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Summative evaluation of climate application activities with pastoralists in western Queensland

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Abstract. Survey methods were engaged to measure the change in use and knowledge of climate information by pastoralists in western Queensland. The initial mail survey was undertaken in 2000–01 ($n = 43$) and provided a useful benchmark of pastoralists climate knowledge. Two years of climate applications activities were completed and clients were re-surveyed in 2003 ($n = 49$) to measure the change in knowledge and assess the effectiveness of the climate applications activities. Two methods were used to assess changes in client knowledge, *viz*., self-assessment and test questions. We found that the use of seasonal climate forecasts in decision making increased from 36% in 2001 ($n = 42$) to 51% in 2003 ($n = 49$) ($P = 0.07$). The self-assessment technique was unsatisfactory as a measure of changing knowledge over short periods (1–3 years), but the test question technique was successful and indicated an improvement in climate knowledge among respondents. The increased levels of use of seasonal climate forecasts in management and improved knowledge was partly attributed to the climate applications activities of the project.

Further, those who used seasonal forecasting ($n = 25$) didn't understand key components of forecasts (e.g. probability, median) better than those who didn't use seasonal forecasts ($n = 24$) ($P > 0.05$). This identifies the potential for misunderstanding and misinterpretation of forecasts among users and highlights the need for providers of forecasts to understand the difficulties and prepare simply written descriptions of forecasts and disseminate these with the maps showing probabilities.

The most preferred means of accessing climate information were internet, email, 'The Season Ahead' newsletter and newspaper. The least preferred were direct contact with extension officers and attending field days and group meetings. Eighty-six percent of respondents used the internet and 67% used ADSL broadband internet (April 2003). Despite these findings, extension officers play a key role in preparing and publishing the information on the web, in emails and newsletters. We also believe that direct contact with extension officers trained in climate applications is desirable in workshop-like events to improve knowledge of the difficult concepts underpinning climate forecasts, which may then stimulate further adoption.

Additional keywords: changed knowledge, grazier, quantitative data, ranchers, seasonal climate forecasting.

Introduction

In a previous paper (Keogh *et al*. 2004*a*) we made reference to the notion of scientists and extension workers taking more responsibility for evaluating the effectiveness of their projects. We reviewed how others had measured project success, how they used climate-based information to aid property decisions, and we described a project being conducted in western Queensland. We provided a formative evaluation of the level of knowledge of climate terms and concepts and described the preferred means of receiving information among a representative sample of pastoral clients in the region (20.5 Mha or 12% of Queensland). After 2 years of climate application activities in the region we completed a summative evaluation re-surveying another representative sample of pastoralists as part of the Natural

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Heritage Trust project entitled 'Sustainable grazing – balancing resources and profit in western Queensland' (Cobon and Park 2003). The second survey was completed to provide an indication of any changes in knowledge that may, or may not be attributable to the climate application activities.

Seasonal climate forecasts are used by agricultural producers in the grain (Hammer *et al*. 1996), peanut (Meinke and Hammer 1997), sugar (Everingham *et al*. 2003), water (Abawi *et al*. 2000) and pastoral industries (Cobon 1999; Johnston *et al*. 2000) to reduce climate-related risks. Tailoring decisions based on seasonal forecasts can lead to improved profitability and sustainability of natural resources (Hammer *et al*. 1996; Cobon and McKeon 2002). Seasonal climate forecasts are now used by 30–40% of agricultural producers in decision making (Australian Government Department of Agriculture Fisheries and Forestry 2004; Keogh *et al*. 2004*a*, 2005). Desired levels of forecast reliability, forecast presentation style, use of terminology, proof of value, access to expertise and perceptions regarding climate information have previously been identified as factors limiting the uptake and use of climate forecasts (Childs *et al*. 1991; Changnon *et al*. 1995; Nicholls 1999; Hartmann *et al*. 2002; McCrea *et al*. 2005).

A review of program evaluation in agricultural extension in Australia (Dart *et al*. 1998) found few publications although evaluation of agricultural extension programs in the United States is relatively active (Lees 1991). The majority of the Australian evaluations were on farmer participation in extension activities (89%, level 3 of Bennett's hierarchy, Bennett 1975), 60% considered changes in knowledge, aspiration, skill and attitude (KASA, level 5), and only 22% measured a change in behaviour or practice (P, level 6). Bennett (1975) has seven levels of goals and claims it becomes more difficult to evaluate at higher levels of the hierarchy as it becomes more difficult to show that changes at these levels are the result of extension activities and not of other factors. Evidence of program impact becomes stronger as the hierarchy is ascended, as does the difficulty and cost of obtaining evidence of program accomplishment generally increase as the hierarchy is ascended (Bennett 1975).

In searching the literature in Australia there were examples of evaluating changes in participant KASA by questioning participants once the extension activity had been completed including at small events (workshop, Keogh 2001) or after a series of workshops (Bagshaw and Ledger 2000). A closed survey before and another after a carcass classification trial (and associated extension) measured changes in retailers' attitudes to and knowledge of carcass classification (Wilson and Wissemann 1980; Wilson *et al*. 1980). The evaluation found little change in knowledge of retailers. They failed to fully interpret a carcass classification ticket which resulted in a recommendation for more resources to be devoted to the retailer extension program. We did not find any published program evaluation of the nature and scale reported here.

The climate applications activities between April 2001 and April 2003 included an extension officer working full-time focusing on gaps in knowledge identified in the first survey.

This paper reports the findings of a second survey conducted in the same geographical area as the first survey (Keogh *et al*. 2004*a*). It compares changes in knowledge and practice (use of seasonal forecasts) between the first survey conducted between November 2000 and April 2001 and the second survey conducted between February and April 2003.

The objectives of this paper were to: (1) establish a new benchmark in terms of the use of seasonal forecasts, knowledge of climate terms and concepts and the preferred means of accessing (no requirement to use in decision making) climate information; (2) evaluate the effectiveness of the climate application activities by assessing the change in use (or change in practice) of seasonal forecasting in decision making, and knowledge of climate terms and concepts among pastoralists between 2001 and 2003; and (3) evaluate the effectiveness of two methodologies for measuring knowledge (e.g. self-assessment and test questions).

Method

Evaluation approach

Two methods were used to assess pastoralist knowledge of climate terms and concepts commonly used in climate science, *viz*., (i) self-rating of knowledge on 15 climate terms or concepts, all of which were the same as in the first survey (Table 1, Section A) and (ii) 6 climate test questions, of which 3 were the same as used in the first survey (Table 1, Section B). To assess pastoralists' preferred means of accessing climate information six questions were asked regarding their preferred information sources, internet access and climate websites (Table 1, Section C).

