Improving Farmer Knowledge and Skills to Better Manage Climate Variability and Climate Change

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Abstract
Although it is expected that farmer education will improve climate risk management, there is only anecdotal evidence that this is true. We wanted to approach and test this in a more rigorous way.

A needs analysis showed that only 30% of farmers believe they are competent or very competent to manage climate risk and, as a consequence, they consider flexible education and training as one way to address this issue. In consultation with farmers, educational resources were developed to cover strategic thinking for managing risk, climate variability impacts, management options, planning and monitoring decisions. Training with this package was delivered to fifteen farmers and consultants over a week, with feedback recorded at the end of each session and post-training. Measurements were made of knowledge, attitude, skills and aspirations (KASA), and followed with assessment of end-result and practice-change.

After this training, farmers improved their competency, from 2.2 (before) to 3.9 (after) on a proficiency scale of one to five. From the feedback, a “problem-based” resource manual was refined to appeal to a broad range of agricultural enterprises such as livestock, horticulture and cropping, and across diverse climates. Farmers can best learn about improving management of climate risk through a variety of ways that include exercises, discussion, reflection and putting their ideas into practice. Actions resulting from the training included development and enactment of strategic plans.

Keywords: Applied Climate Education, Climate Variability, Climate Change, Sustainable Agriculture, Climate Risk

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Introduction

The climate of Australia is one of the most variable in the world. A better understanding of this variability and of the application of seasonal climate forecasts is central to the profitability and competitiveness rural industries and for sustainable resource management (Munro & Lembit, 1997). Recent developments in climate science help us with this understanding and in forecasting events such as El Niño and drought (Hammer, 2000). Traditional approaches by farmers when managing climatic risk include avoidance, minimisation and transfer (Hardaker, Huirne, & Anderson, 1997). Avoiding climate risk often took the form of off-farm investment; minimising climate risk was often presented through diversification of enterprises; and transfer of climate risk was often by insurance. The overlying threat of climate change implies that payoffs from managing climate variability, particularly with risk minimisation by diversification, may not necessarily be similar in the future, particularly if dry times are more frequent, longer and more severe. Thus the importance of climate change becomes even more critical if considered with declining terms-of-trade (Cai et al., 2003; Douglas, 1997).

Few studies examine the effectiveness of climate education targeting farmers in Australia (George, Clewett, Selvaraju, & Birch, 2006; Grimson, 1999). The evidence indicates that applied climate education should improve knowledge and skills, thus build capacity to contribute to a sustainable agriculture in a variable climate and where the climate change issue is increasing in importance (Cai et al., 2003; George, Birch, Buckley, Partridge, & Clewett, 2005; Nelson, Holzworth, Hammer, & Hayman, 2002).

Climate variability, manifested as in drought, adds to social and environmental stress (Judd, Cooper, Fraser, & Davis, 2006; Page & Fragar, 2002; Sartore, Hoolahan, Tonna, Kelly, & Stain, 2005); this means that climate education needs to be managed sensitively because a sudden change in social and economic position may leave individuals unable to cope. In many rural communities, there are only limited educational and employment opportunities, and such social pressures may lead to a sense of powerlessness and loss of hope. There may even be a reluctance to consider applied climate education as an option worth considering (Shrapnel & Davie, 2001). Thus applied climate educators must be mindful of emotional issues, try to complement other programs, and be seen as positive contributors when this work coincides with extreme drought as in much of eastern Australia during 2002 and mid-2006. Producer psyche presenting as bias and rules-of-thumb also need to be recognised in any education (Nicholls, 1999). The complexity of applied climate education requires expertise in climate science, agriculture and education, and the intricacy of the task should not be underestimated (Roberts & Dyer, 2004).

In general, farmers are concerned about the lack of accuracy of seasonal climate forecasts and their use (Buckley, 2002; George et al., 2007-a). This concern may become a justification for not undertaking education and training. The use and value of learning theory (Bransford, Brown, & Cocking, 1999) to enhance farmer management of climate risk may well overcome this obstacle. The issue has not been thoroughly investigated or documented in Australia (Burton, 1997; Howden et al., 2003; Smit, Burton, Klein, & Wandel, 2000).

