

Using seasonal climate forecasting in agriculture: a participatory decision-making approach

Editors: A.K.S. Huda and R.G. Packham

Australian Centre for International Agricultural Research
Canberra 2004

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has a special research competence.

Where trade names are used this constitutes neither endorsement of nor discrimination against any product by the Centre.

ACIAR TECHNICAL REPORT SERIES

This series of publications contains technical information resulting from ACIAR-supported programs, projects and workshops (for which proceedings are not published), reports on Centre-supported fact-finding studies, or reports on other topics resulting from ACIAR activities. Publications in the series are distributed internationally to selected individuals and scientific institutions and are also available from ACIAR's website www.aciar.gov.au.

© Australian Centre for International Agricultural Research, GPO Box 1571,
Canberra, ACT 2601

Huda, A.K.S. and Packham, R.G., ed 2004

Using seasonal climate forecasting in agriculture: a participatory decision-making approach.
ACIAR Technical Reports No. 59, 52p.

ISBN 1 86320 475 X (print)
1 86320 476 8 (electronic)

Cover design: Design One Solutions

Typesetting, editing and layout: Sun Photoset Pty Ltd, Brisbane, Australia

Printing: Elect Printing

Contents

Foreword	5
Introduction and Overview	7
<i>A.K.S. Huda, R.G. Packham, J.F. Clewett and D.A. George</i>	
Factors affecting the use of climate forecasts in agriculture: a case study of Lombok Island, Indonesia	15
<i>R. Sayuti, W. Karyadi, I. Yasin and Y. Abawi</i>	
Experiences of using seasonal climate information with farmers in Tamil Nadu, India	22
<i>A.K.S. Huda, R. Selvaraju, T.N. Balasubramanian, V. Geethalakshmi, D.A. George, and J.F. Clewett</i>	
A farmer's view of the human constraints to the adoption of seasonal climate forecasting in Australia	31
<i>J. Hoffmann</i>	
A background to participative approaches for research and application of climate science	35
<i>R.G. Packham</i>	
Workshop	42
<i>A.K.S. Huda, R.G. Packham, R.D. Macadam and B. McKenzie</i>	
Conclusion	46
<i>A.K.S. Huda and R.G. Packham</i>	
List of Workshop Participants	49

Foreword

The impacts of climate variability on agriculture are large, particularly in those countries affected by the El Niño/Southern Oscillation phenomenon such as Australia, Indonesia, Africa and India.

The challenge in using seasonal forecasts in agriculture is to assess and capture the potential benefits so that the well-being of people is improved in terms of increased food security, protection of the resource base, lower costs or better economic outcomes within the community.

This report arises from an ACIAR project that involved 10 agencies from four countries — Indonesia, Zimbabwe, India and Australia.

The three main benefits of the project were: improved knowledge of climate and seasonal forecasts; the value of seasonal forecasts in agriculture; and how to develop skills in farmers, extension staff, planners and other resource managers to make good use of seasonal forecasts in managing climate variability.

This publication should be of benefit to researchers, farmers, extension and other community workers in the developed and developing world who are wanting to help farmers make improved decisions, particularly about managing with climate variability, but including the implementation of any proposed technological development.



Peter Core
Director

Australian Centre for International Agricultural Research

Acknowledgments

The success of this publication has been achieved through the inspiration and hard work of many people, and the support of many organisations in four countries — Australia, India, Indonesia and Zimbabwe — where the ACIAR-funded project on ‘Capturing the benefits of seasonal climate forecasts in agricultural management’ operated.

Thanks are due to Associate Professor Robert Macadam and Bruce McKenzie for facilitating the workshop held in April 2000 at the University of Western Sydney (UWS), Hawkesbury campus, which formed the basis of this publication.

Special thanks are due to Tim Ellis for his assistance during the workshop and Mamoon Huda for his support in follow-up work after the workshop, which led to the production of this publication.

Finally we give our gratitude and appreciation to ACIAR and UWS for their support.

Introduction and Overview

A.K.S. Huda¹, R.G. Packham¹, J.F. Clewett² and D.A. George²

CLIMATE variability has a large impact on agricultural production, human health and the well-being of communities throughout the world; therefore research in this field has a high priority in many countries, including Australia. The impacts of climate variability are particularly relevant in those countries affected by the El Niño/Southern Oscillation (ENSO) phenomena, such as Australia, Indonesia, southern Africa and India. For example, the 1982–83 El Niño caused devastating drought in southern Africa, India and Australia, and forest fires in Indonesia. The four-year 1991–94 El Niño caused famine and the death of thousands in Africa, and agricultural losses of more than \$6 billion in the Australian state of Queensland. In East Java, the ENSO-related drought in 1991 caused 190 000 ha of rice to be abandoned due to insufficient water for irrigation at a cost of \$28m in lost inputs. The drought of 1997–98 in Indonesia and Papua New Guinea caused significant crop losses and forest fires, resulting in one of the largest famine relief operations mounted by the Australian government to aid these countries. During the mid-1950s and 1970s, higher than average rainfall provided opportunities for better harvests in many parts of Australia, whilst the early 1930s and 1990s brought drought and crop failures.

Farmers and those involved in the agricultural sector are well aware of climate variability. The ability to understand, monitor and predict this climatic variability provides an opportunity to put historical experiences into perspective and to evaluate alternative management strategies for making improved decisions to take advantage of good years whilst minimising the losses during the poor years (Huda, et al. 1991; Huda, 1994; Pollock et al. 2001). Significant progress has been made by scientific research over the last decade to understand the atmospheric and oceanic processes causing ENSO, and this knowledge is now used to make seasonal

climate forecasts on a regular basis. However, a significant problem remains of translating seasonal climate forecast (SCF) information into appropriate actions by farmers and other resource managers so that the potential benefits from forecasts are captured. This problem can be overcome in a number of ways, including:

- identifying the key decisions and practices in the farming cycle to which forecast information may be applied;
- improving the tactical and strategic responses to information; and
- education and effective communication.

This introductory chapter highlights how this publication fits within the ACIAR-funded project *Capturing the benefits of seasonal climate forecasts in agricultural management* by addressing some of the issues related to the use of seasonal climate forecasting (as listed above) through some selected case studies. This chapter also briefly outlines the understanding of ENSO and Seasonal Forecasting Methods (SFM) building on some of the publications arising out of this project.

Context of the ACIAR project and its scope

Several agencies throughout the world are now supporting research and extension programs concerning the application of ENSO-based seasonal forecasts in agriculture. This activity is occurring in countries such as Africa, Australia, India, Indonesia and other southeast Asia countries, and the north and south American continents. An example is the recently completed project *Capturing the benefits of seasonal climate forecasts in agricultural management* funded by the Australian Centre for International Agricultural Research (ACIAR) which involved the participation of some 35 staff from 10 agencies in four countries (Indonesia, Zimbabwe, India and Australia) (Clewett 2004a). Three major components of this study that were successfully achieved, were:

- understanding the mechanisms and impacts of ENSO and assessing the skill of ENSO-based seasonal forecasts;
- application of seasonal forecasts in communities via participative problem-solving extension

¹ School of Environment and Agriculture, University of Western Sydney, Hawkesbury Campus, Locked Bag 1797, Penrith South D.C. NSW 1797, Australia.
e-mail: s.huda@uws.edu.au

² Queensland Centre for Climate Applications, Department of Primary Industries, Tor Street, Toowoomba, Qld, 4350, Australia.

processes to improve the decision-making skills of farmers;

- development of decision-making support systems for seasonal forecast technologies such as workshop processes, printed materials and software including climate analysis tools and agricultural models.

These three issues are central to other chapters in this book and are thus discussed in more detail.

Understanding of ENSO and seasonal forecasting methods

Clewett (2004b) considered opportunities for application of seasonal climate forecasts in Indonesia, Zimbabwe, India and Australia. Forecasts based on the Southern Oscillation Index (SOI) were used to assess the amount, timing and frequency of seasonal rainfall in four study regions. The paper included a review of seasonal forecast methods. Opportunities to use forecasts were considered in relation to grazing systems and streamflow in Australia, management of rangelands in Zimbabwe, irrigation management in Indonesia and dryland cropping systems in southern India.

The weather in Australia is generated as the atmosphere circulates over the continent and its surrounding oceans. From day to day, the weather is controlled by the systems of high and low atmospheric pressure and the fronts that we see on synoptic weather charts on television and in newspapers, and also by upper air systems. However, these systems are only a local response to the general circulation of the atmosphere around the entire Earth (Clewett et al. 2003).

The two main seasonal forecast tools used in this project were the Southern Oscillation Index and an index of Sea Surface Temperature (SST). The historical values of the SOI (1876–2004) were based on the work of Troup (1965) and Allan et al. (1996b) and represent standard deviations ($\times 10$) of differences in air pressure anomalies between Tahiti and Darwin. The SOI is provided by the Bureau of Meteorology and is updated and periodically revised on their website. The SST index is also provided by the Bureau and is for the SST 9 phase seasonal forecast developed by Drosdowsky (2002).

The seasonal forecast analysis method was based on established relationships derived and substantiated from the work of McBride and Nicholls (1983), Nicholls (1984a, 1984b, 1984c, 1986, 1991), Allan (1988), Ropelewski and Halpert (1987, 1989), Clewett et al. (1989, 1991b), Allan and Pariwono (1990), Hastings (1990), Drosdowsky and Williams (1991).

The general circulation

The general circulation is driven by temperature differences caused as the sun heats the Earth's surface unevenly — the equator receives most solar radiation, the polar regions the least.

The higher latitudes are effectively no extra distance from the Sun, but they receive less radiation per unit of surface area because of the more oblique angle of incidence. The effect is greatest over water, which absorbs radiation when the sun is overhead, but reflects more than 70% when the rays are oblique. Much of the radiation towards the poles is reflected off atmospheric clouds and surface ice.

The Southern Oscillation is strongly associated with rainfall in eastern Australia. When sea temperatures are lower than normal around Indonesia and pressures are higher than normal, northern and eastern Australia often experience droughts; when sea temperatures are higher than normal, these areas often receive above-average rainfall.

Because an unusually cool sea off northern Australia usually coincides with an unusually warm sea off South America — known there as El Niño — and a weak Walker Circulation, the combined system is often referred to as the El Niño/Southern Oscillation (ENSO) phenomenon. The reverse situation, with a strong Walker circulation and colder sea surface temperatures off South America, is called La Niña or Anti-ENSO.

The Southern Oscillation has an irregular cycle averaging about four years. The cycle develops through close three-dimensional interactions of the atmosphere and ocean, and is associated with droughts or heavier than average rainfall over many parts of the world.

The key indicators for predicting weather in eastern Australia are:

- Southern Oscillation Index;
- temperature of the sea surface across the tropical Pacific Ocean;
- strength and direction of Pacific trade winds; and
- location of cloud in the tropical Pacific.

Sea surface temperatures in the eastern Indian Ocean may allow improved prediction of winter rainfall over parts of southern, eastern and northern Australia.

The Southern Oscillation Index (SOI)

The strength of the Southern Oscillation is measured by the difference in air pressure between the two regions; the commonly-used 'Troup' index reflects the air pressure difference between Darwin and Tahiti, records for which started in 1869 and 1876 respectively. This Southern Oscillation Index usually ranges from -30 to $+30$.

When the Southern Oscillation Index is strongly positive, the trade winds blow strongly across the warm Pacific picking up plenty of moisture; much of eastern Australia is then likely to receive above-average rainfall.

When the SOI is strongly negative, trade winds are weak, or even reversed, and rainfall in the Indonesian and Australian region can be much below average — a possible drought in an El Niño or ENSO event.