The second survey was conducted between February and April 2003, which was ~2 years after the first survey (November 2000–April 2001). During this 2-year period between the two surveys an extension officer was employed full time to work on a program designed to target gaps in pastoralist knowledge of climate information that were identified in the first survey. During this period 14 workshops, nine invited presentations, four field days, six newsletters focused on climate ('The Season Ahead' – Issue 1 in September 2001 had a readership of 70 and in February 2003

Table 1. Sections of the pastoralist survey

Section	Questions related to
Section A	Pastoralist knowledge of the climate system; Southern Oscillation Index (SOI), El Niño, La Niña, sea surface temperatures (SST), probability of exceedance, median rainfall – all presented as self-rating questions on a 1–10 scale from no knowledge to superior knowledge.
	Use of seasonal forecasts in decision making and drought management decisions – respondents nominate decisions and use of either rainfall or pasture growth forecasts.
Section B	Assessing pastoralist knowledge of SST and La Niña, SOI and El Niño, El Niño Southern Oscillation (ENSO)/pasture growth relationships, probability, mean and median all using multiple choice test questions (3–5 options).
Section C	How pastoralists prefer to access climate information; access to computers, internet and broadband, climate websites used.

Issue 6 had 300) and many radio interviews and newspaper articles were either conducted or distributed in the study region.

Survey region, sample selection, response rate and property size

The survey area consisted of seven shires in western Queensland: Aramac, Blackall, Ilfracombe, Longreach, McKinlay, Richmond and Winton. A total of 826 pastoralists were on the contact list. Pastoralists who answered the first survey (43 of 100 surveyed in 2001) and were still available to be contacted ($n = 37$) were mailed the second survey in 2003. The remaining pastoralists on the contact list (789) were used to select the balance of the sample for the second survey ($n = 104$). These were chosen on a random basis using stratified proportional sampling of the number of properties within each shire. A total of 141 pastoralists were surveyed in 2003 (Table 2). Shire was used as the stratification characteristic as the local government listing of all properties did not contain production or economic information. The sample selection was based on balancing the limitations of time and cost resources and the reduction in final numbers due to variable response rates.

Three groupings were identified after the second survey; Group 1 consisted of pastoralists who had answered both surveys; Group 2 were non-respondent pastoralists in the first survey sample but who answered the second survey; and Group 3 consisted of pastoralists who had not been surveyed in the first survey but who answered the second survey (Table 2). Pastoralists who answered both surveys (Group 1) did not have access to their answers from the first survey when answering the second survey.

Due to a low number of respondents in each shire, shires were grouped into north and south regions. The north region consisted of the shires of McKinlay, Richmond and Winton ($n = 25$), and the south region Aramac, Blackall, Ilfracombe and Longreach ($n = 24$).

The average size of all rural holdings for the seven shires was 31 353 ha (ABS 2000), compared with our respondent average of 26 181 ha (Fig. 1), and 28 270 ha of respondents in the first survey (Keogh *et al*. 2004*a*). The average property size in the north

Table 2. Sample selection in the second (2003) survey and shire response rates
Values are number of respondents out of number sent, with the percentage response rate in parentheses

Shire	Group 1 Respondents to both surveys	Group 2 Non-respondents to first survey and respondents to second survey	Group 3 Non-surveyed in first survey and respondents to second survey	Total
McKinlay	1 out of 8	1 out of 5	4 out of 10	6 out of 23
Richmond	6 out of 6	2 out of 8	3 out of 8	11 out of 22
Winton	3 out of 5	1 out of 9	4 out of 10	8 out of 24
Aramac	2 out of 5	3 out of 9	3 out of 6	8 out of 20
Blackall	1 out of 4	1 out of 9	1 out of 6	3 out of 19
Ilfracombe	0 out of 0	1 out of 4	1 out of 4	2 out of 8
Longreach	5 out of 9	4 out of 6	2 out of 10	11 out of 25
Total	18 out of 37 (49%)	13 out of 50 (26%)	18 out of 54 (33%)	49 out of 141 (35%)

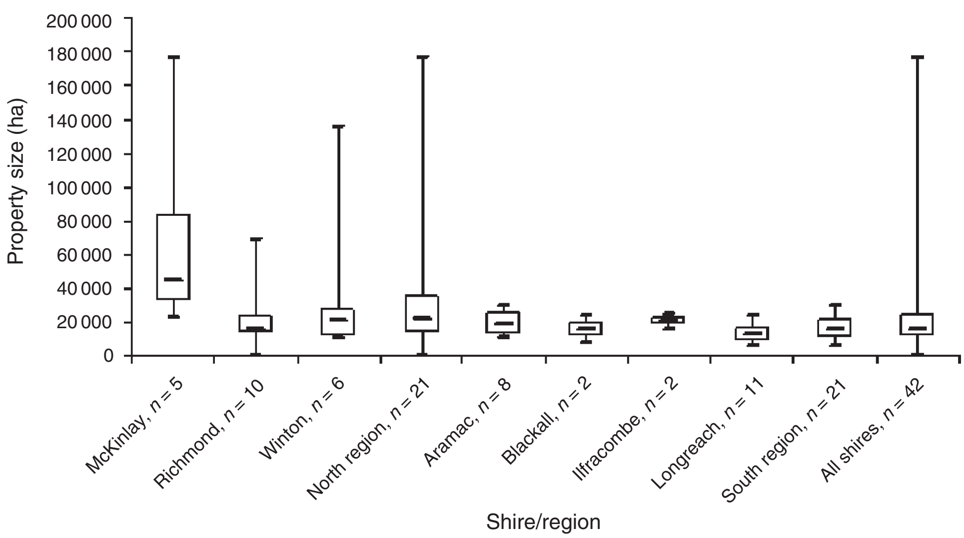

Fig. 1. Number of properties and inter-quartile range of property size of survey respondents in western Queensland.

region was larger than in the south region ($P < 0.05$, using analysis of variance of the square root of property size), due mainly to large properties in the McKinlay Shire.

Statistical methods

Responses to Section A, question 1 were self-ratings on a 1 to 10 scale and these were analysed for differences across regions and shires using a one-way analysis of variance. Analysis of variance was also used to test the difference in overall score of the self-rated questions between 2001 and 2003.

The use of seasonal forecasts in decision making was compared between years using a Z-test to compare the difference between two proportions.

The chi-square test was used to test for difference in correct answers to the overall score of test questions (1) between users of seasonal forecasts and non-users, (2) across years for all respondents and respondents common to both surveys, and (3) of respondents and non-respondents of the first survey who responded to the second survey (i.e. Group 2, Table 2). Chi-square was also used to test for independence between respondents and non-respondents to the first survey and their use of seasonal forecasts in decision making in the second survey.

Counts of responses that formed 2×2 contingency tables were analysed using a chi-square test with Yates adjustment (Howell 1992). The row or column factor was usually the north/south region, with the other factor being the response to a question, for example whether the respondent answered 'yes' or 'no' to a question or correctly/incorrectly answered a knowledge question.