This paper addresses several learning and educational issues that are confronted when developing a vocational education course to enhance management of climate risk. We firstly describe the methods used to develop a course concerning the development and application of relevant strategies for managing climate risk, and then describe content of the course and the resource materials, before evaluation from
pilot testing the course with a group of farmers and agricultural consultants. Issues concerning the development of educational resources and delivery of applied climate education are examined. Examples of risk management strategies relevant to Australian agriculture are given.

Methods

Course Requirements

A reference group of farmers, industry representatives, scientists and educators was established to guide development of a vocational education course for managing climate risk. This group identified the following broad parameters. The course content should be relevant at a managerial level to sectors of the community that are impacted by climate variability and climate change such as the farming sector (farmers, natural resource managers, agricultural consultants and agribusiness). Content should address the performance criteria of units in the Australian Qualifications Framework so that course participants may gain qualifications for their investment in education. The learning methods used should have a strong theoretical basis, be developed to achieve national standards in vocational education and be relevant to the needs of decision-makers. The learning objectives should seek to improve the knowledge and skills of decision-makers in relation to the:

- Capacity to compile and survey data concerning climatic and enterprise issues that are impacting on the performance of their enterprise;
- Analysis of climatic risks and opportunities (e.g., droughts and flood risks associated with climate variability and climate change), impending seasonal conditions (e.g., forecasts of El Niño or La Niña conditions) and managerial options; and,
- Development and application of strategies for more effective management of climatic risks so that the performance of the enterprise is improved.

Given these criteria, the course “ClimEd: Managing Climate Risk” was developed to achieve the elements and performance criteria specified by the vocational education unit “Develop Climate Risk Management Strategies” (DCRMS) which is a nationally accredited Unit of Competency at Level 5 in the Australian Qualifications Framework (George, Clewett, Birch, Wright, & Allen, 2007b). The learning objectives of the ClimEd course require a substantial investment in time and go far beyond a simple one-day skills development workshop. The nominal times for the unit are 40 hours theory and 40 hours practical.

The process used to identify and refine the content of the ClimEd course, and also the methods to most effectively deliver it included:

- An analysis of results from a survey of the farming sector that clearly showed the need for vocational education courses in the community concerning management of climate risk (George et al., 2007a, b);
- Development of printed reference materials;
- Feedback from participants attending a 5-day pilot course and completing (as a subsequent project), the analysis and development of climate risk management strategies for their own business; and
- Commentary and feedback from the “expert” reference group described above to ensure the course meets the needs of participants and is robust from both educational and scientific perspectives.

Educational Design and Delivery

The method chosen to deliver the ClimEd course was based on a combination of experiential learning (Kolb, 1984), participative action research (Zuber-Skerritt,
1993) and learning theory (Bransford et al., 1999). The delivery methods also recognised that farmers generally prefer training that is practical and helps to provide immediate solutions to problems in their business (Kilpatrick, 2000). The educational design incorporated a mix of experiences for activists, review time for analysts, drawing conclusions for theorists and planning the next steps for the pragmatists (Honey & Mumford, 1986). The course-work and project were designed to engage all these preferred learning styles.

A five-day pilot ClimEd course was held in May 2003 and attended by 15 participants who had responded to a national advertisement. The format of this course involved a series of presentations with evaluation sheets completed at the end of each session. The presentations were made by an experienced farmer, scientists with specialities in climatology and agriculture, agricultural extension specialists and the participants. Many of the workshop exercises involved use of the internet and computer software to assess climatic risks and the likely outcome of various management options. This software included the climate analysis and education package “Rainman StreamFlow” (Clewett et al., 2003), and the broadacre crop analysis software “Whopper Cropper” (Nelson et al., 2002). Internet sessions examined data on the weather, climate risks and pasture productivity from a range of web sites including the Bureau of Meteorology and others (see references). The projects started during the pilot workshop were completed by participants in the weeks following. Each participant selected a supporter during the workshop to act as a mentor and for peer review.

Registered training organisations were able to accredit participants who fulfilled the course competencies by including this unit within the scope of courses they offer.