These differences in sea surface temperature between the east and west of the equatorial Pacific cause another great vertical circulation of air — the Walker Circulation (Fig. 1).

The Walker Circulation has three main elements:

- air flows west across the tropics of the Pacific (southeast trade winds), being warmed and gathering moisture from the warmer waters of the western ocean;
- it is uplifted over the Indonesian region, dropping the moisture as rain; and
- the dry air then flows east, at an altitude of about 12 000 metres, to sink again over the normally cold waters of the eastern Pacific.

This ‘normal’ Walker Circulation is greatly changed during extreme phases of the Southern Oscillation. It is strengthened when the sea surface temperature in the eastern Pacific is abnormally low La Niña. It is weakened when that water becomes abnormally warm, making the cross-Pacific air pressures more equal; the trade winds weaken and may even reverse becoming westerly El Niño.

These phases of the Southern Oscillation result from inter-related changes in the atmosphere and ocean in three dimensions.

The changes include:

- temperatures of the ocean surface;
- levels of the ocean;
- circulation of the ocean (currents and upwelling in the ocean);
- temperatures of the atmosphere (surface and upper level);
- pressures within the atmosphere (upper and lower levels); and
- circulations of the atmosphere (winds and cells).

How quickly does the SOI change?

If the Southern Oscillation behaved in a regular cycle, it would allow climate predictions one or two years into the future. Unfortunately, although the average cycle is about four years, strong negative or positive phases occur irregularly at intervals of three to six years.

Extreme phases of the Southern Oscillation usually last for about nine months once they have become established.

Droughts often break when the SOI rises rapidly from extremely low values even if it does not become positive; for example, when it changes from -15 to 0. These trends, or phases up or down, are also used as indicators.

While the Southern Oscillation modifies the climate pattern, the weather continues its natural variability under other influences. These are sometimes so dominant that the Southern Oscillation cannot be a totally reliable indicator of future weather.

Issues related to seasonal climate forecasting

One issue is the use of seasonal forecasts for predicting when events will happen, such as the date of onset of the wet season. Timing of when events occur is of great importance in agriculture. Break of season rains often start a flurry of activity in agricultural communities, such as planting of crops, and thus ENSO-based forecasts of when the wet season will start can be of great value. Median date of onset is a highly variable statistic and thus statistically significant differences are difficult to find without long data sets. Clewett (2004b) showed that ENSO influences are strong in Indonesia and northeastern Australia and can alter the median date onset by several weeks. In contrast, in India and Africa where ENSO influences are not so strong the median dates for planting are altered by a week or so. Quite often a major difficulty with this kind of analysis is the lack of daily data in digital format. Forecasts on the timing of events are important in grazing systems regarding date of onset of pasture growth. They are also important in irrigation systems regarding the timing of river flows and availability of irrigation water.

The seasonal forecast capabilities used in this project have been developed from results of soundly based research on the characteristics of ENSO. The impacts of ENSO have been shown to vary with time of year and location, and to be stronger in the southern areas of Indonesia and northeastern Australia than in Zimbabwe or southern India (for north-east monsoon). People gain confidence in using risky seasonal forecasts when they understand the physical basis of ENSO and thus the reasons for its influence on global, regional and local climate patterns. The relationships of ENSO with changes in the characteristics of seasonal rainfall (timing, frequency of events and amount) at their own location, and consequent impacts on agriculture, are important. Learning to use ENSO information in management is maximised by combining ‘hands on’

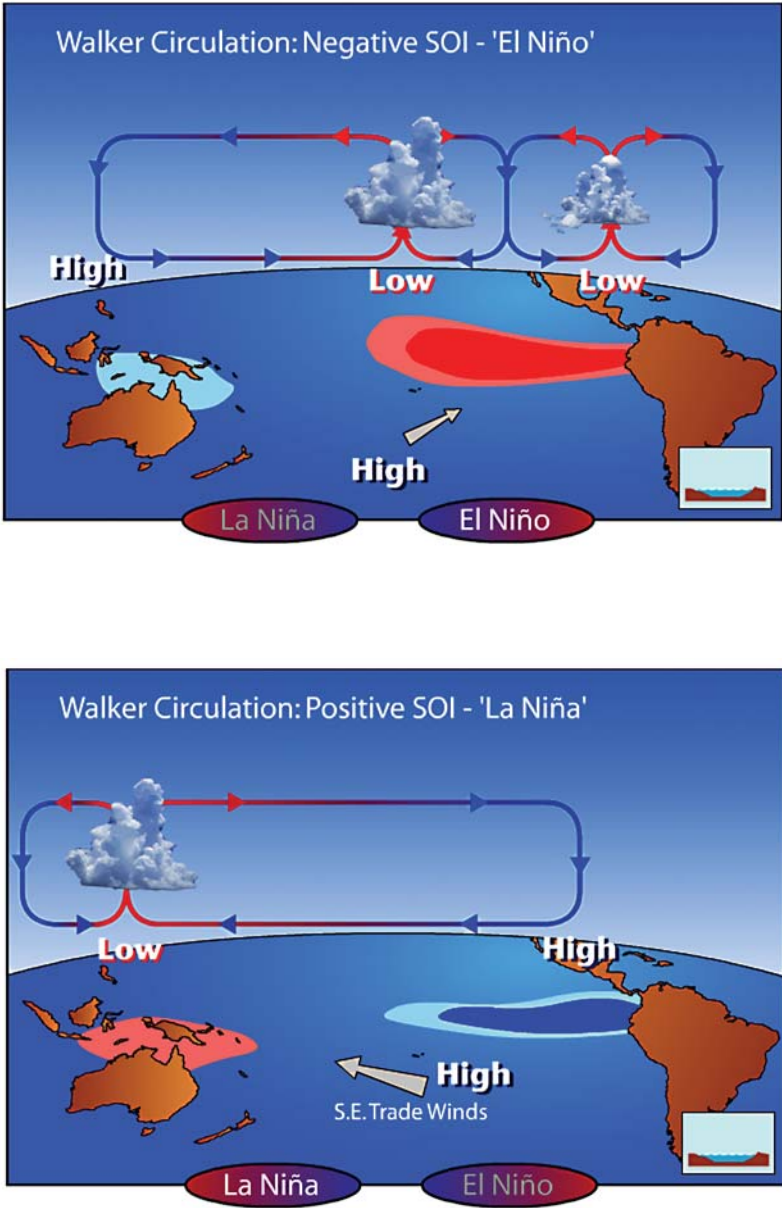


Figure 1. Walker Circulation (after, Rainman, Clewett et al., 2002, 2003).

learning with the software with participation in a workshop where people can test their ideas and also listen to the knowledge and experience of others.

Perceptions of climatic risk

As individuals, people have different needs and learning styles, and thus respond to information in different ways (Clewett, 2004b). Cumulative probability distributions often provide an effective mechanism for scientists to communicate with each other. However, in communicating with the farming community we have found that other diagrams and ways of expressing risk are more effective, such as frequency plots, pie charts, box plots and time series. The simplest statement for communicating risk has been the percent chance that seasonal rainfall will be above or below the median rainfall (or above or below the average) (Stone et al., 1996). While this very simple statement of risk is now widely used in the agricultural media in Australia, the research by Coventry (2001) shows that this statement can be easily misinterpreted by some people because of confusion about probability issues and thus on-going education processes are needed. The text by Hammer et al. (2000) provides a recent review of the application of seasonal climate forecasting in Australian agriculture and natural ecosystems. In this latter text, the paper by White (2000) highlights the potential value of seasonal climate forecasts to agriculture, but also recognises the substantive difficulties that people have in applying probability-based information to management decisions.

The fullest understanding of climate risk often occurs where people have been able to view all of the historical rainfall (for example 100 years of data) as a time-series histogram. These diagrams showing the sequence of historical events can be particularly useful because they are an analogue of people's memory patterns. Research (Coventry, 2001) has shown that people are more able to assimilate statements about frequency (for example seven years in ten) than the more abstract probability statement (for example, 70% chance). Simplicity is often the key to comprehension. Comprehension empowers people with ownership of the forecast and thus gives them confidence in moving towards using it in their decision-making.

Participation and decision-making with farmers

Though several methods for forecasting seasonal climate are available, this area requires refinement, further strengthening and extension. Nicholls (1999)

discussed some of the constraints to the effective use of climate forecasts and suggested that forecasters need to understand the difficulties faced by the users and to make adjustments for them in the way forecasts are prepared and disseminated. However, a significant problem remains in translating the seasonal climate forecast information into appropriate action by farmers to minimise risk. The problematic issues include how climate and weather information (forecast) can be used to make improved decisions for a number of practices including crop/variety selection, sowing time, sowing area, fertiliser application, harvesting, estimation of yields, crop quality and marketing.

Farmers bear the consequences of the decisions taken. For some farmers it is not just an issue of profit and loss but whether can they grow enough food to feed their family and livestock (food security). Thus it is very important for the researchers, extension and community workers to build rapport with farmers based on trust and mutual respect. Most agricultural research scientists in Australia still regard 'technology transfer' as the main concept underpinning extension practice (Macadam, 2000). In this model we are led to believe that progress in agriculture is achieved through transferring the results of scientific research to farmers. Informed critics point to the simplistic assumptions of this model, particularly about farmers not simply being passive recipients of the knowledge of researchers, which has largely discredited this concept (Rollings, 1988; Bawden and Macadam, 1991; Drinan, 1992; Pretty, 1995; and Ison and Russell, 2000). The process of technology transfer would be more effective through mutual interaction and respect for each other's values — a move from a linear to a circular model of information exchange. One result of this has been an increased use of participative action research and other learning-based approaches to better respond to the needs and opinions of local people.

Macadam (1997) traces the historical development of alternative extension paradigms in Australia and identifies the emergence of an appreciation of the need to enhance clients' capacity to make informed and critical decisions. He calls this paradigm, with its emphasis on empowering clients, a 'learning paradigm'; and contrasts this circular approach with the linear, teaching approach inherent in the technology transfer model. To make this switch in practice is, however, a complex and challenging endeavour, introduced in a paper by R.G. Packham on page 35.

Huda et al. (2000) discussed how researchers could build activities into their programs that help them to participate with farmers in experiencing what it means to:

- collect climate information (from whatever source);
- make sense of the information in terms of likelihood of events occurring;
- use decision support tools and techniques to explore biological outcomes, economic risks and potential returns; and then
- take decisions based on this informed analysis, while also bearing the consequences of such decisions.

Thus researchers need to ask:

- How do farmers currently make decisions related to seasonal climate issues?
- How might farmers be educated about using new knowledge of seasonal climate forecasting?
- How might they use these forecasts for decision-making?
- How might farmers develop confidence in the use of such forecasts?
- What are the prerequisites to learning for farmers?
- How might we integrate information (for example, production, pests control, marketing)?
- How might we best disseminate information?
- How might we reach all farmers?

Why a participatory approach? The need for farmers and scientists to work together

Many agricultural decisions are more uncertain than complex. In dryland farming there are often fewer 'levers to pull', but a lot of uncertainty. What research can do is put numbers on that uncertainty and discuss options with farmers. Working with farmers on an issue as multifaceted as risk management is not a case of one way, unambiguous information flows to farmers, teaching farmers or even providing decision support for farmers. Nor is it a case of just listening to farmers and observing what they are doing. Rather, it is a case of intervening, of joining a complex *dance* where it is never clear who is leading whom, and where both farmers and scientists are prepared to modify and learn new 'dance steps' as they manage farming systems (Hayman, 2001).

Huda et al. (1992) and Huda (1994) demonstrated the benefits of working with farmers from the beginning of a project to evaluate alternate management strategies that minimise climatic risk to wheat production in low rainfall areas of southern Australia. At the onset of this project, it was found that trying to provide definitive answers using scientific knowledge and climate models was not what farmers wanted or needed.