Paired and unpaired t-tests were used to test for any differences between answers to the two surveys. Unpaired t-tests compared average ratings across years for all respondents and a paired t-test compared average ratings across years for respondents common to both surveys. Comparing ratings from all respondents from both surveys provided a larger sample size to increase the power of detecting differences in results. The potential downfall is a loss of some power due to not being able to account for the individual respondent changes. We assume that the respondents who completed both surveys are of the same population as the respondents who only answered one survey.

Results

Section A – Climate system knowledge using self-rating, and drought decision making (2003 survey of all respondents)

Self-rating of climate knowledge

On a 1 to 10 scale (1 no knowledge and 10 superior knowledge) the middle response was 5.5. The full rating scale consisted of 1 no knowledge, 3 some knowledge, 5 average knowledge, 7 working knowledge and 10 superior knowledge. Results are shown in Table 3.

The majority of respondents did not rate '7 working knowledge' for any climate term or concept. About 20% of respondents felt they had a working knowledge of 'probability of exceedance', 'decadal climate variability' and 'sea surface temperatures'; 30% a working knowledge of 'median rainfall' and 45% a working knowledge of 'sources of weather and climate information'.

The average score for each question ranged between 3.8 and 5.7 for all respondents in 2003, the lowest two scores being knowledge of 'probability of exceedance' (3.8) and 'decadal climate variability' and 'impact on carrying capacity' (3.9); and the highest score being 'sources of weather and climate information' (5.7). Of the 15 questions, 10 had an average score

Table 3. Number of respondents self-assessing a '7 working knowledge' and average self-ratings of climate knowledge on a scale of 1 (no knowledge) to 10 (superior knowledge) of all respondents and common respondents in surveys conducted in 2001 and 2003 (n is shown in parentheses)

**, $P < 0.01$ between years within respondent groups; otherwise unpaired t-test of all respondents in both surveys and paired t-test of respondents common to both surveys showed no significant difference in ratings of individual questions between 2001 and 2003

Climate term or concept	No. with working knowledge (n = 49)	All respondents 2001 (n)	All respondents 2003 (n)	Common respondents[A] 2001 (n = 18)	Common respondents[A] 2003 (n = 18)
1. Season climate forecasting	10	5.4 (41)	4.7 (49)	5.6	5.4
2. Sources of weather and climate information	22	6.9 (39)	5.7 (49)**	7.5	6.4
3. Southern Oscillation Index (SOI)	15	5.9 (40)	5 (48)	6.3	6.1
4. Southern Oscillation Index phases	11	4.7 (40)	4.3 (48)	5.2	5.3
5. El Niño	15	5.5 (40)	5.1 (49)	5.8	5.7
6. La Niña	14	5.5 (40)	5.1 (49)	5.8	5.7
7. Sea surface temperatures (SST)	9	5.0 (41)	4.2 (49)	5.1	4.9
8. Relationship between SOI and rainfall in your area	11	4.9 (40)	4.5 (49)	5.6	5.4
9. Relationship between SOI and pasture growth in your area	11	4.5 (40)	4.2 (49)	5.2	5.1
10. Forecasting pasture growth	14	6.0 (40)	4.7 (49)**	6.4	5.4
11. Using climate information to adjust stocking rate	15	5.6 (40)	5 (46)	6.2	5.7
12. Median rainfall	14	4.8 (39)	4.6 (49)	5.2	5.2
13. Probability of exceedance	9	4.0 (41)	3.8 (48)	4.7	4.7
14. Impact of climate change on western Queensland	12	5.1 (39)	4.6 (49)	4.9	5.2
15. Decadal climate variability and impact on carrying capacity	10	4.5 (39)	3.9 (48)	4.6	4.2
Mean total score		5.2	4.6**	5.6	5.4**

[A]Common respondents is discussed in a following section.

below '5 average knowledge' and no question had an average score of '7 working knowledge' (Table 3). For each of the 15 questions there was no difference in response scores across shires and regions.

What decisions did you make last year (i.e. 2002) to help manage the drought?

For many parts of western Queensland the drought in 2002 was the worst on record (see discussion for a description). The responses to the question related to the general themes of reduced stock numbers, early intervention practices (e.g. destocking, weaning), feeding supplements, baling native pasture hay, applying decisions using seasonal forecasts, managing macropod grazing pressure, erecting new water points and subdividing paddocks.

What were these decisions a result of?

Pastoralists were able to select more than one option from a choice of four – rainfall forecast, pasture growth forecast, reaction due to current conditions and other. If they selected 'other' they were asked to specify. Of the total 49 respondents, 45% of the respondents indicated that management decisions that were made in 2002 were a result of a rainfall forecast, 16% indicated decisions were made as a result of a pasture growth forecast, 78% indicated decisions were reactive to current conditions and 27% specified other reasons for making decisions during 2002 (Fig. 2). Other reasons included good market prices for livestock, local experience and indigenous knowledge and feed budgets. There was no significant difference in response rates between regions.

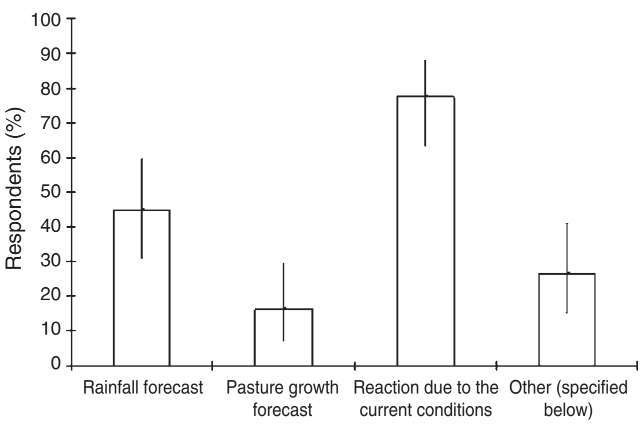

Fig. 2. Decision assistance used by respondents in western Queensland to help manage pastoral enterprises during 2002 (± 95% confidence level) ($n = 49$). Other refers to decisions based on market prices, feed budgets, experience of rainfall in area and use of rainfall records.

Fifty-one percent of respondents used a forecast of either rainfall or pasture growth to assist with decision making. This was an increase from 36% when surveyed in 2001 ($n = 42$) ($P = 0.07$).

Section B – Climate system knowledge using test questions

A summary of the correct results from questions 1 to 6, each with 49 respondents is shown in Table 4. In more detail the results were as follows.