Evaluation

Evaluation of the course was through qualitative and quantitative methods described by Bennett (1976) and Davis (2003). Feedback sheets were used at the end of each session for reflection and consideration as to how information could be applied to their situation. Evaluation immediately following the training covered questions concerning inputs, activities, reactions, and change in knowledge, attitude, skills and aspirations (Bennett, 1976). Post-workshop analyses of “end result” and “practice change” were undertaken by survey and semi-structured interviews at year 1 and 3 as part of the longitudinal study to triangulate results (Cohen & Manion, 1994).

Results

Principles

A key finding was that the course should highlight the need for a strategic approach in managing climate risk. The benefit from adopting a strategic planning approach is that management decisions are focused on ways to achieve goals and integrated with overall business operations. There is a need to go beyond one-off climatic decisions that are isolated from other risks and elements of the farm business (Malcolm, 1992). Isolated decisions (such as one-off responses to seasonal forecasts) do not encourage thinking and planning for an integrated approach to managing climate events such as a sequence of seasons with below-normal rainfall, or the interactions of climatic risk with other production and market risks (McKeon, Hall, Henry, Stone, & Watson, 2004) and climate change projections (George et al., 2005; Howden et al., 2003).

The order of the risk management approach we used covered strategic thinking, analysing climate and weather risks and impacts, assessing options, and developing and acting on plans. This conforms to generic approaches to managing risk such as the Australian Standard on risk...
management as shown in Figure 1 (Climate change impacts, 2006). This process also favours learning for understanding and tailors the work to suit an individual’s circumstances.

The reality of the variable climate on their (farmer) enterprises and business become prominent, climate change projections that are expected to impact on their operations are addressed. The necessary solutions need to be weighed, acted out and assessed according to their viability and capacity to manage. It helped farmers to recognise the climate risks and apply them in their management situation. The logical consequences are then components of the knowledge and skills needed in the course delivery and are described below.

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**Figure 1.** Steps in the risk management process (Source: Climate change impacts, 2006). Permission to use Figure 1 (recommended framework for risk management) is provided by the Australian and New Zealand Standard AS/NZS 4360 Risk Management, as published by the Australian Greenhouse Office (Climate change impacts, 2006).

**Course Delivery**

The second key finding was that the course should have a modular format that provides for a flexible mode of delivery and achieves the required learning outcomes by developing analytical and decision-making skills through the following six units and project:

- **Unit 1.** A strategic approach - investigating climate and weather and business. The objective of this introductory unit is to highlight the benefits of strategic thinking and planning, to clarify terms like “risk,” and to explore participant goals on which climate risk strategies could be targeted.
- **Unit 2.** Weather and climate - assessing weather processes and evaluating climate risk. The unit identifies and analyses risks relating to the enterprise,
explores mechanisms of meteorological processes causing climate variability and phenomenon such as the El Niño - Southern Oscillation (ENSO), Madden-Julian Oscillation and climate change, reviews the availability of relevant data (particularly historical weather data), and examines the basis, skill and interpretation of probability based forecasts.

- **Unit 3.** Impacts - analysing the influence of weather and climate on performance of land and water systems. This unit builds skills to assess the impacts of climate on the environment and agricultural systems. It uses tools to help determine impacts of climate on enterprises and business.

- **Unit 4.** Options - exploring alternative options for business and environmental management. This unit assesses the importance of climate variability on the business and clarifies options and actions to better manage risks and take advantage of opportunities.

- **Unit 5.** Plans - developing strategic plans for better management of climatic and weather risk. This unit integrates previous units and reviews climate and weather risks and opportunities, develops strategies and identifies appropriate actions to address climate risk.

- **Unit 6.** Decisions and actions - establishing methods to monitor and respond to climate and weather information in business. This unit establishes decisions and actions and methods to monitor and respond to climate and weather information.

- **Project.** A project is a requirement of the course. It enables participants to develop the skills needed to apply what has been learnt to their own situation. This project requires a comprehensive survey of climate and enterprise data, an analysis of climate risk and opportunities, and a document showing how climate risk management strategies were developed and applied in the business.