Through dialogue with farmers, extension workers and researchers from other disciplines, it was realised that farmers have few options in their manage-

ment processes to use this complex information. What they needed was simple *rules of thumb* at critical points (often narrow windows) — such as for planting, harvesting, etc — to make better informed decisions that minimised their risk and maximised their opportunities as far as was possible, given the fact that the future may never be fully known.

In response to this situation, and as part of the ACIAR project, it was decided to organise a workshop (Huda and Packham, 2000) to share the experiences of researchers, farmers, community/extension workers and others about issues of working participatively with farmers. We hoped that this would improve and influence future aspects of both the ACIAR project and other climate-related agricultural research. This report emerges from that workshop.

It provides an appreciation of how a participatory approach can be used in a seasonal climate forecasting application context. The case studies presented include the assessment of the impact of climate variability on crop production and water availability in both Australia and the partner countries of India and Indonesia.

References

- Allan, R.J. 1988. El Niño Southern Oscillation influences in the Australasian region. *Prog. Physical Geography* 12: 4–40.
- Allan, R.J. and Pariwono, J.I. 1990. Ocean-atmosphere interactions in low-latitude Australasia. *Int. Journal of Climatology* 10:145–178.
- Allan, R.J., Beard, G., Close, A. Herczeg A.L., Jones, P.D. and Simpson, H.J. 1996b. Mean sea level pressure indices of the El Niño-Southern Oscillation: relevance to stream discharge in south-eastern Australia. CSIRO Division of Water Resources Report 96/1.
- Bawden, R.J. and Macadam, R.D. 1991. Action Researching Systems-Extension Reconstructed. Proceedings of the International Workshop on 'Agricultural Knowledge and the Role of Extension', Bad Boll, Germany, 21–24 May 1991, Faculty of Agricultural Sciences, University of Hohenheim, Germany.
- Clewett, J.F. 2004a. Capturing the benefits of seasonal climate forecasts in agricultural management. A final report to the Australian Centre for International Agricultural Research on project LWR 2/96/215. Department of Primary Industries, Queensland QO04001, 121 pp.
- Clewett, J.F. 2004b. Use of ENSO-based Seasonal Climate Forecasts in Agriculture. Paper presented at the Coimbatore meeting, September 2002. Tamil Nadu Agricultural University, Coimbatore, India.
- Clewett, J.F., Young, P.D. and Willcocks, J.R. 1989. Effect of climate change on agriculture in central Queensland: rainfall variability analysis. In: Anderson, E.R. (ed), 'The changing climate and central Queensland Agriculture'. Australian Institute of Agricultural Science, Rockhampton, Queensland, 43–52.

- Clewett, J.F., Howden, S.M., McKeon, G.M. and Rose, C.W. 1991b. Optimising farm dam irrigation in response to climatic risk. In: Muchow, R.C. and Bellamy, J.A. (eds). 'Climatic Risk in Crop Production: Models and Management for the Semi-arid Tropics and Subtropics'. CAB International, Wallingford, U.K. 307–328.
- Clewett, J.F., Ooi, S.H., Owens, D.T., George, D.A. and Partridge, I.J. 2002. Rainman International version 4: an integrated software package of Rainfall Information for Better Management. QIO2023, Department of Primary Industries, Queensland.
- Clewett, J.F., Clarkson, N.M., George, D.A., Ooi, S.H., Owens, D.T., Partridge, I.J. and Simpson G.B. 2003. Rainman Streamflow version 4.3: a comprehensive climate and streamflow analysis package on CD to assess seasonal forecasts and manage climate risk. QIO3040, Department of Primary Industries, Queensland.
- Coventry, W. 2001. Climate variability and farmers risk assessments and decision making. Post-graduate thesis. School of Psychology, University of Queensland.
- Drinan, J. 1992. The Past, the Present and the Emerging Future. In: Macadam, R.D. and Wilson, A.M. (eds), Proceedings of Conference 'Future Directions in Agricultural Education, training and Extension'. UWS Hawkesbury.
- Drosowsky, W. 2002. SST Phases and Australian Rainfall. *Aust. Met. Mag.* 51(1): 1–12.
- Drosowsky, W. and Chambers, L.E. 2001. Near-global sea surface temperature anomalies as predictors of Australian seasonal rainfall. *Journal of Climate* 14: 1677–87.
- Drosowsky, W. and Williams, M. 1999. The southern oscillation in the Australian region. Part I: Anomalies at the extremes of the oscillation. *Journal of Climate* 4: 619–638.
- Hammer, G.L., Nicholls, N. and Mitchell, C. 2000. Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems — the Australian Experience. Kluwer Academic. The Netherlands. 470 p.
- Hastings, P.A. 1990. Southern Oscillation Influences on Tropical Cyclone Activity in the Australian/South West Pacific Region. *Int. Journal of Climatology* 10: 291–298.
- Hayman, P.T. 2001. Dancing in the Rain, Farmers and Agricultural Scientists in a variable climate. PhD thesis, University of Western Sydney.
- Huda, A.K.S. 1994. Management Strategies to Minimise Climatic Risk to Wheat Production in Low Rainfall Areas of Southern Australia. *Agricultural and Forest Meteorology* 69, 125–147.
- Huda, A.K.S. and Packham, R.G. 2000. Participative Decision Making with Farmers: Capturing the Benefits of Seasonal Climate Forecasts in Agricultural Management, 13–14 April 2000. University of Western Sydney, Hawkesbury campus (mimeograph resource book).
- Huda, A.K.S., Cogle, A.L. and Miller, C.P. 1991. Agroclimatic Analysis of Selected Locations in North Queensland, Bulletin QB91002. Queensland Department of Primary Industries, Brisbane, Queensland, Australia, 177 p.
- Huda, A.K.S., George, D., Salmon, L., Balasubramanian, T.N., Selvaraju, R., Geethalakshmi, V., Pandian, B.J., Wallace, G. and Donnelly, J. 2000. Climate education and extension — from teaching to learning. International Workshop on Farm Management Decision Making. April 2000. Toowoomba, Australia.
- Huda, A.K.S., Rahman, M.S., Egan, J.P., Holloway, R.E. Lymn, A.S. 1992. Assessing and Managing Cropping Risks in Low Rainfall Areas of Southern Australia Using Agroclimatic Data. South Australian Department of Agriculture Technical Paper, Minnipa Research Centre, Minnipa, SA 5654, 199 p.
- Ison, R.L. and Russell, D.B. (eds.) 2000. Agricultural Extension and Rural Development: Breaking Out of Traditions. Cambridge University Press, Cambridge, UK.
- Macadam, R.D. 1997. A Personal History of Extension in Australia. Proceedings Second Australasia-Pacific Extension Conference, Albury. 18–21 November, 1997. Vol 1, 634–43. Australasia-Pacific Extension Network, Albury, Australia.
- Macadam, R.D. 2000. From Pushing Production Inputs to Empowering the Community: A Case Study in the Transformation of an Extension Agency. *Australian Journal of Experimental Agriculture* (in preparation).
- McBride, J.L. and Nicholls, N. 1983. Seasonal relationships between Australian rainfall and the Southern Oscillation. *Monthly Weather Rev.*, 111, 1998–2004.
- Nicholls, N. 1984a. The Southern Oscillation and Indonesian sea surface temperature. *Monthly Weather Review* 112: 424–432.
- Nicholls, N. 1984b. The Southern Oscillation, sea-surface-temperature, and inter-annual fluctuations in Australian tropical cyclone activity. *Journal of Climatology* 4: 661–670.
- Nicholls, N. 1984c. A system for predicting the onset of the north Australian wet-season. *Journal of Climatology* 4: 425.
- Nicholls, N. 1986. Use of the Southern Oscillation to predict Australian Sorghum yield. *Agricultural and Forest Meteorology* 38: 9–15.
- Nicholls, N. 1991. Advances in long-term weather forecasting. In: Muchow, R.C. and Bellamy, J.A. (eds). Climate risk in crop production: models and management for the semiarid tropics and subtropics. CAB International, 427–444.
- Nicholls, N. 1992. Recent performance of a method for forecasting Australian seasonal tropical cyclone activity. *Australian Meteorological Magazine*. 40: 105–110.
- Nicholls, N. 1999. Cognitive Illusions, Heuristics, and Climate Prediction, *Bulletin of the American Meteorological Society*, 80, 1385–1397.
- Park, J.N., Cobon, D.H. and Crabb, D.M. 2001. Integrating climate forecasts and geospatial systems to enhance grazing management in northern Australia. In 'Proceedings of Geospatial Conference'. Sydney, New South Wales. 56–70.
- Pollock, K.S., Meinke, H. and Stone, R.C. 2001. The influence of climate variability on cropping systems in Central Queensland. Australian Agronomy Conference, Hobart, Australia.
- Pretty, J.N. 1995. Regenerating Agriculture. Earthscan Publications, London.
- Rollings, N. 1988. Extension Science: information systems in agricultural development. Cambridge University Press, Sydney, New South Wales.
- Ropelewski, C.F. and Halpert, M.S. 1987. Global and regional scale precipitation patterns associated with the

- El Niño/Southern Oscillation. *Monthly Weather Review* 115: 1606–1626.
- Ropelewski, C.F. and Halpert, M.S. 1989. Precipitation patterns associated with the high index phase of the Southern Oscillation. *Journal of Climatology* 2: 268–284.
- Stone, R.C., Hammer, G.L. and Marcussen, T. 1996. Prediction of global rainfall probabilities using phases of the southern oscillation index. *Nature* 384: 1896–1909.
- Troup, A.J. 1965. The Southern Oscillation. *Quarterly Journal of the Royal Meteorology Society* 91: 490–506.
- White, B.J. 2000. The importance of climate variability and seasonal forecasting to the Australian economy. In: Hammer, G.L., Nicholls, N. and Mitchell, C. (eds). *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems — the Australian Experience*. Kluwer Academic. The Netherlands. 1–22.

Factors affecting the use of climate forecasts in agriculture: a case study of Lombok Island, Indonesia

R. Sayuti¹, W. Karyadi¹, I. Yasin¹ and Y. Abawi²

Abstract

This chapter investigates factors affecting farmers using Seasonal Climate Forecasting (SCF) in Lombok Island, Indonesia. It compares the use and potential of SCF in dryland versus irrigated areas of the island. A survey technique was used, and the characteristics of the respondents drawn out. The findings elaborate on cultivation and irrigation management, decision-making processes on-farm, water use and how this is organised, and finally the farmers' knowledge about weather forecasts. The findings will enable the better implementation of action plans dealing with SCF. They also give a better basis for future participative approaches to the development and application of SCF in Indonesia.

Introduction

INDONESIA is an agrarian country in which more than 50% of the population is engaged on-farm (BPS, 1999). However, the productivity of both farmers and agricultural land is still limited (Sayuti, 1999). There are many programs that have been implemented so far in order to increase both farmers, and land productivity. But the priority of the program, in general, is usually in irrigated areas. Dryland farm areas are still very low in productivity. The data of BPS shows that the productivity of dryland areas is only half the productivity of that in irrigated areas (BPS, 1998). This is due in part to the fact that production processes in dryland areas are restricted by water supply availability. The only water resource that may be expected is rainfall. On the other hand, the knowledge of farmers about rainfall and climate phenomena in general is so limited that they do not know how to optimise the rainfall use in each season for the benefit of their crop production.

The following table (Table 1) shows the average rainfall in Sekotong Sub-District, one of the dryland areas in South Lombok. Without any kind of technological intervention, it is difficult to increase land or commodity productivity in order to improve a farmer's standard of living.