(1) In a La Niña event, sea surface temperatures (SSTs) around the equator in the eastern Pacific Ocean are: colder than average, warmer than average, average or don't know. Fifty-three percent gave the correct answer which was colder than average, 4% didn't know, 12% didn't answer the question and the balance got the question wrong.
(2) The Southern Oscillation Index (SOI) in an El Niño year is: positive, negative, neutral (near zero) or don't know. Eighty-four percent gave the correct answer of negative, 2% didn't know, 6% didn't answer the question and the balance got the question wrong.
(3) In western Queensland, El Niño Southern Oscillation has the largest impact on: rainfall, pasture growth or don't know. Eighteen percent gave the correct answer of pasture growth, 10% didn't know, 10% didn't answer the question and the balance got the question wrong.
(4) The mean of the following dataset (1, 2, 3, 5, 5) is: 2, 3, 3.2, 5 or don't know. Fifty-five percent gave the correct answer of 3.2, 18% didn't know, 14% didn't answer the question and the balance got the question wrong.
(5) The median of the following dataset (1, 2, 3, 5, 5) is: 2, 3, 3.2, 5 or don't know. Fifty-five percent gave the correct answer of 3, 20% didn't know, 12% didn't answer the question and the balance got the question wrong. An identical number of respondents correctly answered questions 4 and 5 ($n = 27$), and of these 85% correctly answered both questions.
(6) What does it mean when a climate forecaster says there is a 70% probability of receiving above median rainfall? The options for answering the question were: rainfall is expected to be above the median by 70%, there will be above median rainfall, 70% of the time when this forecast is presented rainfall will be above the median, the forecaster is 70% convinced that rainfall will be above the median or don't know. Forty-seven percent of respondents correctly answered that 70% of the time when the forecast is presented rainfall will be above the median. Four percent of respondents selected didn't know, everyone attempted the question and 49% selected the wrong answer.

Respondents who used seasonal forecasting in decision making ($n = 25$) did not answer test questions more correctly than non-users ($n = 24$). Across all test questions users answered 48% correctly and non-users 56% ($P > 0.05$), and for questions

Table 4. Percentage of respondents that answered test questions correctly

	Q1. La Niña/SST	Q2. SOI/El Niño	Q3. ENSO impact	Q4. Mean	Q6. Median	Q7. Probability
Correct (%)	53	84	18	55	55	47

5 (median) and 6 (probability) users answered 52% and non-users 50% correctly ($P > 0.05$).

Respondents and non-respondents to the first survey did not differ in the use of seasonal forecasts in decision making or answering the six test questions correctly. Sixty-one percent of respondents to the first survey ($n = 18$) used seasonal forecasts in decision making compared with 54% of non-respondents to the first survey ($n = 13$) ($P > 0.05$). Respondents to the first survey overall answered 53% of test questions correctly compared with 47% for non-respondents to the first survey ($P > 0.05$).

There was no significant difference between the two regions in the proportions of correct answers for any of the six questions.

Section C – Information sources

The sources of climate information were ranked from highest to lowest according to the total proportion of respondents ticking the option (Table 5). Each survey respondent ticked at least one option in this question ($n = 49$). The most favoured way of accessing information was from the Internet, closely followed by email and 'The Season Ahead' newsletter. The least popular options for accessing climate information were using private consultants, local extension officers and group meetings. There was no significant difference between the regions in the proportion of ticked answers for each item.

Internet access and use

Eighty-six percent of respondents indicated they had access to the internet, and of these, 76% were connected to Telstra broadband (67% of all respondents). There was no significant difference between the regions in either the percentage of respondents connected to the internet or the percentage connected to Telstra broadband. Three quarters of respondents accessed the Bureau of Meteorology website which was the most popular (Table 6). Access to websites did not differ significantly between regions.

Comparing results of the 2001 and 2003 surveys using respondents in common

This section compares questions that were common across the two surveys, using respondents who answered both surveys, a possible total sample of 18 respondents.

Self-rating of climate knowledge

Respondents rated their knowledge in 15 questions. There was a significant difference in the mean total scores between 2001 and 2003 with the overall self-rating score lower in 2003 (5.4) compared with 2001 (5.6) ($P < 0.01$). However, the average score for each of the self-rating questions didn't change between 2001 and 2003 (Table 3), despite average ratings for four questions (2, 10, 11 and 15) being apparently lower in 2003 compared with 2001.

Test questions of climate knowledge

Here there were three questions in common across the two surveys. The results below are from the respondents in common across the two surveys.

(1) In a La Niña event, sea surface temperatures (SSTs) around the equator in the eastern Pacific Ocean are? Fifty-percent correctly answered this test question in 2001 ($n = 18$) compared with 65% in 2003 ($n = 17$).
(2) The Southern Oscillation Index (SOI) in an El Niño year is? Seventy-eight percent correctly answered this question in 2001 ($n = 18$) compared with 89% in 2003 ($n = 18$).
(3) In western Queensland, El Niño Southern Oscillation has the largest impact on? Eleven percent correctly answered this question in 2001 ($n = 18$) compared with 35% in 2003 ($n = 17$).

The number of correct answers by common respondents across all test questions increased over time from 43 to 59% ($P = 0.09$). There was no significant difference between the proportions of correct answers across years for any individual

Table 5. Number and proportion (in parenthesis) of respondents accessing information from various sources in 2001 and 2003
n.a., not applicable; n.s., not significant ($P > 0.05$)

Preferred sources for accessing climate (could select more than 1)	2001[A] ($n = 18$)	2003 ($n = 49$)	Chi-square test – Yates adjustment
Download from the internet	7 (39%)	25 (51%)	n.s.
Email	5 (28%)	23 (47%)	n.s.
'The Season Ahead' newsletter	n.a.	23 (47%)	n.a.
Newspaper	6 (33%)	21 (43%)	n.s.
Radio	5 (28%)	19 (39%)	n.s.
TV	4 (22%)	16 (33%)	n.s.
Accessing your own CD-ROM software package	8 (44%)	11 (22%)	n.s.
Industry magazines	6 (33%)	10 (20%)	n.s.
Newsletter articles	6 (33%)	10 (20%)	n.s.
Workshops/conferences	4 (22%)	7 (14%)	n.s.
Faxback service	7 (39%)	6 (12%)	$P = 0.036$
Telephone in service	3 (17%)	6 (12%)	n.s.
Field days	3 (17%)	6 (12%)	n.s.
Other (included BestPrac, Qld Country Life)		4	
Group meetings	2 (11%)	2 (4%)	n.s.
Local extension officer	2 (11%)	2 (4%)	n.s.
Private consultant	2 (11%)	1 (2%)	n.s.

[A]A comparison between 2001 and 2003 is discussed in a following section.

Table 6. Number and proportion (in parentheses) of respondents accessing various websites for climate information ($n = 49$)

Website	Total (%)
Bureau of Meteorology	37 (75.5%)
Weather zone	22 (44.9%)
The Farmshed	14 (28.6%)
Long Paddock	12 (24.5%)
DPI Climate site	8 (16.3%)
Primac Elders	2 (4.1%)
Other	4 (8.2%)

question; however, an upward trend in correct answers for each of the three questions was apparent between 2001 and 2003.

