived usefulness of DSS tools and information. When a DSS takes the form of a computer package, producers may not have access to a computer or have only limited computing skills, interest or time to learn how to use it.

Farmer groups have criticised sustainable land management research and extension projects, because they treat all farmers as one homogenous group and recommend 'one size fits all' solutions for addressing environmental issues (Industry Commission 1998). What might be the consequences if only a few large, influential landholders are consulted and a range of users are left in isolation to operate technical DSS tools and to interpret information with little or no contact with researchers who can answer questions or aid interpretation? Evaluation for DSS tool and information development should aim to canvass all strata of a target audience using methods such as surveys, focus groups, personal interviews, teleconferences, workshops, meetings and field days. These help to gain a broader social snapshot of their usefulness and relevance, or how they can be improved.

Some major hindrances to the use of forecasts in decision-making are cited as being difficulty interpreting the forecasts and limited access to expertise (Changnon *et al*. 1995). A study of 30 Central Queensland farmers, on grain sorghum management practices, found farmers have varying levels of education and concluded information needs to match audience expectations and be presented in many different ways (Daniels and Chamala 1989). Users determine whether models or programs are successful; information about who they are, what they are involved in or what they require does not remain constant, it may change over time (Loucks 1995). Regular interaction with users can help ensure information is timely. The perceived value of information may depend on the season being experienced or water allocation announcements. For example, end-users may assign a higher value to information when the season being experienced, or expected, is poor compared to when there is good stored soil moisture pre-sowing and the season is, or is expected to be, good (Keogh 2001). Announcement of low water allocation entitlements could also influence perceived value of DSS information. Low adoption rates for agricultural knowledge-based systems strongly suggest there is a need to place greater emphasis on user-related issues (Hochman 1995). More research is needed on the best way to involve users in the development of agricultural knowledge-based systems (Hochman *et al*. 1994).

Do users understand the technical language researchers use?

If intended end-users of research do not understand the technical terms used in climate or streamflow forecasts, useful information may be misunderstood or discounted. It is important to explore language, social and technical vocabularies, motivators, personal goals, information needs and preferred learning or communication styles of your intended audience; and ensure they understand yours. Climate-based forecasts often use technical terms, such as probability and results of statistical tests, but how well do intended audiences understand these? It is 'what people know' that is important, not how quickly practices are adopted; there are 'multiple ways of knowing' and DSS information should be tailored to user requirements and match audience knowledge (Daniels and Chamala 1989: p. 29; Kloppenburg in Lobry de Bruyn 2001: p. 188). Levels of understanding are likely to vary by enterprise type, locality, farm size or demographic group.

Evaluation offers many approaches to explore issues that may lead to improvements in information design and dissemination. Results can create new experiences, and promote and encourage new beliefs (Rallis 1980).

Irrigator context evaluation study

Survey region

The Murray–Darling Basin (MDB) contains more than 70% of Australia's total irrigated area (Crabb 1997). The MDB produces more than $8 billion annually and contributes around 40% of the nation's gross value of agricultural production (Crabb 1997). Water resources in many of its catchments are fully committed and reform is underway. This reform includes public participation and consultation, pricing and institutional reform, clarification of property rights, water allocation for the environment and adoption of water trading arrangements (Council of Australian Governments 1994). Irrigation development in the northern MDB is influenced by erratic streamflow and a highly variable climate. Competing demands for water increase the uncertainty over decisions on cropping area and environmental flow. In this background, decision support systems might have the potential to aid irrigators' water and climate-related decisions, but the relevance and understanding of DSS must be subject to evaluation.

Water resource project

A Department of Natural Resources, Mines and Energy, Queensland project was funded by the Murray–Darling Basin Commission, to develop a decision framework integrating hydrologic and agronomic models with climate indices such as the SOI. Their pilot study surveyed cotton growers in the Border Rivers catchments and provided information on probable streamflow and water availability several months ahead of the irrigation season, to aid cropping and water management decisions. An essential component of the project involved communication and dissemination of research. The context evaluation described in this paper was designed for this project.

Goals of the evaluation

In an attempt to develop effective decision support tools and information for the core project 'Decision Support Systems for improving water use efficiency in the northern Murray–Darling Basin', this study was conducted in 4 MDB catchments, to gain a better understanding of irrigators' practices, climate knowledge and information needs. To address these issues, the following 3 null hypotheses were tested: (i) irrigators do not consult others when making cropping area decisions; (ii) irrigators do not have sufficient knowledge of climate phenomena to use in planning; and (iii) irrigators do not consider water availability forecasts useful in decision-making.