Table 1. Rainfall data in Sekotong Sub-District, 1987–1997.

Year	Rainfall (mm)	Number of rain days per year	Average rainfall per day (mm/day)
1987	936	28	13.14
1988	1449	106	14.14
1989	1617	105	15.40
1990	1407	70	20.10
1991	1602	85	18.84
1992	1586	68	23.32
1993	1661	75	22.13
1994	1492	73	20.44
1995	1137	57	19.95
1996	1416	89	15.91
1997	1457	76	22.15

Source: Statistics Bureau of West Lombok District, 1997.

According to Rasahan and Gunawan (1993), there are about 7.7 million ha of dryland areas in Indonesia that have the potential to be developed in order to increase farmers' productivity, along with increasing national farm production. However, there are a number of problems faced by such dryland areas, including those of human resources (i.e. education, skill and behavior), natural resources, as well as institutional problems (Sayuti, 1998; Sayogyo and Amri Marzali, 1993; Pasandaran et al., 1993). According to Steven and Jabara (1988), there are two

¹Faculty of Agriculture, University of Mataram, Indonesia.
²QDNRM, Toowoomba, Queensland.

interactive problems on dryland in Indonesia, namely the low level of its productivity, and the low quality of human resource capacities.

On the other hand, the number of farmers, especially small scale farmers and farm workers who live in or move to dryland areas, tends to increase. Based on the 1993 Agricultural Census, the number of small-scale farmers has increased since 1983, with an annual growth rate of 1.78%, while the growth rate of farm workers in the same period of 1983–1993 was 10.37% annually (Sayuti and Tajidan, 1996). Even though this number included all types of land, it can be predicted that the distribution was more in dryland areas than that in wetland areas. Therefore, any studies to increase farmers’ productivity is very important. One possible factor that may benefit farmers and land productivity is taking advantage of climate forecast in agricultural activities.

Dealing with the improvement of dryland productivity, Rasahan and Gunawan (1993) proposed two strategies, namely: sustainable agribusiness and development of rural economy in general; and giving priority to dryland agricultural development equal to irrigated agricultural development. The first strategy focuses on human resources and natural resources improvement as well as economic system development. The second strategy is related to any efforts (for example government programs) that focus on developing the productivity of dryland farm based on its potential. This means the government should pay more attention to the dryland areas, including the budget and skilled human resources provided to help farmers develop their land. Dryland in West Nusa Tenggara Province comprises about 1.8 million ha including that in Sumbawa Island. Most of this is state forest and people’s forest (Momuat and Momuat, 1993). Some of the land is cultivated by farmers for rice and horticulture commodities. The following table (Table 2) shows the distribution of dryland areas throughout West Nusa Tenggara Province.

Objective of the study

The study aimed to investigate factors affecting farmers using climate forecast in agriculture in Lombok Island. The study also compared the condition of irrigated areas and dryland areas. By knowing factors related to the extent to which farmers use climate forecast in agriculture practice, it will enable us to design programs that are relevant to the condition of farmers in both dryland and irrigated areas in Lombok Island.

Research methods

The location of the survey was in several irrigated and dryland areas in Lombok Island. To simplify the

Table 2. Dryland distribution in each district throughout West Nusa Tenggara Province.

No.	District	Dryland area (Ha)	Percentage (%)
1	West Lombok	165 095	9.11
2	Central Lombok	69 309	3.82
3	East Lombok	112 108	6.19
4	Mataram City	4 140	0.22
	Lombok Island	350 616	19.34
5	Sumbawa	809 744	44.73
6	Dompu	218 151	12.05
7	Bima	431 759	23.85
8	Sumbawa Island	1 459 654	80.66
9	West Nusa Tenggara	1 810 270	100.00

Source: Statistical Bureau of West Nusa Tenggara Province, 1998.

naming of the research location, the name of villages was used instead of using names of irrigated areas. The idea was to make the respondent selection easier, because the administrative border was clear. In West Lombok District, the name of the sub-district included in the survey was Narmada (30 respondents). In Central Lombok District, sub-districts included were Praya Barat, Praya Timur, Pringgarata, Jonggat, Kopang and Batukliang (85 respondents). In East Lombok District, sub-districts included were Keruak and Sakra (30 respondents). Respondents from dryland areas came from Batujai and Janapria in Central Lombok and Keruak in East Lombok (35 respondents). The selection process of respondents involved systematic random sampling based on the list of farmers available in each village.

The data collected was by face-to-face interview (Nazir, 1988). There was a questionnaire provided as a guidance in the field. By using face-to-face interviews, the aim was to avoid the possible misunderstanding by the respondents of any ambiguous questions. Before selecting all research locations, the authors conducted field observation on all irrigated infrastructure in Lombok Island to obtain information about the infrastructure and farmers’ community condition.

The survey was conducted in July 2000 (the dry season in Lombok Island). The questions asked related to issues such as family background, social and economic conditions, the process of decision-making commonly practised in the field, and capacity and habit on climate forecast related to farming activities.

Characteristics of respondents

Table 3 shows the total number of respondents involved in the survey. Of the 180 respondents, 145 of them were farmers from irrigated farm areas and 35 were from dryland areas.

Table 3. Distribution of respondents based on age and farmland characteristics.

Age range	Irrigated area		Dryland	
	Total	%	Total	%
≤ 30 years	22	15.17	3	8.57
31–40 years	51	35.17	15	42.86
41–50 years	47	32.41	7	20.00
51–60 years	19	13.10	6	17.14
≥ 61 years	6	4.14	4	11.43
Total	145	100.00	35	100.00

Most of the respondents (almost 70%) were between 31 and 50 years of age. In other words, most of the respondents were in the productive age range and were relatively young. Potentially, there were farmers capable of adopting new technology such as climate forecasts.

In terms of the level of educational attainment (Table 4), most respondents (about 75%) have only attended elementary school or were never in school. This indicates that the educational level of respondents is relatively low. Only about 20% from both irrigated and dryland areas had experienced junior or senior high school. According to Rogers (1983), the educational attainment influences the ability of people in the adoption of innovation processes. The problem in this regard was how to take advantage of those farmers with relatively high education to influence those who had low education. Another problem was how to design an extension program based on climate forecast that enabled most farmers to understand it and be willing to use it.

Table 4. Education level of respondents.

Level	Irrigated area		Dryland	
	Total	%	Total	%
Never in school	39	26.89	9	25.71
Elementary School	75	51.78	17	48.57
Junior High School	15	10.34	4	11.43
Senior High School	13	8.97	5	14.29
College/Academy	3	2.07	0	0.00
Total	145	100.00	35	100.00

Another characteristic of respondents was their family size and the way it relates to the extent to

which farmers can overcome their family problems, including how their income can meet the family needs. Income of farmers usually relates directly to the productivity of their farm and to some extent the income of other members of households, either from on-farm or off-farm activities (Sayuti, 1992; 1995).

Table 5 shows the family size of respondents. Most respondents had a family size of between two and six persons. About 40% of respondents had two to four children, while another 40% may have had only one child; only 7% of them had more than four children. This finding is consistent with the age of respondents. The younger farmers tend to have fewer children compared with those of the older generation.

Table 5. Family size of respondent.

Family size	Irrigated area		Dryland	
	Total	%	Total	%
1 person	5	3.45	2	5.71
2–3 persons	70	48.28	17	48.57
4–6 persons	60	41.38	14	40.00
7–9 persons	10	6.89	2	5.71
Total	145	100.00	35	100.00

Findings and discussions

There are several factors that influence farmers in using climate forecast in agricultural activities. Based on the data collected for this study, those factors are:

1. Cultivation and irrigation management

Cultivation and irrigation management are important for dealing with the use of climate forecast in agriculture activities in order to maximise farm production. These two aspects are related to each other. Cultivation management is generally based on the water irrigation availability and on the amount of rainfall. The extent to which water is available in a season is usually considered by farmers when deciding on cropping pattern. As an example, the numbers of farmers in irrigated areas who consider water availability in deciding cropping pattern are 18.62%, while for farmers in dryland areas it is 45.71% (Table 6). This number indicates the concern of farmers on irrigation water and rainfall. Problems of water availability for irrigated areas are not as big as those in dryland areas. Therefore, in deciding crop pattern for dryland areas, farmers usually take the monsoon and rainy months into account.

Interestingly, most farmers take either the price of the product or government recommendation into

account in deciding crop pattern. This means that farmers have been influenced by the market. In other words, to some extent, it can be concluded that farmers in Lombok Island have changed from subsistence level farmers to relatively commercial farmers. Another conclusion from these findings is that the role of government agencies on farm decision-making is relatively high. (See the table below).

Table 6. Determinant factors in crop pattern decision-making.

Explanation	Irrigated area		Dry land area	
	Total	%	Total	%
• No answer	2	1.38	0	0.00
• Water availability	27	18.62	16	45.71
• Price of product (yield)	48	33.10	15	42.86
• Refer to other (neighbouring) farmer	13	8.97	2	5.71
• Refer to government recommendation	33	22.76	1	2.86
• Water availability and price of yield	12	8.28	1	2.86
• Water availability and recommendation	4	2.76	0	0.00
• Others	5	3.45	0	0.00
Total	145	100.00	35	100.00

In terms of the irrigation water problems that farmers may have had, there are about 60% who have not had a bad experience or any other problems with the water irrigation (Table 7). The problem that is common for those in irrigated areas is one of less water availability. This is acknowledged by 24.14% of respondents. Another problem is related to canal infrastructure.

Table 7. Problems related to irrigation water availability.

Explanation	Irrigated Area		Dryland Area	
	(Total)	%	(Total)	%
• No bad experience	92	63.45	—	—
• Water in wrong direction	2	1.38	—	—
• Less water	35	24.14	—	—
• Less than expected rainfall	5	3.45	—	—
• Problems with irrigation canal	11	7.59	—	—
Total	145	100.00	—	—

Even though the percentage of farmers who said the irrigation canal is a problem was only 7.59%, it is still a serious problem. Without any particular action either from local government or farmers them-

selves, the condition of many irrigation canals can deteriorate. Based on the field observation, it is known that much irrigation infrastructure is in need of rehabilitation. In this regard, a maintenance aspect using a participatory approach is another issue that needs to be discussed. Participation of farmers so far is limited to the tertiary irrigation canal, directly adjacent to their property. Farmers think that maintenance of irrigation infrastructures in the main canal and dam is a government responsibility. Therefore, the initiative and other programs of farmers only focus on the lower infrastructure irrigation system.

2. Decision-making process on-farm

Decision-making process on-farm is another aspect that influences the use of climate forecast in agriculture processes. This aspect is also important when dealing with the process of adoption of innovation (Rogers, 1983). Dealing with weather or climate forecast, there are several factors affecting farmers in making a decision. For instance, if drought occurs, or if rainfall is more than is needed, what will be their decision?

Dealing with this question, we asked farmers the following question: If you get information explaining that rainfall will decrease in this season, what will you do on your farm (in relation to cropping pattern)? Most farmers (70%) said that they would not change their normal cropping pattern. There are about 16% who said they would replace the crop with other crops that need less water; and only 2% said they would reduce the planting areas. These answers indicate that most farmers still adopt traditional methods of forecasting without modern knowledge of how to maintain the level of production, especially in drought years.

The answers were consistent when the authors asked the respondents the opposite question: If you get information explaining that rainfall will increase in this season, what will you do on your farm (in relation to planting pattern)? 74% of respondents said they would not change the crop that they usually plant. Another 17% said they would follow the suggestion from the government agencies. In this regard, Table 8 shows the extent to which extension workers of the government agencies get involved in the decision-making process on-farm.