On an individual basis 17–24% of respondents improved their knowledge between 2001 and 2003 (Table 7), however 0–6% answered correctly in 2001 but incorrectly in 2003.

Comparisons of results across the 2001 and 2003 survey using all available respondents

In this section, the questions are compared using all available responses from each of the surveys. The comparisons have more respondents than the last section, but there is potentially a different pool of respondents between surveys.

Self-rating of climate knowledge

There was a significant difference in the mean total scores between 2001 and 2003 with the overall self-rating score lower in 2003 (4.6) compared with 2001 (5.2) ($P < 0.01$) (Table 3). There was a significant ($P < 0.01$) decline in the self-assessed knowledge of respondents between 2001 and 2003 in two questions which related to sources of weather and climate information; and forecasting pasture growth (Questions 2 and 10, Table 3). Knowledge of these two questions also trended downwards among respondents common to both surveys (see previous section) but the differences were not significant. This downward trend in knowledge was apparent for all 15 questions when all respondents in both surveys were considered (Table 3).

Test questions of climate knowledge

There were three test questions in common across the two surveys. The results below relate to all respondents who answered the questions in both surveys.

The number of correct answers by all respondents across all test questions increased over time from 41 to 57% ($P < 0.01$). The proportion of correct answers to all three test questions trended upward between 2001 and 2003, however, an increase was significant ($P < 0.05$) only in question 2 relating to the SOI in an El Niño year (Table 8).

Table 7. The joint distribution of correct and incorrect answers to the three climate test questions answered by respondents common to both the 2001 and 2003 surveys

Outcome	Question 1	Question 2	Question 3
Number both years correct	8 out of 17	13 out of 18	2 out of 17
Number both years incorrect	5 out of 17	1 out of 18	11 out of 17
Number 2001 correct and 2003 incorrect	1 out of 17	1 out of 18	0 out of 17
Number 2003 correct and 2001 incorrect	3 out of 17	3 out of 18	4 out of 17
Total number of respondent in common	17 out of 17	18 out of 18	17 out of 17

Table 8. The number and proportion of correct and incorrect answers all respondents to both surveys (2001 and 2003) provided to three test questions
n.s., not significant

Question	Answer	2001	2003	Chi-square test
1. In a La Niña event, Sea Surface Temperatures around the equator in the eastern Pacific Ocean are:	Colder than average[A]	19	26	–
	Warmer than average	19	14	–
	Average		1	–
	Don't know	4	2	–
	Total respondents	42	43	–
	% correct	45%	61%	n.s.
2. The Southern Oscillation Index (SOI) in an El Niño year is:	Positive	9	3	–
	Negative[A]	28	41	–
	Neutral (near zero)	1	1	–
	Don't know	3	1	–
	Total respondents	41	46	–
	% correct	68%	89%	$P = 0.033$
3. In western Queensland, El Niño Southern Oscillation has the largest impact on:	Rainfall	32	30	–
	Pasture growth[A]	3	9	–
	Don't know	5	5	–
	Total respondents	40	44	–
	% correct	8%	21%	n.s.

[A]Indicates the correct answer.

Information sources and internet access

The general ranking of sources of climate information and the proportion of respondents accessing each source of information didn't change between 2001 and 2003. One exception was a decline in the use of faxback between 2001 and 2003 (Table 5). The preference for internet and email established in 2001 remained in 2003, with the addition of 'The Season Ahead' newsletter (see Table 5) in 2003 ranking equal second.

The proportion of respondents with internet access went from 75% ($n = 20$) in 2001 to 86% ($n = 49$) in 2003 but this change was not significantly different.

Discussion

The use of seasonal climate forecasts in decision making and knowledge of climate terms and concepts

Did they change over time?

The proportion of respondents using seasonal climate forecasting in decision making in the survey area in 2003 was 51%, an increase from 36% in 2001 (Keogh *et al.* 2004*a*). Despite the increase in use of forecasts we found that respondents' self-assessed knowledge of climate terms and concepts didn't change, and some trended downwards. In contrast, the climate test questions indicated an improvement in overall knowledge and of some individual climate terms and concepts. The differences between the two evaluation techniques in assessing knowledge of respondents are discussed later.

How did the use of seasonal forecasts compare to other regions?

First, a national survey of Australian farmers in 2002 showed over a third used seasonal forecasts in decision making (Australian Government Department of Agriculture Fisheries and Forestry 2004). Second, in 2002 a survey of pastoralists in the Gascoyne Murchison region of Western Australia found 61% of respondents' either access or use weather or climate forecasts with 18% explaining how this information influenced decision making (Keogh *et al.* 2005). These decisions related to setting stocking rates, mating, livestock sales, timing of tasks such as cut off dates for shearing and fencing, mustering stock placement on the property, developing more country, and budgeting. The decisions made on pastoral properties using either weather or climate forecasts were similar in western Queensland. Third, in the northern Murray-Darling Basin a survey of irrigators in 1999 found 29% used the SOI in farm decisions including choice of crop and area, rate of fertiliser application, harvesting, sowing date, water availability and sales (Keogh *et al.* 2004*b*). To accurately compare the results from the three studies above with our study, the wording of each question and its interpretation by the respondent should be identical in each case. The first and third studies referred to above posed a similar (but not identical) question to our study, relating to using seasonal forecasts in decision making. In the second study the question was more general, including accessing and using both weather and climate forecasts (i.e. not only seasonal forecasts). Here, respondents may have accessed a forecast without using it in decision making. Standardising questions will help evaluate change across regions or over time but interpretation of questions will always contribute to variation in survey data.

Can changes be attributed to the climate applications activities?

These activities occurred between April 2001 and April 2003 which coincided with the 2002–03 drought. For many locations in the survey area this drought was the worst on record. The towns of Barcaldine, Blackall, Isisford, Longreach, Muttaburra, Stonehenge and Winton each have between 110 and 120 years of rainfall records. These towns each recorded percentile 1 rank rainfall for the 12 month period 1 February 2002 to 31 January 2003 (Australian Rainman V 4.3.0447, Clewett *et al.* 2003). The severity of the drought and other factors may have influenced more respondents to use seasonal forecasting in decision making compared with 2001, and, therefore, we cannot fully contribute the increased use to the extension activities undertaken in the project. Generally, we have received greater enquiry for climate information and seasonal forecasts among primary producers at field days, and the number of telephone calls, office visits and website hits are greater during drought than when conditions are favourable. However, we do not entirely discount the targeted extension activities and therefore partly attribute the apparent improvement in knowledge of climate terms and concepts and the use of seasonal forecasts to the climate application activities conducted as part of the project 'Sustainable grazing – balancing resources and profit in western Queensland'.