Our design sought to: (i) highlight opportunities for researchers; (ii) improve product utility, project planning and decision-making; and (iii) devise suitable dissemination channels and extension strategies to maximise effective knowledge transfer.

Methods

Research findings from the project have application for other MDB catchments, so the decision was taken to survey areas in and around the pilot study area in the Queensland–New South Wales Border Rivers catchment, targeting 4 MDB catchments: Border Rivers; Gwydir; Namoi; and Upper Condamine (Fig. 1). Considering our study objectives, we adopted a context evaluation approach (Madaus *et al*. 1983), using a structured questionnaire to test our null hypotheses.

Context evaluation

Context evaluation can be a useful tool for researchers and developers of DSS tools, because it provides an opportunity to explore target audience knowledge, levels of understanding and use of technology; technical skills, practices; decision processes and information critical to decision making. Madaus *et al*. believe that the

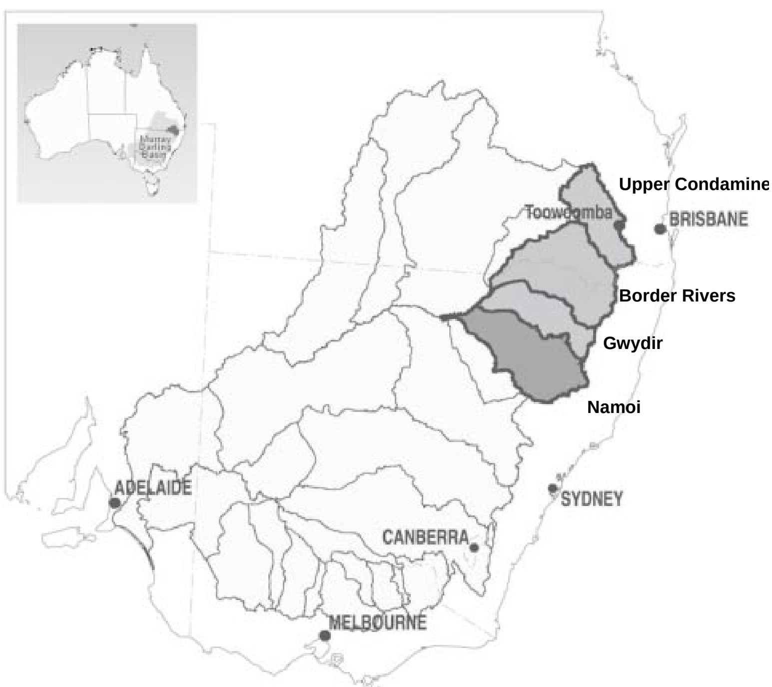

Figure 1. Context evaluation of regulated irrigators in the location of the studies in 4 Murray–Darling Basin catchments, Australia.

Table 1. Questionnaire topics

Part	Questionnaire topics:
A	General farm characteristics
B	Irrigator knowledge of the climate system
C	Optional section which tested irrigator's knowledge of the relationships between El Niño Southern Oscillation and rainfall/streamflow
D	Explored how irrigators make cropping and water decisions: important decision variables; who they consult; information sources; and use of computer technology
E	Specifically for irrigated cotton growers
F	Canvassed irrigators' interest in participating in a focus group working with the project team; and receiving a copy of survey results

context evaluation approach of the CIPP (context, input, process and product evaluation) model can provide a definition of institutional context and can identify and assess target audience needs and how these might be addressed. It identifies weaknesses, strengths and directions for improvement and also provides a basis to adjust goals, judge outcomes with results useful for planning changes needed (Madaus *et al*. 1983).

Our study was a formative evaluation (evaluation during the life of the project). It was used to emphasise learning and improvement and to gather contextual information that may help identify factors that contributed to successful or low uptake of the research (Patton 1999). Evaluating a project upon completion only enables outcomes to be assessed (Turban 1995). Formative evaluation offers an opportunity to identify ways to improve a program or project, while it is in progress. Evaluation findings can be treated as working hypotheses, to help develop a learning culture within an organisation (Posavac 1997).

Questionnaire used in the study

An anonymous, mail questionnaire was designed by the evaluation team, which comprised members of the research team, an evaluation specialist and a senior administrative officer. The questionnaire contained 128 questions, presented in 6 sections. Each survey question specifically addressed 1 or more of the key evaluation hypotheses, which were linked to the project objectives. An overview of the questionnaire topics is shown in Table 1.