**Educational Resource Materials**

A resource book was developed with sections covering key concepts, introduction, and a body with relevance of the topic to industry (George, 2004). The course was developed in a module format to make it more attractive for participants to attend in one-day training rather than as a one-week block. The structure was problem-based and enabled course participants to think about their own risk management issues and work towards their own risk management plan by the end of the course, with applicability to any rural enterprise and climatic zone. Each section of the notes has exercises to support the text, and is used by participants to see how information may be applied. Gross margin budgets were used for financial impacts. A position statement covering personal, financial and an environmental situation analysis was outlined, along with steps for strategic planning. The course refers to examples of local conditions relevant to the participant.

**Achievement of Learning Outcomes**

Fifteen participants attended the ClimEd Pilot training in May 2003. The participants represented agricultural industries of grazing and wool-sheep, prime lambs, beef cattle, irrigation and dry-land crops and agribusiness from several states throughout Australia. There was a relatively even age spread amongst the group (from 20 to 65 years of age), which comprised thirteen males and two females. The participants had diverse educational backgrounds including those who finished primary school only and others with vocational, tertiary and post-graduate qualifications. Nearly half of the participants had over 21 years of experience in their industry.

Feedback from all the sessions are summarised and described in the following tables. Table 1 shows a pre-post achievement of learning outcomes. Table 2
shows ratings about session relevance and usefulness. Data was also collected on where forecasts and climate information could be used in key decisions (Box 1) and some strategies developed (Box 2).

Participants completed the one-week course and were then expected to undertake projects to apply principles learnt to their own situation. Twelve out of the fifteen developed written strategic plans to better manage the variable climate. Three of the twelve submitted their projects to receive accreditation with The University of Queensland.

Table 1

Achievement of Learning Outcomes by Comparing “Before” versus “After” Self Ratings of Workshop Participants (n = 15)

<table>
<thead>
<tr>
<th>Competency</th>
<th>Start of course Mean (variance)</th>
<th>End of course Mean (variance)</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey climate and enterprise data</td>
<td>1.9 (± 0.1)</td>
<td>3.6 (± 0.5)</td>
<td>5.67**</td>
</tr>
<tr>
<td>Analyse climate risk and opportunities</td>
<td>2.1 (± 0.6)</td>
<td>4.0 (± 0.3)</td>
<td>7.25**</td>
</tr>
<tr>
<td>Develop climate risk management strategies</td>
<td>1.9 (± 0.6)</td>
<td>4.0 (± 0.3)</td>
<td>8.10**</td>
</tr>
<tr>
<td>Ability to develop a plan for the business</td>
<td>2.8 (± 0.8)</td>
<td>4.3 (± 0.2)</td>
<td>4.28**</td>
</tr>
</tbody>
</table>

Note. Self-assessed rating (1-5) before/after workshops: 1 = not very competent; 3 = competent; and 5 = very competent.

**p < 0.01.

Results from Table 1 demonstrate that, by attending the course, participants were now better able to: survey climate and enterprise data; analyse climate risk and opportunities; develop climate risk management strategies; and, develop a strategic plan for their business.

Participants were very satisfied that the material was relevant and useful. All participants said they would recommend this course to a colleague (Table 2). The longitudinal study revealed 13 of the 15 participants had implemented new climate risk management strategies developed from the course.

Table 2

Summary of Session Feedback (n = 15)

<table>
<thead>
<tr>
<th>Items</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response to “…would you recommend this to a colleague.”</td>
<td>100</td>
</tr>
<tr>
<td>Participants implementing climate risk management strategies developed from the course</td>
<td>86</td>
</tr>
<tr>
<td>Participants Ratings:</td>
<td></td>
</tr>
<tr>
<td>Course relevance*</td>
<td>4.1</td>
</tr>
<tr>
<td>Sessions</td>
<td></td>
</tr>
<tr>
<td>Analysis of climate impacts on cropping systems</td>
<td>8.3</td>
</tr>
<tr>
<td>Development of climate risk management strategies and plans</td>
<td>7.2</td>
</tr>
<tr>
<td>Introduction and strategic thinking / planning</td>
<td>7.3</td>
</tr>
<tr>
<td>Analysis of climate impacts on pastures and grazing systems</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Note. *Scale: 1 = not satisfied; 3 = satisfactory; and 5 = extremely satisfactory. Scale: 1 = not so good…10 = excellent.
Box 1 presents information on where seasonal climate forecasts and climate information could be used in key decisions. The data supported previous research results to the effect that improving knowledge and skills in climate and agriculture can be used in enhancing decisions about cropping, grazing and natural resources (Hammer, 2000).