Based on the table above, 31.72% of farmers from irrigated areas and 25.71% of farmers from dryland areas said that they would follow suggestions by extension workers regarding the type of crop that they should cultivate for certain season. On the other hand, 66.21% and 74.29% of farmers of irrigated and dryland areas said there is no suggestion by extension workers regarding the type of crop they should

cultivate. There is no recommendation given by government extension workers about the process of decision-making. Once the authors had interviewed more farmers in-depth it became clear that the problems are because of the infrequent visits of extension workers to the areas. That is to say, if there are extension workers working in the area and giving a recommendation, the farmers will follow them most of the time (Sayuti, 1999a). This finding shows the extent to which extension workers in Lombok Island have a strategic position in influencing farmers on decision-making processes on-farm.

Table 8. Influence of extension worker on type of crop planted by farmers.

Explanation	Irrigated area		Dryland	
	Total	%	Total	%
• No answer	3	2.07	0	0.00
• Influenced by extension workers	46	31.72	9	25.71
• Not influenced by extension workers	96	66.21	26	74.29
Total	145	100.00	35	100.00

Another factor that influences farmers' decision-making processes is leaders' opinion (Sayuti, 1999a). In Lombok Island, the existence of informal leaders has a big influence on the rural community, including traditional and religious leaders. Most rural community members including farmers will follow their informal leader's opinion without argument. Therefore, in some cases, the extension programs of the government use these leaders to pass on the message.

3. Water users and their organisations

There are two types of institutions on-farm that are related to water management. The first is called *Subak*, a traditional institution that contains a person who is called *Pekasih*. The *Pekasih* is a traditional leader on water management who is in charge of water distribution. This person takes responsibility for collecting irrigation fees from farmers, usually in kind (after harvest). The secondly institution is called *P3A*, a relatively modern organisation introduced by government throughout Indonesia. The new institution consists of farmers in one irrigation area. In some cases, the *Pekasih* becomes head of this organisation, while in other cases, the *Pekasih* is the head of the water division, but not of *P3A*.

Based on the data collected for this survey, it seems that respondents were not able to distinguish between the traditional institution of *Subak* and the modern organisation of *P3A*. Regarding the question

of whether or not there is a traditional water users' group (*Pekasih/Subak*) still available in the village, 97.93% of the respondents believed a *Subak* institution existed in the village. When the authors asked respondents if they thought *P3A* existed in the village, 78% believed it did. This indicates that farmers or the community can accept the existence of both institutions. The extent to which each institution has played the role effectively in managing water for farmers, is another topic of study. The main task of the organisation is to guarantee the availability of water for farms and distribute it among all farmers who are members of the organisation (Drechsler, 1993). The following table shows how organisation distributes water to its members.

According to Table 9, 50% of respondents said that they had a schedule that was agreed when the water was distributed. Another type of distribution depends on farmers' requests (33.79%). It was also found that almost all decisions of the organisation are made by consensus.

Table 9. Water distribution system in Water User Organisation (*P3A/Subak*).

Explanation	Irrigated area		Dryland	
	Total	%	Total	%
• No answer	4	2.76	—	—
• Refers to schedule agreed	73	50.34	—	—
• Depends on farmers' request	49	33.79	—	—
• Depends on the officers	3	2.07	—	—
• Priority	1	0.69	—	—
• Others	15	10.34	—	—
Total	145	100.00	—	—

The organisation of water management on-farm is another factor that plays an important role in the decision-making process. It also has an important role in affecting farmers in terms of how they may use climate forecast in agriculture. The process of transfer of technology, including that of modern climate forecast, may be applied using this organisation. Application of participatory techniques in transferring a new technology to farmers will be easier using water user organisation than in other farmers' groups. This is due in part to the fact that the intensity of its activity (i.e. meetings) is high, and that water is the most important resource for farmers. So, the farmers must agree that the water user organisation is the most important organisation for them. The distribution of farmland of each member of this organisation is usually located so that the members are close to each other. For this reason, it will be easy to be organised and to promote the idea of modern climate forecast technology.

4. Knowledge about weather forecasts

The last factor that influences farmers in using climate forecasts in agricultural activities, is their knowledge of weather forecasts. This factor is related to the idea of sharing information and using modern techniques of forecasting weather for the purpose of agricultural activities. Based on the data shown below, it can be concluded that farmers, to some extent, have adequate knowledge on weather forecasts. According to the survey about 60% of farmers, both in irrigated and dryland areas, have knowledge of the forecasts. About 35% of them do not have knowledge of weather forecasts (Table 10).

Table 10. Farmers' knowledge of climate forecast methods.

Explanation	Irrigated area		Dryland	
	Total	%	Total	%
• No answer	3	2.07	1	2.86
• Have knowledge	90	62.07	21	60.00
• Do not have knowledge	52	35.86	13	37.14
Total	145	100.00	35	100.00

The information and knowledge of farmers on weather forecasts is still related to a traditional one. They usually determine the weather or climate forecast based on the stars or moon position, or migration of fauna and the condition of flora. Almost 27% of farmers with irrigation and 35% of dryland farmers said that the forecast is always correct, while another 30.34% (from irrigated areas) and 14.29% (dryland farmers) said that the forecasts are sometimes correct (Table 11).

Table 11. Farmers' opinions about traditional weather forecasting.

Explanation	Irrigated Area		Dryland	
	Total	%	Total	%
• No answer	51	35.17	14	40.00
• Always correct	39	26.89	12	34.29
• Sometimes correct	44	30.34	5	14.29
• Often correct	11	7.59	4	11.43
• Often incorrect	0	0.00	0	0.00
• Always incorrect	0	0.00	0	0.00
Total	145	100.00	35	100.00

More information that is relevant to the process of adoption of innovation is shown in Table 12. When we asked respondents about the possibility of

transfer of technology, especially on weather forecast in agriculture, 80% (irrigated) and 65.71% (dryland) said that they will learn it first and then they will try it. Less than 4% said they will refuse it, because they considered that the old methods of forecasting are good enough.

Table 12. Farmers' response to new methods of climate forecasting.

Explanation	Irrigated area		Dryland	
	Total	%	Total	%
• No answer	5	3.45	5	14.29
• Learn new method first and then try it	116	80.00	23	65.71
• Refuse new method because a farmer's way is better	5	3.45	1	2.86
• Others	19	13.10	6	17.14
Total	145	100.00	35	100.00

The finding indicates the willingness of farmers to learn and then try the new methods of climate forecast, rather than persisting with the old methods of forecasting. This is a very positive attitude on the part of farmers who are usually eager to overcome their low level of production. By learning the new technology on climate forecast, it is hoped that agricultural production on Lombok Island will increase, because farmers will be able to determine more exactly the relationship between commodities, location of farmland and the time to plant crops.

Conclusion and suggestion

Based on the explanation above, it can be concluded that factors affecting farmers on Lombok Island in terms of adopting climate forecast technology are as follows: cultivation and irrigation management; on-farm decision-making processes; organisation of water users; and, knowledge of weather forecasting. These four aspects are related to one to another. The knowledge and attitude of farmers on these four factors are very important to learn in more detail. By knowing this information, it will be easier to implement an action plan dealing with the transfer of technology, especially in the climate forecast.

Therefore it is suggested that it is important to have more in-depth information on each factor explained above. More studies need to be conducted, as well as more workshops to extend the results of the study and to get farmers well informed about such technology that is appropriate in order for them to increase their productivity.

References

- Biro Pusat Statistik (BPS) NTB 1998. West Nusa Tenggara in Figures 1997.
- Drechsler, H. 1993. Strengthening the Role of Relevant Institutions in Upland Farming System Development. Paper presented on Workshop on Status and Development of Dry Land in Indonesia, Mataram, November 1995.
- Momuat, E.O., D. Sitepu, dan J.S. Momuat 1993. Status and Dryland Development in Nusa Tenggara: A Case Study of P3NT Project. Paper presented on Workshop on Status and Development of Dry Land in Indonesia, Mataram, November 1995.
- Nazir, M. 1988. Research Methods. Ghalia, Jakarta, Indonesia.
- Pasandaran, Effendi, Hermanto, Sumaryanto, dan Nizwar Syafaat 1993. Investment on Dry Land Agriculture Development: Natural Resources Analysis. Paper presented on Workshop on Status and Development of Dry Land in Indonesia, Mataram, November 1995.
- Rasahan, Chairil Anwar 1993. Dry Land Agriculture Development on Five Year Plan VI and PJP II. Paper presented on Workshop on Status and Development of Dry Land in Indonesia, Mataram, November 1995.
- Rogers, Everett M. 1983. Diffusion of Innovation. The Free Press, New York.
- Sayogyo dan Amri Mazali, 1993. Analysis on Social Economics Factors on Dry Land Agriculture. Paper presented on Workshop on Status and Development of Dry Land in Indonesia, Mataram, November 1995.
- Sayuti, R.H. 1992. The Role of Non-Governmental Organizations in Agriculture Development on Lombok Island, Indonesia (Masters Thesis), The Ohio State University, Columbus, Ohio, Amerika Serikat.
- Sayuti, R.H. dan Tajidan 1996. Preparation of West Nusa Tenggara Community on Agribusiness Era: Social Economic Study. Paper presented on Agribusiness Seminar in Mataram, July 1996.
- Sayuti, R.H. 1995. Status Attainment, Human Capital and Religiosity in Indonesia: A Case Study of West Nusa Tenggara. Unpublished Ph.D. dissertation, The Ohio State University, AS.
- Sayuti, R.H. 1998. Dry Land Conservation and Rural Community Empowerment through Farm System and Sustainable Agribusiness. Research Report, National Research Council, Jakarta, Indonesia.
- Sayuti, R.H. 1999. Social Change and Global Influence on Rural Indonesia. Paper presented at the Asian Rural Sociology Association Conference, Bangkok, February, 1999.
- Sayuti, R.H. 1999a. Group dynamics and sustainable agricultural development practices. A case study of dryland areas. *Komunitas, Journal of Rural Studies*. Vol 3 (1), December 1999.
- Stevens, R.D. and Jabara C.L. 1988. Agricultural Development Principles. Economic Theory and Empirical Evidence. The John Hopkins University Press, Baltimore and London.
- Wang, In-Keun, 1999. Promise of Group Farming for Agricultural and Rural Development in Asia. Paper presented at the Asian Rural Sociology Association Conference, Bangkok, February, 1999.

Experiences of using seasonal climate information with farmers in Tamil Nadu, India

A.K.S. Huda¹, R. Selvaraju², T.N. Balasubramanian², V. Geethalakshmi²,
D.A. George³ and J.F. Clewett³

Abstract

This chapter describes some of our experiences in dealing with the application of participatory decision-making procedures with farmers to manage climate risk/opportunities in the Coimbatore district of Tamil Nadu, India. Climate indicators including the Southern Oscillation Index (SOI) were used to estimate the probability of seasonal rainfall ahead of the commencement of the cropping season in southern India. Farmers' indigenous knowledge, experience and traditional farm practices were considered alongside the alternative management options derived from the climate science and agricultural research.

Agronomic recommendations were derived from process-based models using simulated soil water and crop yields. This process of mutual learning resulted from the inclusion of all participants in the exploration of decisions as a particular season unfolds. This encouraged individual farmers and their communities to take ownership as well as bearing the consequences of their decisions. Benefits arising from the use of seasonal climate information in agricultural management included better crop choice, improved financial returns, more sustainable resource use and enhanced community development. It should be noted however that, despite every endeavour, outcomes were not always positive for every individual, but overall, beneficial outcomes outweighed these negative ones.