Members of the evaluation team pre-tested the survey by visiting 22 farmers across the region. To maximise response rate, the final survey was mailed to all 931 irrigators involved in agricultural production from regulated water supplies in the Border Rivers, Gwydir, Namoi, and Upper Condamine catchments of the MDB in August 1999. The response rate was 18.7%; there were 174 valid responses with 74 from cotton growers and 100 from non-cotton growers (Table 2). This was considered reasonable when compared to a 20% response rate to a similar survey by Hayman and Alston (1999), who also invited responses from their entire population. Forty-one irrigators registered their interest in working in a focus group, to provide advice to the research team on irrigators' requirements. Also, 108 irrigators requested that a copy of survey results be sent to them.

Results and discussion

The study revealed a profile of the knowledge, skills, practices and information needs of a major target audience: whom irrigators consult; rates of technology adoption; levels of use and understanding of seasonal climate outlook information; factors important in deciding cropping area; and general irrigation practices. It also highlighted demand and preferred formats for decision support tools and the potential of the research to influence area and crop type decisions (Keogh *et al*. 2000*a*, 2000*b*).

Respondent irrigated cropping area

Seventy-four cotton growers and 100 non-cotton growers responded to the survey. Collectively, respondents manage ~43% of the total area of the 4 catchments that is developed for irrigated cropping using regulated water supply. The total area developed for irrigated cropping was 83 399 ha and cotton growers manage 75% of this area. The mean farm irrigation area is 1017 ha for cotton growers and 85 ha for non-cotton irrigators.

Table 3 shows the number of survey responses, based on total area developed for irrigated cropping categories. The percentage of irrigated area in each catchment under different crops in 1999 is shown in Table 4. Cotton dominated in each catchment.

Preferred advisers consulted by irrigators when deciding cropping area

We found irrigators consult widely when making cropping decisions, with members of their family, business unit and private consultants featuring prominently. When deciding area to plant, 61 irrigators (mainly cotton growers)

Table 2. Total sample and response rate

Item	Border Rivers	Gwydir	Namoi	Upper Condamine	Total
Regulated licences	372	224	541	117	1254
Non-irrigation licences[A]	13	37	66	0	116
Irrigation licences[B]	359	187	475	117	1138
Effective in-scope sample[C]	314	150	360	107	931
Completed questionnaires	45	27	69	33	174
Response rate (%)	14	18	19	31	18.7

[A]Non-irrigation licences: not used for irrigated crops.
[B]Irrigation licences: used for irrigated crops.
[C]Effective in-scope sample: any individual or corporate farm that may possess one or more licenses.

Table 3. Numbers of licensee responses in different irrigator categories

Irrigator categories based on total area developed for irrigated cropping in the region

Irrigator category	Border Rivers	Gwydir	Namoi	Upper Condamine	Region
Small irrigators (<100 ha)	21	7	30	13	71
Medium irrigators (100–600 ha)	16	6	27	18	67
Large irrigators (>600 ha)	8	12	9	2	31
All irrigators	45	25+2[A]	66+3[A]	33	169+5

[A]We received 174 responses; 5 licensees did not specify their developed area.

consult a private consultant (Fig. 2). This suggests private consultants are a likely target audience for the project's DSS and extension of forecast information.

Usual timing of irrigating cotton in the 4 catchments

Cotton growers were asked questions about approximate timing of critical decisions, such as planting dates, irrigation windows (usual start and finish dates) and the average quantity of irrigation water (ML) they need to grow a good crop in dry, average, and wet years. Their responses provided clues about likely optimal timings to distribute forecasts in different catchments and the value of information in different seasons.

Profile of technology adoption

Figure 3 presents a profile of irrigator technology adoption and Figure 4 shows uptake tended to increase with farm irrigation area. It was found that as farm irrigation area increases, there was significantly (P<0.001) higher use of the SOI in property decision-making.

The study found two-thirds of irrigators have access to a computer with CD ROM and half have access to the internet. Most (85%) cotton growers had access to a computer, as did just over half of the non-cotton growers. Almost half the irrigators (around two-thirds of cotton growers and almost one-third of non-cotton growers) use computer packages to aid farm or water management decisions, as shown in

Table 4. Percentage of irrigated area in each catchment under different crop types in 1999

Crop type	Border Rivers	Gwydir	Namoi	Upper Condamine	Region
Cotton (%)	77	93	73	60	81
Cereals (%)	10	2	14	12	8
Soybeans (%)	2	1	4	7	2
Other crops (%)[A]	11	4	9	21	9
Total area (ha)	13695	28609	16145	6828	65277

[A]Other crops include sorghum, lucerne, pasture, legumes, peanuts, vegetables, fruit.