The formative evaluation in the first survey (Keogh *et al.* 2004*a*) and the summative evaluation completed here, together, were able to measure change in knowledge of climate terminology and of changed practice in the form of the use of seasonal forecasts in decision making. However, it was difficult to determine the extent to which these changes were attributable to the project activities. Our experiences, therefore, support the work by Bennett (1975), and, in addition, we found the evaluation process we used to be time consuming and demanding on labour resources. Perhaps this helps explain the low publication rate of this form of program evaluation.

The effectiveness of the evaluation techniques

Self-assessment v. *test questions*

The apparent discrepancy in the trend of knowledge between the self-assessment and test questions may be because people seem to be imperfect in appraising themselves and their abilities, providing an overall tendency towards inflated self-appraisals (Kruger and Dunning 1999). They found that providing training and improving the knowledge of participants increased their capacity to distinguish accuracy from error, and helped them recognise the limitations of their abilities. As such, it's likely that the climate application activities implemented during the project helped respondents recognise that their knowledge of climate terms and concepts was lower than previously rated and subsequently rated themselves lower in the second survey.

> 'It is the tragedy of the world that no one knows what he doesn't know – and the less a man knows, the more sure he is that he knows everything.' Joyce Cary (1888–1957) British novelist.

You don't know what you don't know, so we hypothesise that self-assessment may not provide a completely accurate indication of the level of knowledge of individual terms and concepts and that test questions are a better tool for this type of evaluation.

Self-assessment to indicate gaps in knowledge

Despite the shortcoming of self-assessment as a tool to compare knowledge over time and assess the level of knowledge, we found the technique useful to help indicate apparent gaps in climate knowledge. Respondents self-assessed their average knowledge of 'probability of exceedance' and 'decadal climate variability' as lowest, and 'sources of weather and climate information' as highest. This information was useful to focus the future climate application activities and indicate potential problems with the interpretation of seasonal forecasts.

Self-assessment indicated that none of the 15 climate terms and concepts averaged a working knowledge (rating of 7), suggesting the average level of knowledge of respondents was inadequate for application in decision making. Twenty percent of respondents rated they had a working knowledge of 'probability of exceedance' and 30% a working knowledge of 'median rainfall'. This suggests that these respondents felt their level of knowledge was adequate to apply these climate terms and concepts to decision making. A working knowledge of these terms is important to accurately interpret probabilistic forecasts.

Unmeasurable bias attributable to the non-respondents

There was uncertainty associated with possible bias in the results because of those who received a survey but failed to respond. As such, the use of seasonal forecasts and knowledge of climate terms and concepts between the respondent and non-respondents in the second survey may have been different. However, respondents and non-respondents to the first survey did not differ in the use of seasonal forecasts in decision making or answering the six test questions correctly when they responded to the second survey. Therefore, in the first survey there was no bias associated with the non-respondents.

Bias in survey results may occur because some respondents may have a particular interest in climate or, alternatively, non-respondents may be correlated with other factors such as management skill, income or climate knowledge. Another check against possible bias in the results between respondents and non-respondents was provided by respondents providing the size of their property. These data was compared with the Australian Bureau of Statistics (2000) recordings of number and size of rural holdings. The average size of all rural holdings for the seven shires was 31 353 ha (ABS 2000), compared with our respondent average 26 181 ha (Fig. 1), and 28 270 ha of respondents in the first survey (Keogh *et al*. 2004*a*). The seven shires cover 20.5 Mha or 12% of Queensland and the variability of property size was large across the survey area.

Because there was no bias associated with non-respondents in the first survey, the second survey sample was randomly drawn from the same population as the first survey sample and the average property size of respondents to the second survey compared with all rural holdings was similar it is possible that little bias was associated with non-respondents in the second survey.

Response rates

The overall response rate of 35% was adequate for the purposes of the survey and fell within response rates of other relevant agricultural surveys. Mail-out surveys using non-purposive sampling of farmers returned variable response rates between 6 and 52% [Childs *et al*. 1991 (43%); Bayley *et al*. 1994 (6%); Hayman and Alston 1999 (20%); Austen *et al*. 2002 (52%); Keogh *et al.* 2004*a* (43%), 2004*b* (19%); Keogh *et al.* 2005 (47%)]. Purposive sampling of selected Queensland graziers returned a 65% response rate (Paull and Hall 1999) and of selected farmers with previous experience in dryland and opportunity cropping practices in southern Queensland and northern New South Wales returned a 30% response rate (McCrea *et al*. 2005).

Use of seasonal forecasts and understanding the terminology

Respondents who used seasonal forecasts in decision making did not have a better knowledge of the terminology used to describe seasonal forecasts (i.e. probability of exceedance, median rainfall) compared with the non-user respondents. This finding may differ from McCrea *et al*. (2005), who found the level of forecast understanding important in predicting the use of seasonal climate forecasts by grain growers in southern Queensland and northern New South Wales. Our study indicates that some seasonal forecasts maybe misinterpreted by graziers, and management decisions may have been made that were not intended. A continuation of the process of learning is required to ensure appropriate use of seasonal forecasting; and the manner in which a forecast is presented and communicated is critical to application success (Lemos *et al*. 2002). More work is required to improve the understanding of climate terminology in the community and the extent to which inappropriate management decisions are made due to misinterpretation of forecasts requires further research and definition.

The nature of current operational forecast systems (e.g. SOI phases, Stone *et al*. 1996) requires knowledge of probabilities and median to adequately understand and apply the forecast to management, but it is apparent from the test questions that about half of our clients in western Queensland don't fully understand these terms. In 2002 given the same question and set of five multiple choice answers provided in this survey, 20% of respondents in pastoral areas of the Gascoyne Murchison in Western Australia selected the correct answer to the same probability question and 44% correctly selected the median value from a set of five numbers (Keogh *et al*. 2005). Keogh *et al*. (2005) attributed the apparent better understanding of probabilities among pastoralists in western Queensland compared with the Gascoyne Murchison was due to (1) the extension activities of the Queensland Centre for Climate Applications officially opened in 1997 exposing Queensland producers earlier and more frequently to climate terminology and seasonal forecasts, and (2) the perceived low SOI forecast skill in Western Australia accounting for lower levels of knowledge. In addition, before the Queensland Centre for Climate Applications was established, Department of Primary Industries and Fisheries officers had exposed Queensland primary producers to ENSO, SOI and seasonal climate forecasts as early as the late 1980s (McKeon *et al*. 1988; Clewett *et al*. 1991, 1994, 1998; McKeon and White 1992). Furthermore, funding of climate applications activities from industry and national organizations such as National Landcare Program, Natural Heritage Trust, Climate Variability in Agriculture Program, Land Water and Wool, which facilitated the appointment of regional climate extension officers from the late 1990s, may have partly attributed to the better knowledge of climate terminology in Queensland.