Background

RESEARCH activities related to climate variability have been taking place in many developed and developing countries throughout the world. Seasonal climate information, used for farm decision-making, represents strong scientific knowledge and understanding (Wise et al., 2001) and transforms climatic data into agronomically useful information. Applications of seasonal climate forecasts potentially had enormous benefits for better managing climate variability in fragile environments. The climate forecast information has been used for the socio-economic benefits to farmers. Recent advancements in climate

prediction based on some of the Ocean-Atmospheric processes explored further hopes for better prediction of the behaviour of atmosphere. Such processes include El Niño Southern Oscillation (ENSO) and other related climate forecasting signals. The persistent problem however is how best to: Translate climate science to farmers for them to take appropriate actions; and to improve researchers' understanding about the needs of farmers/users to make forecast information available in appropriate formats.

Selection procedure: eight villages, 240 farmers

This investigation centered on the Coimbatore district of Tamil Nadu in southern India (Fig. 1). The user communities for the monsoon rainfall forecasts were farmers and extension workers from selected locations of Coimbatore district. Five sub-divisions (taluks) of Coimbatore district were involved in the study. These sub-divisions were selected because they contain the maximum area of the crops of

¹School of Environment and Agriculture, University of Western Sydney, Hawkesbury Campus, Locked Bag 1797, Penrith South Distribution Centre, NSW 1797, Australia. e-mail: s.huda@uws.edu.au

²Tamil Nadu Agricultural University, Coimbatore – 641 003, Tamil Nadu, India.

³Queensland Centre for Climate Applications, Department of Primary Industries, Tor Street, Toowoomba, Queensland 4350, Australia.

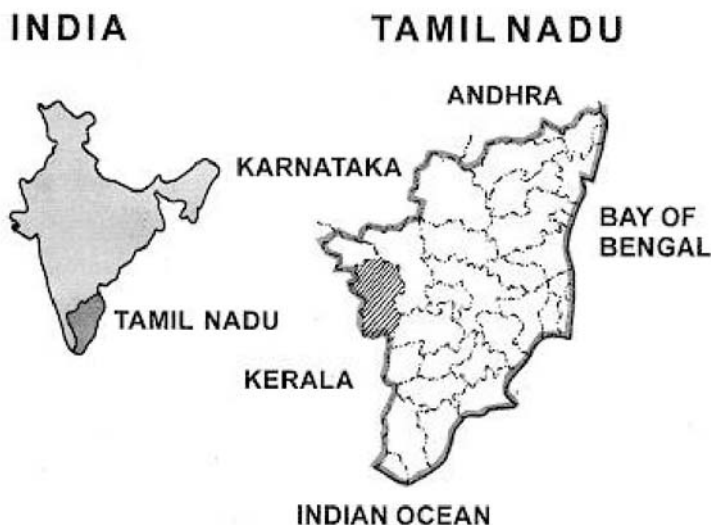


Figure 1. Location map of Coimbatore district of Tamil Nadu, India.

interest to this research (cotton and sorghum). District level agricultural officers were consulted and records were used to help select these sub-divisions. Across these five sub-divisions, eight development blocks were selected. The stratification criteria used were crop (sorghum and cotton), soil (Vertisols, Alfisols) and water availability (rainfed and irrigated), with matching villages for each block selected. In each of the eight blocks one village was selected randomly and key informants were identified. Key people were locals who knew the village system and could link the villagers with community workers. They were, relatively, better placed in the society because of their public work. Thirty farmers were randomly selected from each village, so that in all 240 farmers were selected and surveyed by questionnaire.

The farmers surveyed regarding any improved participation in problem solving had the following characteristics:

- farmers of different age groups and educational status (farmers' age distributions and educational status for the study area are given in Table 1);
- female farmers were included as well as males;
- some farmers were employed off-land;
- some farmers were engaged in some other business as well as being involved in farming; and
- there were different farm sizes (marginal, small and large).

The eight farmer groups formed in the study region included four groups established by state agricultural extension officials, and two by village presidents, who already had contact with the university

through an earlier watershed management project at village level, and two through the Farmers' Discussion Group (FDG) conveners, who had good contact with the University Krishi Vignyan Kendra (Training Centre).

Table 1. Age distributions and educational status of the farmer network at the study area in Coimbatore district.

Characteristics	Categories	Frequency	Percentage
Age	Young (≤ 34 years)	46	19.2
	Middle (35–45 years)	90	37.5
	Old (> 45 years)	104	43.3
Educational status	Illiterate	28	11.6
	Primary education	72	30.0
	Middle education	52	21.7
	Secondary education	69	28.8
	College education	19	7.9

The observations made in these groups indicated the following:

Among the groups, all the farmers involved in *Alfisol-rainfed sorghum* and *Vertisol-irrigated cotton* had shown interest in using seasonal climate forecast information. The *Alfisol-rainfed sorghum* village was in a comparatively low rainfall area dominated by dryland farmers, while *Vertisol-irrigated cotton* farmers were growing mostly commercial crops, including cotton under irrigation.

The four groups formed with the help of extension officials reacted positively to Seasonal Climate Forecasting and their involvement in the discussion was

good. However, they expected some benefits to be provided from the government. The reason for their involvement was the familiarity with the existing extension system and the personnel who had frequent contact with them for other extension activities, such as the distribution of subsidies. In the two groups formed with the help of village presidents, the individual farmer involvement in the group was less compared with the other groups. Researchers had to initiate any discussion. More than half of the farmers were not actively involved in the discussions. While the number of farmers attending the meeting was large, the involvement was small due to the informal hierarchy of the political system.

Involvement of dryland farmers was greater than for farmers from irrigated areas in all the groups formed. The main reason was considered to be that dryland farmers were more exposed to problems related to climate variability. The farmers from irrigated areas became more involved after finding out about the long-term impact caused by climate variability on the depletion of their ground water.

Assessing farmers' needs: preliminary survey results

The primary data on resource availability, peoples' participation in extension programs, knowledge on weather and climate and their access to such information were collected by employing participatory methods such as general discussion and semi-structured interviews. A general conclusion on the local crops and farmers' need for forecast information was drawn based on the initial survey. This survey was carried out before the onset of the 1999 northeast monsoon in the region. Of the 240 farmers selected, only 146 farmers had participated in the initial survey, but this was followed by a more detailed survey in which all (240 farmers) participated.

About 92% of all farmers contacted had knowledge about short-range (up to 48 hours) weather forecasting. One hundred per cent of farmers of dryland, and irrigated vertisols knew about short-range weather forecasts. The farmers with irrigated black soil were growing mostly cotton, and because cotton is a weather-sensitive crop, the farmers were interested in knowing about the weather. This explains the improved initial knowledge of short-range forecasts that was found. However, 96% of farmers interviewed were not aware of seasonal climate forecasting. Five farmers out of 146 interviewed knew about seasonal climate forecasting through their indigenous knowledge without any technical background. Forty two per cent of farmers knew and used short range forecasting to make decisions about their

farming activities, such as fertiliser application, weeding and harvesting. However, the farmers were not consistent when they used this information in their decisions, due to confusion about forecast messages.

The results of the initial survey indicated that farmers receive forecasts from varied sources. Most of the farmers were receiving forecasts through mass media like radio (54%) and television (37%). The information on weather and climate has also been received through other sources like newspapers, friends and relatives. Farmers believed that the weather and climate messages varied greatly from different sources, and this prevented them from adhering to any one forecast for decision making.

Decision-making and farmer perceptions

Our analysis from the detailed survey to identify the various decision-making approaches of the farmers indicated that about 38.8% of the farm decisions were taken by the farmer on his own. Considerable importance has also been given to female members of the family to take farm decisions (14.0%). Overall, 31.7% of the decisions were made through consultation with all family members, while 14.6% of the decisions were made through involvement of other farmers. Considerable variation was observed in involvement of different decision-making members across the categories of decisions. The result shows that the influence of different decision-making approaches is very important in farm management. Such analysis also helped the decision-making process to be effective through identification of appropriate decision-making personnel for providing climate information.

The importance of farm decisions in relation to seasonal climate forecasts based on the farmers' perception was also analysed. Among the list of decisions, sowing season, selection of crops and varieties were classified under 'most important' by more than 40% of the farmers. The mean score was highest for decisions on sowing season followed by selection of crops and varieties. Decisions like fertiliser application irrigation and application of plant protection chemicals taken during the cropping period were considered 'important' by more than half of the farmers. However, only a few decisions made, such as those on irrigation, were considered important by about 97% of the farmers. Among the harvest-related decisions, time of harvest was considered the most important by 46% of the farmers due to the sensitive nature of the operation. Decisions on types of contingency measures and application of growth regulators were considered unimportant with respect to climate information.

Southern Oscillation and monsoon rainfall

In south Asia most of the rainfall is associated with summer (southwest) and winter (northeast) monsoons. Over the Indian subcontinent the southwest monsoon (June to September) rainfall accounts for 80–90% of the annual rainfall (De, 1990). The northeast monsoon (October to December) is considered important in the extreme south of peninsular India and there are relationships with the ENSO (El Niño/Southern Oscillation) phenomenon at certain times that can be used as a seasonal climate-forecasting signal. In some cases, the lag prediction skill is low and the issue of predictability is being addressed.

The results of the ENSO response analysis (Sridharan and Muthusamy, 1990) revealed that the number of above average northeast monsoon years during warm phase (El Niño) years were about 24% higher than in neutral phase years, and 32% higher than the cold phase (La Niña) years (Selvaraju et al., 1998). The cumulative distribution graph shows that the use of SOI phases provides some advantage for forecasting the northeast monsoon rainfall (Fig. 2), but the non parametric tests are not always significant with sufficient lead time.

Impact of short-range weather forecasts

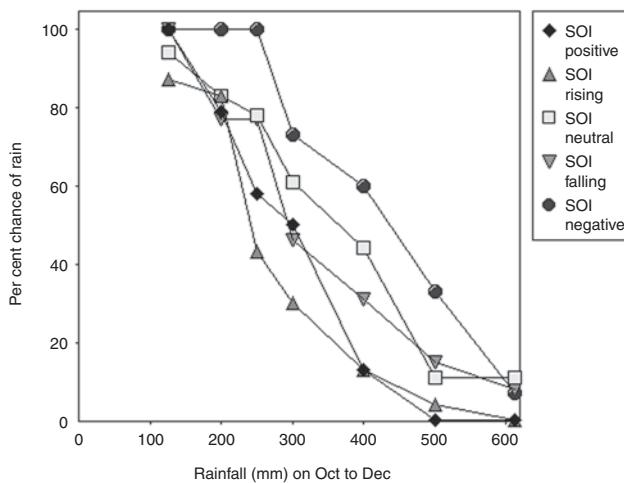
During our farm visits we discussed the short-range weather outlooks with the farmers. The need for the information varied widely among the farmer networks and time of the year. The short-range (up to

two days) forecasts were provided based on the synoptic observations and conditional probabilities of rainfall.

There are specific instances of cost benefits from using the short to medium range forecasts. One example includes farmers who were advised not to irrigate the banana crop due to expected rainfall. The rainfall occurred and the cost of saving in labour and diesel was \$A12 per hectare (\$A1 = 24 Indian Rupees in 2001).

There are instances when the forecast had problems. During the southwest monsoon of 1999, farmers were advised to apply fertiliser to their coconut crop anticipating rainfall, but rainfall did not eventuate. This created problems with labour management, fertiliser application and planning of irrigation, with the problems being most severe in water-deficient areas. The forecast information and associated advice led to a loss of A\$195/ha (Rs. 4687/ha). The entire amount spent on this activity may not be considered as a loss. However, the fertiliser use efficiency is lost due to inadequate moisture.