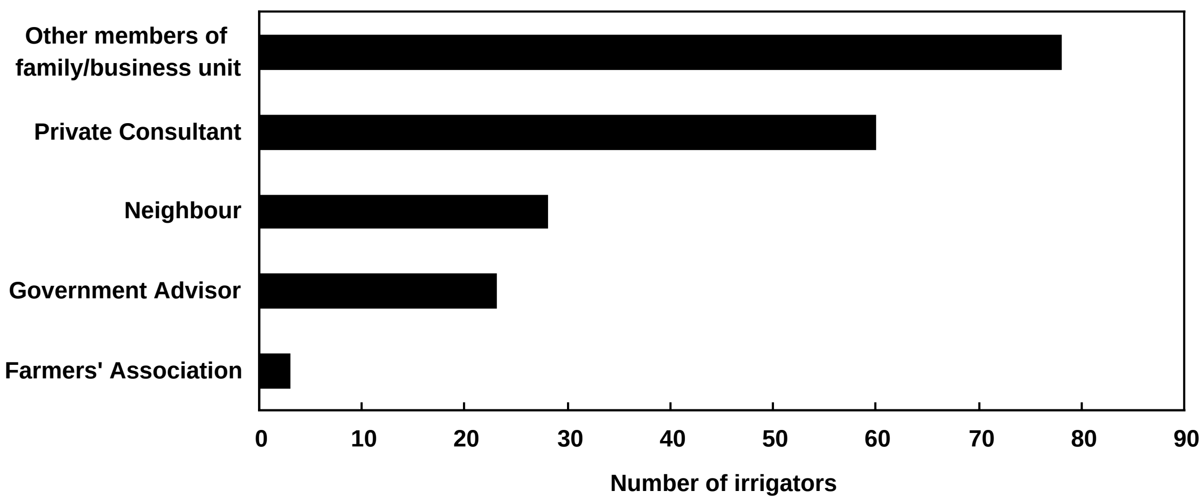

Figure 2. The preferred advisers consulted by irrigators when deciding cropping areas. Respondents could select more than one adviser (n = 101).

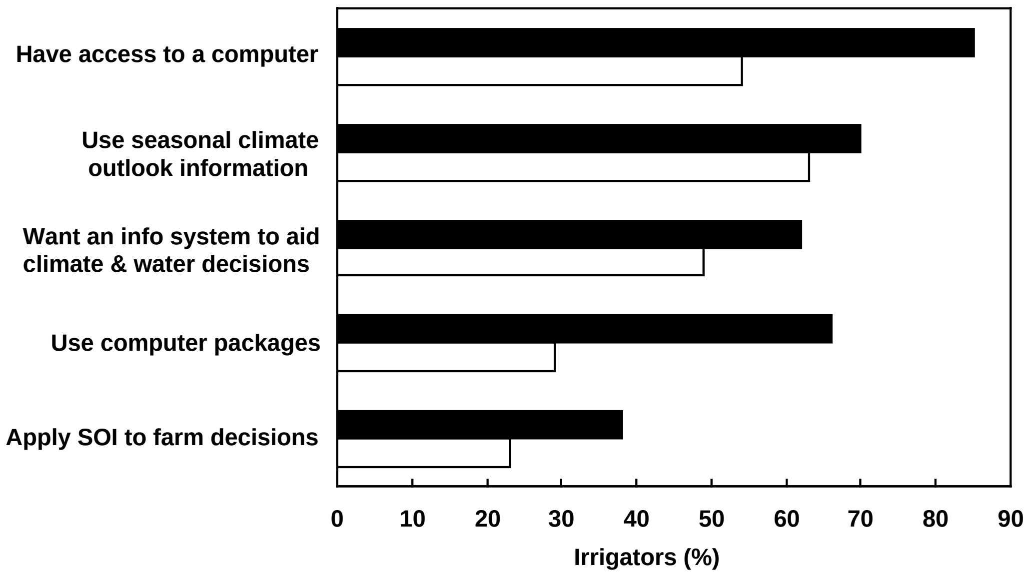

Figure 3. Profile of technology adoption by irrigators (solid bars, cotton growers; open bars, non-cotton growers).

Figure 3. However, two-thirds of irrigators rated their personal computing skill only either nil or basic (31% rated it nil; 36% basic; 27% intermediate; and 6% advanced). This means that, if computer-based decision support tools are developed, they will need to be very simple.

Results suggest private consultants are an important target audience; they may bridge the gaps in irrigator computer skill levels and climate knowledge, identified by this study. Private consultants were subsequently invited to participate in project focus group activities and provided invaluable suggestions. The findings of this study also highlight the importance of ensuring that the products developed match the technical skill of the intended audience.