**Box 1. Some responses to “What do you think are the key decision points in the agricultural system where seasonal climate forecasts may be useful?”**

- Using the Southern Oscillation Index in spring to forecast summer rainfall and thus determine best crop or livestock options
- Preparing “drought” policy - grazing and budgeting for our mixed livestock, cropping and irrigation operation
- Probability and reliability assessments for water trading and irrigation management

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Examples of climate risk management strategies developed by participants, to achieve the goal of “developing improved drought-resilient farming systems” are shown in **Box 2**.

**Box 2. Examples of some climate risk management strategies developed by participants, to achieve the goal of “Develop improved drought resilient farming systems.”**

- Adjust crop type and area based on current soil moisture and expected future climate conditions
- Develop objective livestock decisions in rangelands by matching stock numbers to expected feed supply
- Adjust irrigation regimes based on expected water supplies and irrigation demand
- Develop off-farm investments to generate cash-flow in years of expected lower production and prices

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In response to *what worked well in different sessions*, it was clear that there was value in describing weather and climate systems, plus the latest climate change information. Climate prediction limitations and reliability information were also undisputed as important. Modelling tools for cropping and grazing were also considered valuable insofar as examining the impacts and options of weather and climate on enterprises and natural resources. Comparing different forecast systems and including forecast accuracy and climate change projections were some of the suggestions of *what could be included* in any applied climate education and are described in detail in a companion paper (George et al., 2007a). The discussion elaborates on analysis and implications of these results.

**Discussion**

The most important finding from this work was confirmation that the educational content and process used with the pilot group led to improved knowledge and skills to better manage climate risk. Furthermore, the subsequent longitudinal study with this group showed that the improved knowledge and skills translated into more sustainable practices (George, Clewett, Wright, Birch, & Allen, 2006). The main reasons for this success are discussed below, together with several ways to improve the course. This discussion on applied climate education is based on learning theory (Bransford et al.,
1999), experiential learning and action research and is framed on the following six areas.

**Cultural and Social Norms**

Conducting the pilot within the cultural and social norms of the participant group helped to achieve learning outcomes. This helped the educational process in several powerful ways as described by Bransford et al. (1999). Two examples of this concern “credibility” and “subject matter.” Firstly, the credibility of the learning was consistent with social norms because it was organised and delivered by respected organisations and individuals. Secondly, the subject matter with its focus on developing climate risk management strategies was highly relevant to the needs of participants. We recognised the current circumstances of the industry concerning compounded years of drier than normal times, and often associated low cash flow, low equity and high emotional stress. This meant the immediate problems for many were about the “…here and now…” that needed to be addressed before new learning could be considered.

Managing climate in Australia is a complex socio-economic and environmental problem that has no simple answer and there have been numerous inquiries to address climate variability and drought issues confronting agriculture. However, vocational education on risk management has a role to play and can improve knowledge in the farming sector to better manage climate variability and change. The depth and extent of the current drought (viz. mid-2006), in parallel with climate change, lead us to think the importance of social and cultural norms will be even more important in the future and necessary to consider for any successful applied climate education.

**Building on Pre-existing Knowledge**

The ClimEd course is targeted to people already managing farm and natural resources who want to enhance their climate risk management skills. Their previous experience provides the basis on which participants can survey climate and enterprise data, analyse climate risks and opportunities and develop better climate risk management strategies. Thus, pre-existing knowledge plus information from the course is used to progress from basic to more advanced concepts (George et al., 2005; George, Birch, Clewett, Wright, & Allen, 2005). There is also a need to pay attention and address any unhelpful or false concepts learners bring with them.

A challenge for educators with applied climate education is to determine the “acceptable level of improved knowledge and skills?” Incremental improvements in knowledge and skills that build on pre-existing knowledge are important, but the overall objective is to attain autonomous learning. This is a notion for lateral-thinking and problem-solving as advocated by de Bono (1967). It has advantages in utilising collective wisdom to resolve complex issues and leads to greater autonomy in thinking and problem-solving. We found this approach is achievable with producers who have backgrounds of either elementary or advanced education, who progressed along the didactic-autonomous learning spectrum (Knowles, 1975).