Thus, while the short- to medium-range forecast is useful to farmers, it requires further refinement and would be strengthened with longer lead times from long-range forecasting to allow more strategic and tactical decisions to be made. The use of the seasonal climate forecast (SCF) system might, therefore, be considered beneficial. It should be noted that farmers were unaware of SCF and subsequently used such information, introducing it through planning, monitoring and evaluating the entire processes.



Source: Australian Rainman

Figure 2. Cumulative distribution function for October to December rainfall at Coimbatore using June–July SOI phases.

Methods used to communicate climate information

In the process of participative decision-making, the seasonal climate forecasting was explained to the farmers by conducting participatory workshops at regular intervals in the farmers' holdings, before the start of the season and through the northeast monsoon season. The sequence of the discussions in the workshop were:

- What makes it rain in our region?
- Impact of climate variability on rainfall, crop yields and sustainability.
- Utilities of climate and weather forecasting in managing climate risk/opportunities.
- A series of questions were asked to the farmers during the workshop to understand their needs and accordingly to respond with explanations to questions such as: What crop did they plan to plant in the season? What amount of rainfall did they need to take any meaningful farm decisions?

The expected probability of receiving a particular quantity of rainfall (information from the

farmers) during the season (or a specific month) was explained to the farmers based on the seasonal climate forecast indicators like Southern Oscillation Index (SOI) in different formats (pie charts, cumulative distribution graphs and tables) (Clewett et al., 1999). The formats of information given to the farmers are presented in the bar diagram, pie chart, cumulative distribution curves and tables with probabilities (Fig. 3A and 3B). Extension staff also had been provided with the seasonal climate forecast before the start of the season, so that they could share this information with their farmer contacts.

The participatory approach encouraged discussion with questions and answers. Farmers took some time to talk freely with the researchers and after getting involved in the discussion they shared a great deal of information. Once trust had been built between the two parties, an easier exchange of information took place. About 95 per cent of farmers were willing to work closely with researchers after realising the importance of climate variability to their goals.

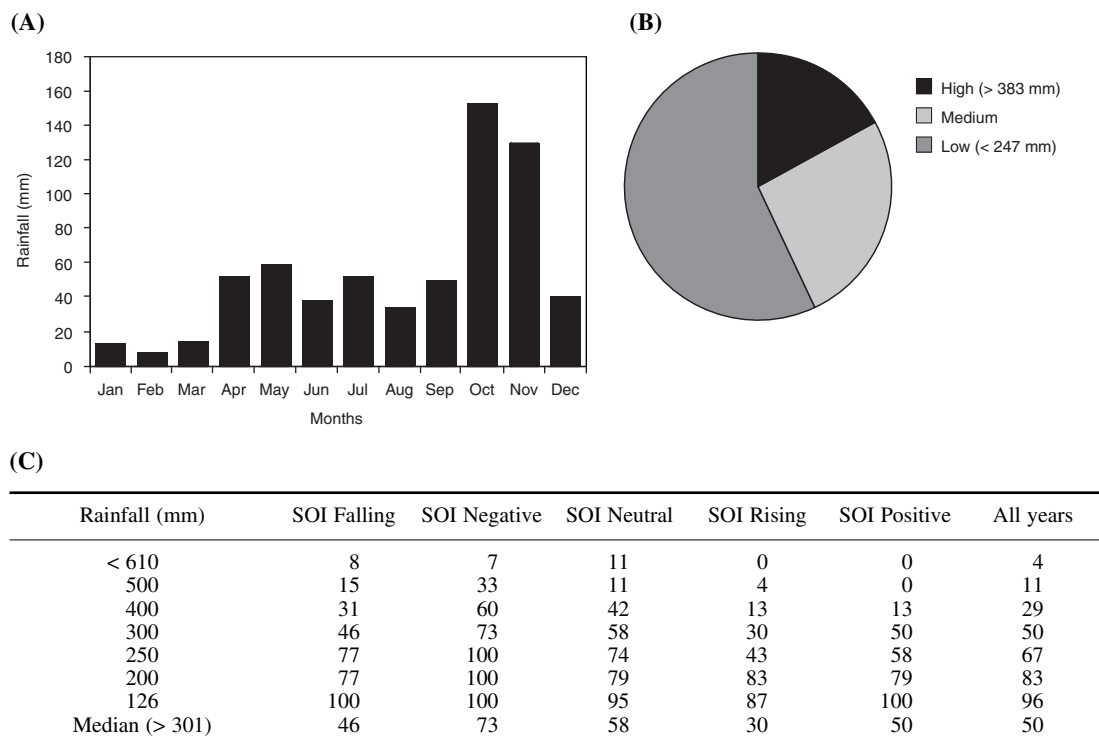


Figure 3. Formats of information shown to the farmers during the climate workshops: **A**—Monthly rainfall distribution; **B**—pie chart showing chance of rainfall during a rising SOI phase; and **C**—table containing the chances of receiving different amounts of rainfall during northeast monsoon season with various SOI phases.

Using climate information to simulate soil water and crop yields

A number of simulations were conducted to provide information to farmers in an effort to seek more useful ways of using climate information. One of these was the simple weekly water budgeting scheme (Frere and Popov, 1979) used to calculate available soil water at critical stages of a crop under different average SOI values to manage weather abnormalities like water stagnation and drought. A participatory mode was used to discuss the results of these analyses with the farmers.

Mechanistic process oriented crop growth models are highly useful to identify the planting opportunities of crops under rainfed conditions. A sowing window from September 12 to October 31 was established, based on farmers' local practice. The conditions suitable for sowing were simulated when the soil moisture at the surface layer (10 cm) attained 50% of the available soil moisture within the sowing window. The results revealed that when the June to July SOI was consecutively negative, the sowing date was about 15 days earlier than under rapid rise SOI phase (Table 2).

The model was also run to simulate the yield time series under low and high level of input management practice, which has provided the understanding on risk and opportunities. The yield deviations associated with these phases indicated that the yield potential in the negative and falling SOI phase during June and July was greater than all phases, while, it was lowest with rising SOI phase years (Fig. 4). Implica-

tions of these results are discussed with the farmers. Explaining the mean or median yield will not be sufficient to understand the variability in yield levels. Adopting forecast-based strategies may not always yield benefit. One has to understand the negative side of the implications because of forecasting.

Table 2. Simulated planting dates for sorghum at Coimbatore under different SOI phases during June–July.

SOI Phase	Historical planting date when soil moisture was 50% of PASW
Cons -ve	28 Sep
Cons +	4 Oct
Rapid fall	29 Sep
Rapid rise	12 Oct
Neutral	29 Sep
All years	2 Oct

The model results were discussed with the farmers during the climate workshops. The researchers and farmers had considerable difficulty in communicating problematic information. The use of a simpler approach, as discussed by Huda (1994), will go a long way in applying climate information to work with farmers in making improved farm decisions. However, such difficulty has not been observed with all the farmers. There are farmers who reacted positively to the climate forecasts and management information and they understood the uncertainty in the climate system and also in the approach used to quantify the impact of climate variability, including the model analysis. Huda et al. (1988) demonstrated

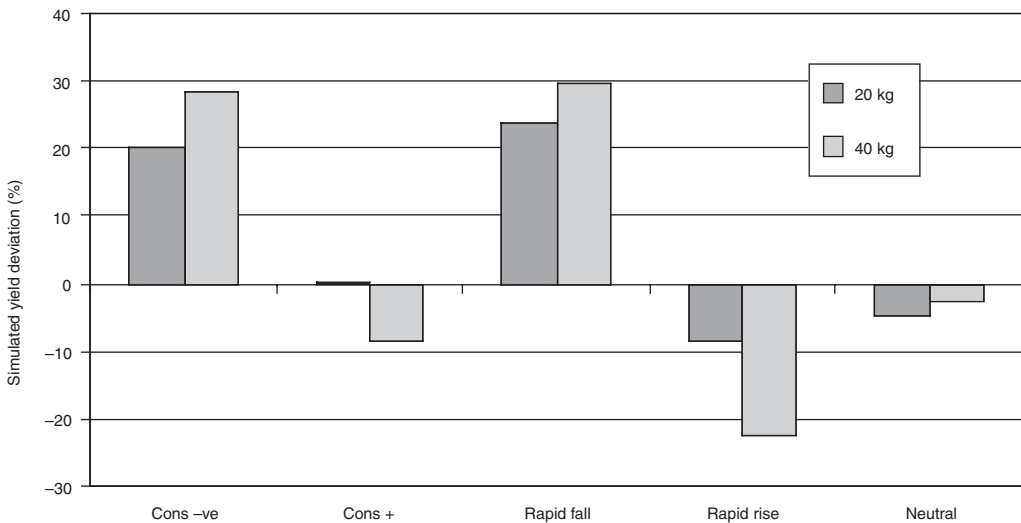


Figure 4. Deviation of simulated sorghum yield level by SOI phases at Coimbatore, India under two levels of fertiliser.

how simple climate information could be used to identify sorghum-growing environments in India.

Use of climate information for farm decisions: case studies

Case studies were conducted to evaluate the use of seasonal climate information in the context of exploring 'choices, chances and consequences' with participating farmers. Our experience with farmers is illustrated below under different key farm decisions. These experiences were recorded based on our interaction with the farmer groups and individual farmers during cropping seasons over the two-year period 1999–2000 and 2000–2001.

In the **first case study** carried out, a progressive farmer (S. Rangasamy) in one of our case study villages used the climate forecasts information for making cropping adjustments on his farm. The farmer had 2.4 hectares of cultivable area and planted 1.2 hectares of sugarcane every year (he sometimes maintained ratoon sugarcane) using ground water potential through his open wells. The planting season for sugarcane is from December to January. In his remaining 1.2 hectares he planted rice if there was adequate rainfall in October and November. Otherwise he would allot some area to paddy and to tomato and sorghum. Sometimes, if the rainfall onset was very late, the farmer preferred to sow local photosensitive sorghum. However, late sown rainfed sorghum (October–November) is at the risk of terminal drought.

In September 1999 the area faced a dry season and the open wells were not sufficiently recharged. During early discussions the farmer indicated that the forecasting at early September for the northeast monsoon would be very useful for him to make some important decisions on the crop choice. The SOI of June–July and July–August was in neutral phase. Based on the SOI phase, Mr Rangasamy was informed that there was a 44% chance of 388 mm of rainfall (median), compared with a 62% chance during falling phase.

Based on this information the farmer decided to avoid the risk of growing high water requirement crops such as rice during an expected dry season; he reduced the area under sugarcane and rice to 0.8 hectares each from the originally planned 1.2 hectare each. The 0.8 hectares of land was allotted to forage sorghum. The farmer planted sorghum during late September under rainfed conditions. He used his well water to irrigate sugarcane and rice with moderate stress. If he had taken the decision to follow the 'usual' practice, he would have abandoned at least 0.4 hectare each of sugarcane and rice during the mid-season to safeguard the remaining area. Consid-

ering his decision and our experience with the local situations, the economic benefit of the climate information was worked out. An added cost was incurred due to the decision to grow sorghum is Rs. 1200 (A\$50). The additional return gained due to the decision to plant sorghum in 0.40 hectares of land is Rs. 4800 (A\$200). The farmer also saved Rs. 12 180 (A\$507) by not planting paddy and sugarcane.