Distribution of attitudes to a DSS to aid water and climate-related decisions

We found that there is demand for the project's research. Almost 60% of irrigators indicated they would find a tool/information system useful to aid water and climate-related decisions and 30% indicated that they might find one useful (Fig. 5). We asked irrigators their preferred methods for accessing this information and they nominated faxback, media (print, television, radio) or internet downloads (Fig. 6).

The survey found two-thirds of irrigators use seasonal climate outlook information, sourced mainly from mass media (print, television, radio), Bureau of Meteorology, faxback, internet sites and consultants. This suggests it is important to design a suite of formats and a broad

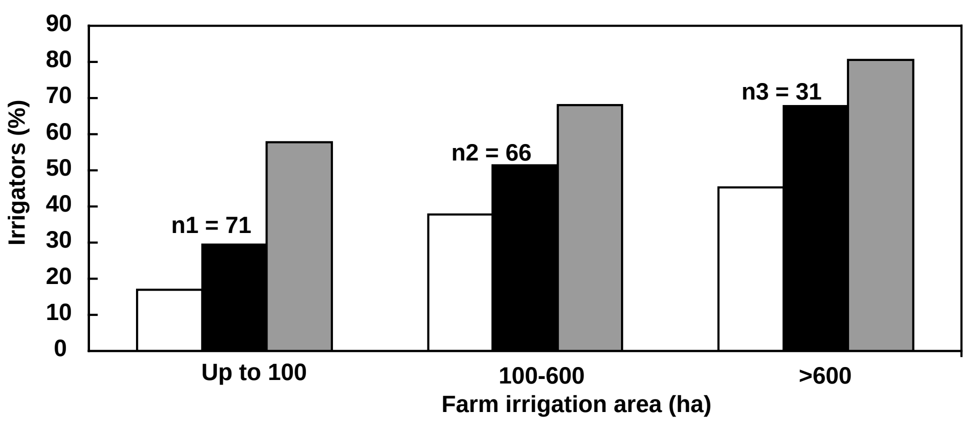

Figure 4. The effect of technology uptake on the farm irrigation area. Open bars, SOI used in on-farm decisions; solid bars, computer packages aid farm or water management decisions; shaded bars, use seasonal climate outlook information.

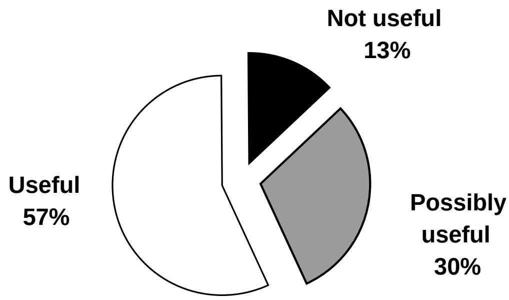

Figure 5. Distribution of attitudes to a decision support system to aid water and climate-related decisions.

communication strategy to reach this audience. Broadcast time on television and radio is brief, so information communicated must be clear and easily interpreted. Irrigators' preference for faxed information will enable more detail to be included in forecasts and should aid interpretation and improve timeliness of delivery.

Application of the SOI to farm decisions

A key concept in the project's research is understanding the relationship between the Southern Oscillation Index (SOI) and rainfall. We found almost one-third of irrigators use the SOI in farm decisions (Fig. 4). Sixty-seven percent of those who use the SOI apply it to decisions such as choice of crop and area, rate of fertiliser application, harvesting, sowing date and stock rates; whereas 20% apply it to water availability and management decisions; 6% use it for sales discussions; and 7% as a general rule of thumb.

We used climate test questions to assess irrigators' understanding of the relationship between SOI and rainfall in their area and found their understanding was generally good (Fig. 7). We found, however, that only 20% are very confident in applying climate information to decision-making. Sixty-two percent have some knowledge/understanding of how to apply the SOI to property decisions and the other irrigators have no knowledge of such applications. Given that one-third of irrigators source seasonal climate outlook information and a large percentage are not confident to apply it to decisions, there may be a substantial potential market for a saleable suite of products for climate applications workshops and training courses in the region.

Understanding of terms commonly used in climate science

It was important for the project to determine how well irrigators understand terms commonly used in climate science. Irrigators were asked to rate their understanding of these terms. Their ratings indicated that their understanding was quite good. Seventy-six percent claimed some knowledge/understanding or a working knowledge of the term 'mean rainfall'; 74% 'median rainfall'; 62% 'probability of exceedance'; 69% SOI phases; and 70% sea surface temperature. Results suggest care should be taken in the use of technical terms in forecast information. Also, opportunities should be provided for training in the use and interpretation of DSS information, with technical staff accessible if clarification is needed.

Is research likely to influence decisions and what decision variables are important?