One climate concept known to pastoralists was the relationship between El Niño and SOI. Eighty-four percent correctly answered that the SOI in an El Niño year is negative, however, the understanding of El Niño and its on-ground impact was less widespread. About half (53%) knew that during a La Niña the sea surface temperatures along the equator in the eastern Pacific Ocean were colder than normal. Many pastoralists falsely associate El Niño's with certain drought, and this perception has probably developed because the droughts of greatest impact in western Queensland in the last 30 years have occurred during El Niño's (e.g. 1982–83, 1991–95, 2002–03) (Cobon and Park 2004).

The low to moderate knowledge of climate terms and concepts among users and potential users of climate information highlights the importance of describing simply, but adequately the (1) meaning of terminology when climate forecasts are issued, and (2) likely consequences if used in decision making.

Preferred means of accessing climate information

The most preferred means of accessing information was internet, email, 'The Season Ahead' newsletter and newspaper. The least preferred were private consultants, extension officers, group meetings and field days. This general preference for methods that focus on self-learning at home rather than direct contact with experts at organised events was seen in the first survey (Keogh *et al*. 2004*a*) and in other isolated pastoral regions (e.g. Gascoyne Murchison region of Western Australia, Keogh *et al*. (2005). In remote areas long distances can make traveling to workshops/meetings both time-consuming and costly, so whenever possible, development of remote learning facilities should be fostered.

The internet was accessed by 86% of respondents and 67% used ADSL broadband internet (April 2003). The download/upload speeds of broadband (up to 1500/256 kbps) enable relatively quick access to large electronic files such as maps, diagrams and photos, which are essential components in communicating climate information.

Strategies for improved communication

Develop and foster remote learning media

The first and second surveys showed a preference for an extension service that focused on delivery of materials to homes where producers could read and learn when it was convenient. As a result we produced 'The Season Ahead' newsletter and a website. The first issue of the newsletter in September 2001 was mailed in hard copy to 70 people and grew through readers promoting and registering themselves to 515 in November 2004 (Issue 12). The newsletter was a quarterly publication containing four pages. The first page featured either articles that were timely or written to target gaps in climate knowledge, the second and third pages contained a map showing proportion of annual rainfall relative to historical records, current climate forecasts of rainfall and pasture growth, current sea temperature maps (surface and sub-surface), positioning and strength of the Madden Julian Oscillation (MJO), surface wind anomalies in the central Pacific, a probabilistic forecast of ENSO for the NINO 3.4 region and simple descriptions of their meaning and likely impact on the region. The fourth page featured articles from invited authors or reported on current research work and other activities in the project.

The newsletter proved to be an effective form of communication because (1) it targeted 'learning from home' or 'self-learning', (2) the information in the newsletter was timely and coincided with key management decisions being made on properties, (3) scientific jargon was left out making it easy to read and understand, and (4) it fostered more learning by referring pastoralists to important and useful websites and other sources of climate information.

The effectiveness of the newsletter as a communication tool was shown (1) by the substantial increase in the mailing list between 2001 and 2004, (2) through feedback received from pastoralists during that time, and (3) by the higher level subscribers used seasonal forecasts in decision making (76% in 2004). Some of the comments received from different subscribers showed that the newsletter was a valuable source of learning material were: 'very informative', 'one of the best things DPI is doing at the moment', 'a very interesting newsletter-keep, it up', 'keep it going', 'it's good-very informative and bright', 'it is a good publication which should continue'. A feedback sheet sent out with the seventh issue of the newsletter showed that 100% of respondents wanted the newsletter to continue and many asked for 6 or 12 issues a year.

The high level of internet access at broadband speed provided an opportunity to distribute 'The Season Ahead' newsletter via email (~120 of the 515 copies distributed by email in November 2004) and to communicate using a website. A website containing climate information specifically targeted to the region went online in August 2004. The continued development of the newsletter and website occurred as part of a subsequent project entitled 'Improved seasonal conditions for wool producers in the Queensland pastoral zone' (Cobon and Park 2004) which was funded by Land Water and Wool Climate subprogram.

Focus on gaps in knowledge

Articles in the newsletter were written specifically to address gaps in knowledge identified in the surveys. Articles on the front page have covered a range of topics including the SOI, SST patterns, ENSO and its effect on rainfall and pasture growth, and the MJO. The contents of the website were developed to improve knowledge of the (1) terms and concepts used in everyday climate science and climate applications, and (2) climate systems that influence rainfall in western Queensland.

Customising climate information to suit user needs

Desired levels of forecast reliability, forecast presentation style, use of terminology, proof of value, access to expertise and perceptions regarding climate information have previously been identified as factors limiting the uptake and use of climate forecasts (Childs *et al*. 1991; Changnon *et al*. 1995; Nicholls 1999; Hartmann *et al*. 2002; McCrea *et al*. 2005). Despite this awareness there have been only minor adjustments to the SOI phase system (a key statistical operational forecast system in

Australia) and its presentation format since 1991, for example some modifications to wording and map definition. Scientists developing new and emerging forecast systems could improve their future use by incorporating features that potential users find desirable.

The pastoral users of seasonal climate forecasts in Australia have identified the need for forecasts to be issued that target the key rainfall period (Day *et al*. 2000; Cobon and Park 2004; Paull 2004; Keogh *et al*. 2005) and have an indicator of forecast skill (Cobon and Park 2004; Keogh *et al*. 2005). These forecasts that target the key rainfall period countdown from long lead-times (0–6 months) and provide more opportunities for decision making compared with existing operational forecasts (e.g. SOI phase) that operate in rolling mode for 3-month periods at zero lead-time (Cobon *et al*. 2005). A thorough understanding of forecast performance helps decision makers determine when and how much to rely on the forecasts as well as how to respond to expected climate anomalies (Hartmann *et al*. 2002). Decision makers need to know when forecasts are not reliable enough for their purposes (Sarewitz *et al*. 2000) and consistent communication of forecast uncertainty can increase forecast credibility (O'Grady and Shabman 1990). It is currently uncommon for operational forecasts to be issued showing past forecast performance so providing an indication of forecast skill that may help producers calculate the risk associated with making a decision that includes the use of a forecast.