Feedback coming from the evaluation shows that participants believed they were better able to manage climate risk as a result of attendance at this training. We recognise that participants can sometime overvalue their abilities (Kruger & Dunning, 1999) and so longitudinal investigations were undertaken and will be reported in a future companion paper.

**Introduce Important Concepts for Advanced Reasoning**

The pilot training recognised six key concepts for applied climate education refined from work by Clarkson (2000) and Clewett (2003). These were:

1. Awareness and determination of the extent of climate variability. An up-to-
date climate record is valuable as a learning tool on which to build from recent experience. This includes interpreting weather systems and knowledge of how climate is modified by seasonality and other forces such as ENSO and greenhouse gases.

2. Description of climate systems and the causes of variability and using information from historical records for the particular location to describe local variability. The ENSO phenomenon explains a large part of the climate variability in Australia but users must know where and when ENSO may be useful as a climate predictor. An ability to understand specific terms like “mean,” “median” and “probabilities” to assess climate risk was also essential.

3. Adaptation and mitigation to climate change issues including changes that may have occurred in recent decades and those likely to occur in the next several decades in both the global and local contexts.

4. Capability to use analytical tools to describe the variability and assess climate risk. Information useful to management includes expected rainfall probabilities concerning the amount, timing and frequency of seasonal rainfall, incidence of frost and heatwaves and decadal shifts in climate. Characterising drought duration and frequency (and forecasting) is recognised as being the most important climate skill required by producers (George et al., 2007a). Inherent uncertainty is covered by probabilistic forecasts.

5. Evaluation of forecasts used in risk management strategies including short-term forecasts associated with daily conditions and decision making, seasonal forecasts associated with tactical or strategic responses, and long-term climate change forecasts that may be linked with structural changes to the resource base or business enterprise.

6. Application of climate and weather forecasts and risk information to key decisions. Forecasting climate variability provides producers with an edge in the goal of producing a right quality product at the lowest unit cost possible under a sustainable system.

These were manifested in the six units delivered to the group and described previously in the “course delivery” section of the results. That this was important and helped reasoning, can be speculated from the high rating of satisfaction from course participants and in the unanimous recommendation of the course to colleagues (Table 2). To help demonstrate important concepts, the educational materials and support of specific rainfall, streamflow, pasture growth and temperature data analysis tools help to empower participants, because these tools illuminate the importance of climate impacts, and the increasing relevance of this to their business.

**Structuring Learning Experiences**

Farmers are predominantly action-oriented (Kilpatrick, 2000; Shrapnel & Davie, 2001). They want to know about climate science and change projections and how this is likely to impact on their operations, the options available and the consequences of their choices. The benefit of the strategic planning project was the opportunity for participants to apply new information and concepts as outlined above, in new settings to their business, using the structured risk management approach in Figure 1. This is consistent with the action research cycle (Zuber-Skerritt, 1993) which is known to promote adoption of autonomous learning. Eighty percent of the fifteen participants completed their projects and hence developed climate risk management strategies for their business. The three who submitted their work for certification, did so to achieve business and personal goals. The remaining nine used their plans for on-farm and business uses.
that did not require the qualification. The formal qualification was appealing to a small but important percentage of participants and this is consistent with other research (Kilpatrick, 2000), but it was incidental to most participants who emphasised learning for specific solutions to problems. The extent of what was applied from the participants learning is detailed in a future companion paper.

In addition to the project, another factor of importance was our delivery being held over five consecutive days. This had advantages for the national workshop but participants were fatigued by the end of the week because of the unfamiliarity of sitting and doing desk-work for that period of time. A better approach for local workshops would be to collaborate with participants to schedule when and how often to meet to complete the desired tasks with smaller amounts of information being able to be considered and applied before re-meeting and discussing the next stages of work. It is important to offer the education and training as a set of modules that can be tailored to suit the needs of participants and trainers.