We found the project's streamflow forecasts are likely to influence decisions relating to area and crop type. Cotton growers dominate the agricultural sector in the study region. They manage 75% of the total area developed for irrigated cropping and off-allocation forecasts may strongly influence cotton grower area decisions.

About 75% of irrigators indicated they might change crop area and 43% might change crop type, if given advance

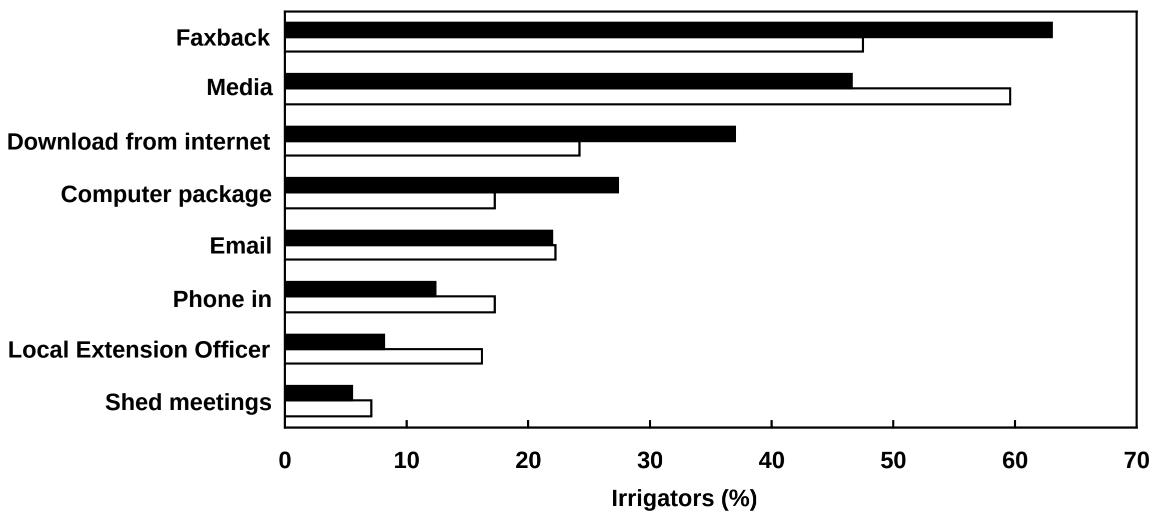

Figure 6. Irrigator preferences for accessing tools and information to aid water and climate-related decisions. Solid bars, cotton growers; open bars, non-cotton growers.

information on probable water availability up to 4 months ahead of irrigation season. Forecasts appear to be particularly useful for cotton growers; 80% of them were prepared to consider changing their cropping area, compared to 45% of non-cotton growers. This result validates, to some extent, the value of the project's decision framework that was developed for cotton growers.

The factors considered very important to irrigators deciding cropping area differed between cotton and non-cotton growers. Cotton growers placed a major emphasis on water availability. On-allocation is the volume an irrigator is able to access from government storage; a licence issued by the state water authority specifies the amount. Off-allocation licence holders may also have access to 'off-allocation' water when dams spill or high flows enter the river system. State authorities announce the access only when all other user needs (including environmental) have been met and access is independent of licence holders' annual volume of on-allocation. Of the 22 water, agronomic and economic factors cotton irrigators consider very important when deciding area, the top 5 were: on-allocation; carryover from previous year's allocation; on-farm storage; off-allocation; and current crop price. For non-cotton growers, the top 5 factors were: on-allocation; stored soil moisture prior to planting; land preparation; current cash flow; and current crop price. Results suggest user information needs can vary between commodities.

Opportunities to improve on-farm water use efficiency

Study findings suggest there may be opportunities for research projects to improve water use efficiency at the farm scale, using irrigation scheduling and water measurement. For example, we found: (i) 80% of irrigators decide that irrigation is needed by the appearance of the plant; and (ii) precise methods for measuring irrigation water are not commonly used. This highlights the possible value of tools and projects that aid irrigation scheduling decisions and contribute to improvement of water use efficiency at the farm scale. We found that 42% of irrigators do not estimate or measure water applied and 58% do measure and estimate. Of those who do, 35% estimate how much water is applied for each irrigation using water/flow meter readings and 7% estimate this manually (estimate flow rate × time); another 13% use soil moisture probes to measure the amount of water applied and 3% use rain gauges (most likely sprinkler irrigation).