Local champions

The low knowledge of some climate terms and concepts in the Australian agriculture sector is not a new finding (Coventry 2001; Dalgleish *et al*. 2001; Keogh *et al*. 2004*a*, 2004*b*, 2005), but it has not been demonstrated until now that the knowledge of climate terminology is similar between users and non-users of seasonal forecasts. Terms such as median and probability form the basis of many seasonal forecasts and a thorough understanding is important for their correct interpretation and use in decision making. Discussions with users of seasonal forecasts in the United States indicate that even managers with technical backgrounds consistently misinterpret Climate Prediction Centre outlooks (Pagano *et al*. 2001). Alternative ways of describing seasonal forecasts such as using frequencies rather than probabilities (Coventry 2001; McCrea *et al*. 2005) may have merit. The challenge of educating producers exists because these terms and concepts are difficult to understand (and apply) (Tversky and Kahneman 1974) and repeated tuition is often needed. Regional extension officers that have post graduate training in climate science and applications can provide the expertise and interaction with producers that maybe required to lift the level of knowledge of climate terminology.

Develop tools that enable analysis of decision options in conjunction with climate forecasts

A systems modelling capability enables analysis of decision options that incorporate many factors that can influence profitability, natural resources and social values (Hammer 2000). Modelling tools that have the capability to incorporate seasonal forecasting into grazing (GRASP; McKeon *et al*. 1990) and farming (APSIM; McCown *et al*. 1996) systems enable whole-of-system simulations to compare the factors that influence agricultural productivity. In this way the value of using a seasonal forecast can be identified and used to help decision making. Use of these tools by extension officers undertaking climate applications activities with producers can improve profits and natural resource management (Hammer *et al*. 2000; McKeon *et al*. 2000; Stafford Smith *et al*. 2000).

Other qualitative findings from the survey and extension activities

Despite the focus of the project using self-learning methods at home and the preference among clients for internet and email delivery of information we feel that face-to-face contact with pastoralists is important to improve the level of understanding of difficult climate terms such as median and probability. Direct contact with extension officers at workshops, information days and field days is needed in association with other techniques to improve the knowledge of climate terminology. With this, an increase in the use of forecasts in decision making is more likely. Collaboration and education between different stakeholder groups in the scientific and user communities is needed (Klopper 1999) and this communication and exchange needs to be ongoing to ensure the application of scientific outcomes.

About half the users of seasonal forecasts didn't fully understand median and probability. However, the question about probability was relatively detailed and technical in nature which may not prove that the respondents didn't understand the basic principles of probability. For example, they may know that as the probability rises (or falls) from 50% the greater (or smaller) the chance that the forecast event will occur. In the same fashion, most of pastoralists know the median is close to the mean or 'middle'. Knowledge at these basic levels may be all that is needed in order for pastoralists to correctly apply seasonal forecasts to management decisions.

Limitations with the research

The program evaluation process we completed was time consuming and demanding on resources and although we measured improvement in overall climate knowledge, we were not able to demonstrate that knowledge of many individual terms and concepts changed over time. In addition, we could only partly attribute the overall improvement in knowledge to the climate applications activities of the project. The main limitations were (1) the measures used (i.e. self-rating of knowledge), (2) the limited power of the statistical tests caused by the survey response rate, (3) the limited power to compare overall change in knowledge of test questions across years caused by too few of the same questions in both surveys, (4) the technical wording in some test questions may be open to misinterpretation and act as a source of respondent error, (5) comparing all respondents in both surveys provides improved statistical power of detecting differences in results through higher sample sizes, compared with smaller sample sizes of respondents common to both surveys, however a potential downfall is a loss of some statistical power due to not being able to account for the individual respondent changes, (6) comparing all respondents in both surveys assumes that the respondents who completed both surveys are of the same population as the respondents who only answered one survey, and

(7) uncertainty associated with possible bias in the use of seasonal forecasts and in climate knowledge between respondents and non-respondents (those selected in the sampling process but failed to respond) to the survey.

Evaluation of programs in future

To help evaluate projects in future we suggest considering the following points: (1) ensure the initial sampling process is designed to meet the objective(s) of the evaluation, (2) use techniques to draw a representative sample and calculate minimum optimum sample size (Scheaffer *et al*. 1990), (3) survey more than the minimum required to fulfill the minimum required and enhance timeliness of response, (4) ensure test questions are technically accurate, (5) use test questions to identify levels of, and change in knowledge, (6) use self-assessment to identify gaps in knowledge, (7) to evaluate project success as a result of an extension program, and (8) endeavour to complete the evaluation when sources of external information (e.g. radio, newspaper, TV headlines) and public interest in the topic are low so it's easier to conclude that changes are more likely due to the project.

Conclusion

About half the surveyed clients used either a forecast of rainfall or pasture growth during 2002. However, about half of these didn't fully understand key components of seasonal forecasts (e.g. median, probability). This identifies the potential for misinterpretation of seasonal forecasts that focus on maps presenting the 'probability of exceeding median rainfall' (or pasture growth). However, the test question about probability was relatively technical and most of pastoralists may understand the basic principles of probability. Knowledge of probability and median at these basic levels may be all that is needed for pastoralists to correctly apply seasonal forecasts to management decisions. Despite this the respondents didn't rate their knowledge of most climate terms and concepts as having a 'working knowledge', highlighting the need for more climate applications activities, ideally with a mix of email, internet, newsletter and face-to face activities.

The process of having a survey at the beginning and end of a climate applications campaign provided an opportunity to assess the change in climate knowledge during the project and evaluate the effectiveness of the extension campaign. We found an increase in the use of seasonal forecasting in decision making. There was an overall decrease in self-assessed knowledge of climate terms and concepts, but test questions indicated an increase in knowledge. The apparent difference in knowledge change between self-assessment and test question techniques was attributed to optimism bias and inflated self-appraisals in the initial survey. After the extension activities, the respondents may have recognised their knowledge limitations and subsequently rated themselves lower in the second survey.

Therefore, we found the self-assessment technique unsatisfactory over the short 2-year timeframe to identify changes in levels of knowledge. Alternatively, the test question technique removed the possibility of optimism bias distorting the results and was preferred over short intervals between surveys (1–3 years). However, we have not examined the utility of using self-assessment to measure change in knowledge over longer timeframes. We did find self-assessment useful to provide a snapshot of the level of knowledge of a range of climate terms and concepts to identify the gaps in knowledge and target extension activities.

The increase in the use of seasonal forecasts or improvement in knowledge of climate terminology was partly attributed to the work completed in the project as learning from sources external to the project was likely to have occurred. The challenge for research and extension workers is to develop evaluation methods that identify the extent of learning from exogenous sources.

Surveying clients at the beginning and end of the project was a useful means of improving project design and delivery, and of measuring its success. The initial survey provided a benchmark of levels of knowledge, and identified gaps in knowledge that were addressed in the climate applications activities during the project. Importantly, the first survey identified a client preference for printed material and an opportunity to publish and distribute a newsletter and website was identified. By development of 'The Season Ahead' newsletter, we increased our ability to communicate and impart complex climate terms and concepts via print. The development of a customised website in a subsequent project provided the opportunity to expose climate information via electronic medium. Both media provide vehicles for portraying maps and other visual tools and offer the means of learning at home in ones own time.

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