**Emerging Technologies**

Learning and the development of risk management concepts were enhanced through use of new technologies. In particular this included advances in agriculture and climate sciences coupled with advances in information technology to analyse climatic risks at locations relevant to the enterprises of workshop participants. Examples include: (1) use of the Southern Oscillation Index and the analytical capabilities of the Rainman Streamflow software (Clewett et al., 2003) to assess the skill of seasonal climate forecasts concerning probabilities of seasonal rainfall, on-set of the wet season, frequency of storm events, likelihood of frosts, and expected levels of runoff and streamflow, (2) analysis of various grain sorghum cropping options using the latest advances in knowledge contained within the Whopper Cropper crop modeling software (Nelson et al., 2002), and (3) analysis of real-time climate impacts on the condition and productivity of native pastures in the Australian rangelands using the on-line Aussie GRASS model (Carter et al., 2000). Recognition of changes in the skill of ENSO-based seasonal forecasts with time of year, lead-time and location are important in risk assessments (Clewett, 2003). These new technologies help to demonstrate agro-climate concepts in the training and were used to approach the problem of better managing climate variability with strategic planning. The technology helped to understand the elements of competency (Tables 1, 2), with actual applications (Box 1). These tools were then able to help answer, “What if…” questions that arise from the exercises, discussion and reflection sessions.

The following kinds of questions can be addressed by the new technologies and assist discussion about climate variability and better decisions.

- **Cropping** - what are the chances of getting sufficient rainfall over the next cropping season?
- **Livestock** - when is the wet season likely to break and how much pasture will be produced over the growing season? What will be the optimal stocking rate?
- **Irrigation** - how many high flows could be expected in the local river this year? What are the chances of getting heatwave conditions during the crop’s flowering period?
- **Resource management** - have heavy rainfall events become more frequent in recent years? Is it getting hotter with climate change at this location?
- **Up-to-date and accurate climate change projections** are needed to ensure the accuracy and necessary “cutting-edge” work is maintained and credible.

**Learning from “Wisdom of Practise”**

Our training used experienced climate scientists. We also used discussion sessions where participants shared their
experiences of managing the variable climate. The producer peer review process we put in place was good in theory. In practice though, this was difficult to achieve because unless cooperation occurs on a regular basis, it is difficult to obtain success. The pilot group came from distant locations so that synchronising times and availability to compare and discuss work was difficult (and also expensive if using long-distance phone calls when email was not the usual way of communication - which was the case for some). It is felt that if a local group was established, this problem may be more easily overcome.

In summary, this pilot group information has been helpful to derive the development, delivery, evaluation and subsequent direction of the applied climate education. The response from producers is that applied climate education has helped and will help to improve knowledge and skills, enhance agricultural and natural resource management decisions and reduce climate risk. This work supports the use of experiential learning, participative action research and learning theory.

**Conclusion**

Our study has provided evidence that appropriate and timely applied climate education that develops climate risk management strategies, is an important factor that can improve knowledge and skills to better manage climate variability and climate change. Emphasis on a flexible modular course that has a strategic approach to risk management is important. Key steps are: defining components of the strategic approach, analysing weather and climate data, assessing impacts, evaluating management options, developing plans and making decisions by applying these plans to the farming business. The response from participants was that this course provided new information and was an achievable challenge that was helpful to the way they strategically and tactically approached their management of the variable climate. An appropriate management level course on climate risk can be successfully delivered to a broad-based audience by combining the knowledge and skills of participants with sound facilitation processes, rigorous education resources and up-to-date technical knowledge. Learning needs to go beyond awareness of climate issues to skills development and application in decision-making.

These results are supported by a small but significant sample with intervention from experts that may or may not be available for all training. Significant results in this work can be attained if vision, personnel and resource issues are addressed and targeted to this end. It is unclear what can be attributed to climate education alone in the overall scheme of improved climate risk management demonstrated by the group members in addition to other factors such as increased availability and use of weather and climate tools on the internet, and increased awareness of climate change. Climate education is a positive factor that should not be ignored. Furthermore, if it is argued climate education helps to better manage climate variability, this will also then help to better manage and adapt to climate change. The impacts of climate change are becoming increasingly clear and rapidly evolving, and so adding to the resources and delivery of this work as new research results become available is critical.

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