Potter (1999) had similar findings in his survey, involving interviews with 135 irrigators in Border Rivers, Condamine, Maranoa–Balonne, and Warrego–Paroo catchments of the MDB. He found almost one-third did not know their application rate or the amount of water applied and did not consider this information important enough to record, nor were many using scheduling tools (Potter 1999). These findings are likely to reflect the current lack of availability of tools and methods for measuring water applications at the farm scale or that irrigators are possibly unwilling to use tools or methods to measure water applications.

Focus group interaction with the research team

The survey enabled community partnerships to be developed with irrigators and private consultants in the form of a focus group. Forty-one irrigators, dispersed throughout the 4 catchments, expressed interest in working with the research team in a focus group.

Irrigators and a number of private consultants with a specific interest in the Border Rivers region attended the first focus group meeting (held in June 2000). They were involved in evaluating project tools and information under development by the team. We provided an outline of the research being conducted and presented the key results from the survey. FLOWCAST, the decision support computer software package being developed by the team, was demonstrated and participants were shown features such as forecasts of streamflow and rainfall for the Border Rivers catchment.

With respect to the graphical outputs of FLOWCAST presented, participants suggested a change to labeling on one of these graphs. This suggestion has been adopted. They

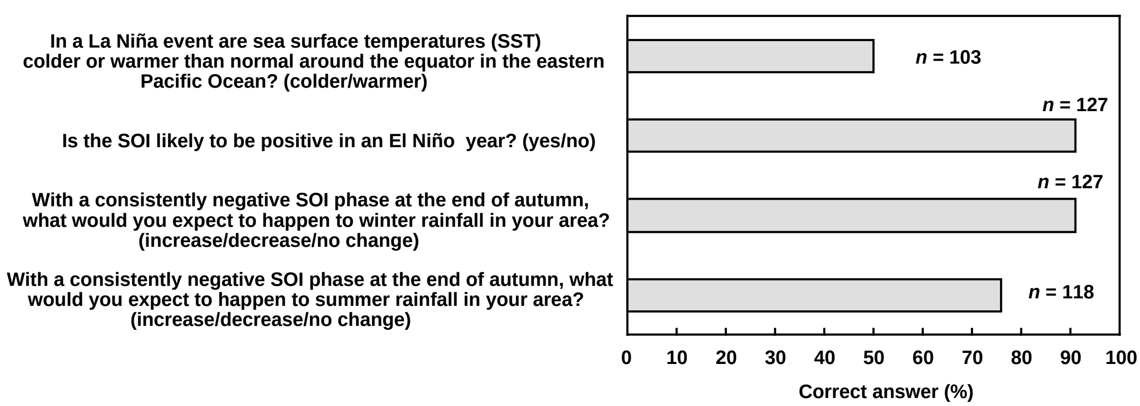

Figure 7. The percentage of questions answered correctly in the SOI knowledge test.

showed a preference for the use of line graphs to present percentile or probability distribution output, rather than as bar graphs. They suggested forecasts should be specific to particular sections of the catchment, for example, based on irrigation nodes or groups of nodes where irrigators regularly consult together on decisions. Interest was shown in specific streamflow variables, such as off-allocation opportunities and state dam inflows. The team was cautioned, by participants, to be careful of the impact of forecasts on people who may consider a probabilistic forecast equates to certainty.

The best times to distribute information, such as prior to planting date, were discussed. Participants said they would prefer to receive information monthly and would find off-allocation forecasts (expressed in pumping days) very valuable. They suggested that these should be included in FLOWCAST.

Participants were enthusiastic for other irrigators to have access to the information and offered the project use of a local cotton grower faxstream, linked to ~90 growers. The project extension officer forwarded a monthly forecast and climate update using this faxstream. Private consultants were sent information directly by the project team.

The second focus meeting was held in September 2000. Project progress and the latest climate update on streamflow and rainfall for the upcoming spring–summer in the Border Rivers catchments was presented. The meeting also sought to strengthen participant understanding of the science behind seasonal climate forecasting, work with them to develop streamflow forecasting tools, and help the project team to better understand producer needs.

Explanations were provided on terms commonly used in climate science, such as mean, median and probability of exceedance. Irrigators had been asked, in the survey, to rate their understanding of these terms. Examples of how to calculate a mean and median were also given. Climate indices including SOI, SOI phases and sea surface temperature were also explained. A sample media article, written for growers, was presented for comment. Attendees were asked which parts they found useful, which parts they did not understand and what suggestions they wished to make. The FLOWCAST computer package, still under development, was demonstrated. Participants raised concerns about the sample size used in some of the analogue years forecasts and stated that, if more years of data were used, the certainty of forecasts could be improved. While there is further research being carried out in this area (Abawi *et al*. 2001*b*), the comments demonstrated a level of understanding of the methodologies being used in the software package. In order to improve the sample size, different climatic indices (such as the Interdecadal Pacific Oscillation Index, Pacific Decadal Oscillation Index, sea surface temperature) have been incorporated into FLOWCAST. The team also learned the importance of delivering information when it is needed and by means, such as the fax, that are convenient and fast to reach the target audience.

Project team recommendations

Evaluation has the potential to highlight or indicate areas that may need review or change, but the process itself does not implement change (Luukkonen-Gronow 1987); it is people who implement change. The project team devised a number of recommendations for their project based on the survey findings. These are listed below.

(i) Develop simpler language to communicate technical terms, such as ‘mean rainfall’, ‘median rainfall’ and ‘probability of exceedance’, by consulting a focus group of irrigators and private consultants and by liaising with in-house climatologists.

(ii) Explain, more fully, terms such as SOI phases and sea surface temperature, in communication of information and workshops. This was highlighted by irrigator responses to test questions and ratings of general knowledge about these phenomena.

(iii) Develop an information kit that provides ‘easy-to-understand’, simple explanations of graph interpretations and commonly used climate terms.

(iv) Employ a broad range of formats to transfer knowledge and streamflow forecasts to suit faxback, mass media and the internet and, where possible, monitor uptake/output using, say, internet site counts and faxstream numbers.

(v) Organise a small group from interested private consultants and develop their skills in application of climate information to enable greater access for irrigators to expertise.

(vi) Test information formats and computer package outputs, such as graphs, with a focus group to ensure clarity and ease of interpretation of technical information, such as probabilistic forecasts.

(vii) Survey private consultants to identify their levels of climate knowledge, personal computing skill, information requirements and interest in the team’s research.

(viii) Gather evidence of research impact on water use efficiency, risk management and profit, by way of irrigator case studies for different irrigation nodes.

(ix) Share findings of this study with researchers and colleagues working in similar fields.

The key findings of the study are valuable and show the potential benefits of exploring the context in which intended users of research operate, as well as involving them in critiquing and reviewing decision support tools and information as to their relevance and usefulness. The project team has planned a joint meeting of focus group members and irrigators from the 4 catchments, to demonstrate the team’s suite of DSS tools and information developed to date. Irrigators attending the meeting from the Border Rivers catchments will be asked about the impact, usefulness and value of the forecast faxed to 90 irrigators in Border Rivers in September 2000.

Limitations of the study

A limitation to interpretation of the findings is that the reliability of survey data could not be tested, because the population was anonymous. Differences between respondents and non-respondents could not be explored for possible bias or questions that may have been misunderstood. The survey was conducted on an anonymous basis because water was a sensitive issue at the time of survey and the Department of Natural Resources, Mines and Energy has a water regulatory role. Given this situation, we considered that an anonymous approach would be more easily accepted and we felt that the response rate would be higher. It is not unlikely that respondents with an interest in, or knowledge about, climate technology may have biased the results. The survey was indicative and was conducted in order to obtain more insight into the irrigator profile and their needs, so that appropriate sampling techniques may be adopted in future studies.

Conclusion

The evaluation helped broaden the research team's understanding of their intended audience. A profile of irrigator information needs, knowledge and practices emerged, and an understanding was gained of how water and cropping decisions are made. Results provided a snapshot of whom irrigators consult, what decision variables are important, as well as the levels of knowledge and use of seasonal climate outlook information.

We learnt about how irrigators prefer to access information, possible research uptake rates and the importance of language in forecast information. The influence of private consultants on area decisions was also highlighted. Partnerships with irrigators and consultants were built and researchers now have key information on irrigation information needs and how best to distribute climate and water-related information.

Evaluation findings lead to the following inferences: (i) we found irrigators consult widely when making cropping area decisions and a large number seek advice from private consultants; (ii) irrigators' general understanding of climate phenomena and technical terms commonly used in climate science is good; and (iii) irrigators consider water availability forecasts would be useful for decision-making.

The impact of the study is that: (i) findings and focus group meetings helped to improve presentation of forecast information in the decision support tools, including the computer package, FLOWCAST; (ii) the team has endeavoured to understand irrigators' needs and deliver relevant and useful information, and skill their clients for successful technology uptake; (iii) the method and framework used in this study have been adapted for 2 further QCCA climate information studies with graziers in western Queensland (Keogh *et al*. 2004) and in a needs assessment study currently underway with pastoralists in the Gascoyne Murchison region of Western Australia; (iv) findings formed the basis of the project's extension and communication plan published in the project's final report (Abawi *et al*. 2001*a*); (v) members of the focus group are in close contact with QCCA team members and continue to request climate forecast information to assist their cropping area decisions.

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Disclaimer

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