The **second case study** illustrates the advantage of a decision to transport water for giving supplemental irrigation, anticipating a normal rainfall during the following season. During late 1999, a farmer (Mr Kandasamy) at Arasur village planted Banana crop in his 0.8 ha of land with well-irrigation facilities. It was a one-year crop, which matured during November 2000. Though the water storage was considered to be sufficient for the crop at the time of planting, with an expectation of normal rainfall during summer (March and May) and southwest monsoon (June–September), the farmer could not manage his crop at the half-way stage due to inadequate planning. The water level in the well declined more than expected and Mr Kandasamy found it very difficult to manage his banana crop. The options he considered were: to abandon the crop unirrigated; or to purchase the water outside and irrigate the crop. If the option of abandoning the crop was selected, he might have lost an amount of Rs. 40 000 from 0.8 ha through cultivation expenses. If the second option was selected, he could invest only on one or two irrigations until the start of northeast monsoon season in October. Hence the risk of water purchase for irrigation needed to be considered.

The seasonal climate information for the northeast monsoon, and the possible associated options, were discussed with him during September. The probability of exceeding the average rainfall of 324 mm in the northeast monsoon season was 50%. The farmer considered this as a high risk. However, the farmer decided to purchase water from another well and transport it to his banana field. Subsequent rainfall events during October also supported his crop. He was able to harvest the banana crop successfully and to obtain a gross profit of A\$5000 and a gross margin of A\$3000. The most important aspect to note here is that the farmer has taken a risk and understands the consequences of various options in economic terms and the uncertainty related to each of those options.

The **third case study** illustrates the risk and problems associated with wrong interpretation of climate information. Mr. Palanisamy of Kodangipalayam village owns 2.4 ha of land with well irrigation facilities. We discussed with the farmer the probability of exceeding median rainfall of 70–100 mm as 55% during the southwest monsoon season. Based on the

southwest monsoon rainfall probabilities and his own farming experience, the farmer decided to plant Maize in 1.2 ha, tapioca in 0.75 ha and cowpea in 0.3 ha. The farmer also had an option to allot 0.75 ha for banana, reducing the maize area to 0.75 ha if the north-east monsoon forecast was for average rainfall. He was sceptical about the forthcoming season due to the uneven distribution and prolonged early dry spell during the south-west monsoon. He was carefully weighing up his options for the northeast monsoon season.

The probability of rainfall exceeding 310 mm in the northeast monsoon was 50%. The farmer misinterpreted this information to mean if he received 50% of 310 mm rainfall he would be able to sustain his banana crop that he was planning to cultivate on 0.6 ha of land, and he would forego 0.6 ha of maize crop. He planted accordingly and there was not even a single day of rainfall. If the farmer understood the implications of probability information (that there was also a 50% chance in getting lower than 310 mm rainfall), he would not have planted banana and planned only for maize in all the 1.2 ha. He applied 9 tonnes of Farm Yard Manure (FYM) and planted banana crop. Since there was no rainfall, he was unable to irrigate his banana crop and decided to irrigate tapioca since it requires less water and he would be assured of getting yield with limited irrigation. He left the banana unirrigated. Mr. Palanisamy invested the equivalent of \$A720 for planting and field management (field preparation, fertiliser application and weeding). This case study illustrates the problem of distorted communication and wrong interpretation of climate information. If the farmer had understood the choices and chances, there would not have been a question of misunderstanding between the parties involved in such a complicated exercise.

The **fourth case study** was related to adjusting sowing time of dryland maize. A farmer (G. Easwaran) at Chinnakodangipalayam village near Coimbatore has a 2.4 ha farm with 1.2 ha under dryland. Due to below normal rainfall in the preceding season, he had no intention of raising maize crop in his drylands. We discussed the advantage of taking up early sowing of maize during September. After the discussion, he changed his decision and planted early maize in 0.8 ha of dryland. The crop utilised the few rainfall events during the southwest monsoon season in late September 2000. The soil profile was filled enough to support the entire crop growth period. Though very limited rainfall was received during the northeast monsoon season, the farmer harvested 900 kg of grain yield from 0.8 ha of dryland (1125 kg ha⁻¹). The farmer benefited financially by adopting an early sowing option as facilitated through the use of seasonal climate information. In

the above example it has been observed that the approach of participatory decision-making not only helped the farmer to benefit from seasonal climate forecasting but was also useful for transferring important no cost technologies.

Conclusions

Building relationships with farmers and developing mutual respect for each other are key aspects for active participation (Huda et al., 2000; Packham, this publication). Participatory decision-making and the farmer survey have adequately demonstrated how improved knowledge and skills with respect to the variable climate have helped farmers in such matters as crop selection, time of sowing and irrigation. Use of the seasonal climate forecasts can benefit agricultural production and resource management. However, predictability of climate is the major issue with the current level of skill in this region.

The participating researchers have learnt to better understand the critical needs of farmers in making vitally important decisions on weather and climate-sensitive farm operations. The discussions with farmers and scientists, which considered choices, chances and consequences of any decision, helped to put into perspective the short- and long-term risks and benefits. This participative decision-making approach provided an opportunity to build confidence and trust among the farmers to better manage climate risk.

Use of a participative approach has enabled a greater level of collaboration between researchers and farmers to make more improved farm management decisions using climate information. Results of this work support the idea that there may be an opportunity to apply this work to other identified areas. However, it requires careful analysis and interpretation; as such types of response analysis often lead to the development of unrealistic information.

References

- Clewett, J.F., Smith, P.G., Partridge, I.J., George, D.A. and Peacock, A. 1999. Australian Rainman Version 3: An integrated software package of rainfall prediction.
- De, U.S. 1990. Medium range forecasting in India. An overview. *Mausam*, 41 (2): 35-338.
- Frere, M., Popov, G.F. 1979. Agrometeorological crop monitoring and forecasting. Plant production and protection paper 17. FAO, Rome, 64 pp.
- Huda, A.K.S. 1994. Management strategies to minimise climatic risk to wheat production in low rainfall areas of southern Australia. *Agricultural and forest meteorology* 69, 125-147.
- Huda, A.K.S. 1987. Simulating yields of sorghum and pearl millet in the semi-arid tropics. *Field Crops Research*, 15: 309-325.

- Huda, A.K.S, Pathak, P, Rego, T.J. and Virmani, S.M. 1988. Agroclimatic considerations for improved soil and water management and efficient fertiliser use in semi-arid India. *Fertiliser News*. Vol. 33. No. 4, 51–57p.
- Huda, A.K.S, Selvaraju, R, Balasubramanian, T.N., George, D.A., Geethalakshmi, V. and Pandian, B.J. 2000. Learning with farmers in making improved decisions to manage with agroclimatic risks/opportunities. Symposium on social transformation in rural sector, 1–3 February 2000. Visva-Bharati, Sriniketan, India.
- Nicholls, N. 1999. Cognitive, illusions, heuristics, and climate prediction. *Bulletin of the American Meteorological Society*, 80: 1385–1397.
- Packham, R.G. This publication. A background to participative decision-making with farmers.
- Selvaraju, R., Balasubramanian, T.N. and Geethalakshmi, V. 1998. On the variation of northeast monsoon rainfall over Coimbatore during warm and cold phases of El Niño/Southern Oscillation (ENSO). *Vayu Mandal*, January–June, 1998: 50–53.
- Sridharan, S. and Muthusamy, A. 1990. Northeast monsoon rainfall in relation to El Niñ and Atlantic hurricane frequency. *Vayu Mandal*, July–Dec., 1990: 108–111.
- Wise, A., Van crowder, L., Bernardi, M. 2001. Communicating agrometeorological information to farming communities. *Agricultural and Forest Meteorology* 103: 185–196.

A farmer's view of the human constraints to the adoption of seasonal climate forecasting in Australia

J. Hoffmann¹

Abstract

This chapter provides an Australian farmer's view of seasonal climate forecasting. It emphasises the need for "science" to take account of human factors when it is applied to practical and real-world contexts. The chapter gives a different window on the current situation of seasonal climate forecasting in Australia, from the perspective of a farmer rather than that of a climate scientist. The chapter asks for recognition of the value of history and the knowledge of elders – those people with extensive experience of the complexities of managing a farm in an unpredictable climate. It recognises the ability of such people to understand local factors, and their tacit experiential knowledge (indigenous knowledge). The chapter provides an example of how the application of seasonal climate forecasting results in dilemmas as well as information for farmers. It also notes the need for ownership by the farmer of the climate data collection and the analysis phases, if there is to be local and successful use of seasonal climate forecasting. The chapter ends with a poignant statement about the very real human and emotional consequences of decisions taken.

Introduction

IN all our endeavours to understand and improve the 'farming game' we must remember that farming is about the people doing it. Scientific research, on the other hand, is about clinically analysing information and relies on demonstrable facts. When we apply scientific principles to farming we cannot ignore the human element if we wish to understand the application of the knowledge. Farming is heavily reliant on the seasonal fluctuations in the climate. Seasonal climate forecasting has progressed from an invoking of the gods for information, to a sophisticated scientific discipline; however, the application of this new knowledge may not be as universal as we may expect. Much progress has been made in the disciplines that relate to understanding climatic phenomena and the knowledge base is increasing rapidly (Meinke, 2000). The fact remains that scientific seasonal climate forecasting has an inherently high level of randomness that will limit the level of forecasting skill (Meinke, 2001). Very high levels of skill would guarantee the uptake of climate information but anything less will mean that the uptake will be constrained by the human factors as much as the relevance and profitability of the technology.

Farming is a human activity. 'Men and women on the land continually confront the challenges of change. Most are open to new ideas and techniques, and are quick to adopt relevant profitable technology'. (Makeham and Malcom, 1981). By the same authors: 'The bleached bones of those who've lost at the farming game litter the uncertain arduous path to the pastures of plenty'.

If a change in the behaviour of farming people is desired, in this case the increased adoption of climate information, then the basic reasons for non-adoption may need to be addressed. Vanclay (1997) noted the need for education and training but also commented that 'farmers do not make conscious decisions about most issues, they do what is consistent with their social situation'. This study looks at human factors in the utilisation of modern climate information, particularly how the people involved feel in times of stress. It also highlights the need for farmers to participate in the learning processes.

Current situation

The historical record is the gold standard by which a future climate will be assessed. Predictions are commonly couched in terms of the likely deviation from the long-term averages, usually the mean. The first step in utilising climate forecasting is to gain a clear

¹ Ceranya, Lockhart, NSW 2656, Australia.

understanding of the historic record. The lack of a clear understanding of what is the 'normal' climate for a farming area can cause unrealistic expectations in the minds of farmers, agricultural researchers, government and advisers alike. Daly (1994) has dealt with the subject extensively for Queensland. Contrary to what we would expect, farmers do not appear to have a clear and accurate knowledge of the rainfall patterns. Of 12 local farmers who were interviewed by the author in 1998 as part of another study, only two could tell what the average annual rainfall in the area is. In spite of this, all the farming systems were similar and appeared to cope very well.

Knowledge on how to manage the climate is there even if the data is not. Many farmers are actually wiser than we give them credit for. One reason why a farmer will not adopt technology that seems appropriate to a technologist can be that the farmer is wiser than the technologist. Wisdom and knowledge are not quite the same thing. Rather than trusting climate forecasts a farmer may be more prudent and have a moderate stocking rate, conservative cropping practices and a cash reserve. This strategy would have close to a 100% chance of tiding the farmer through variations in the climate. If a climate forecast has a 30% chance of being wrong it will not be hard for a farmer's own systems to have a better outcome. It is not the lack of rainfall that restricts production in most seasons. It is the lack of knowledge of the future. Conservative management practices must be used to reduce risk and it is these conservative practices which restrict production. Climate is the one factor that cannot be managed by a farmer in any other way than by understanding it.

The wisdom of the elders

Humans attempt to understand the world by linking cause and effect, and amid the defining of cause and effect is the basis of much of our science. Humans linked thunder and lightning in a cause and effect relationship long before science understood the phenomena. We still commonly link thunder and lightning with rain as a cause and effect relationship because they commonly occur just before rain, and our general understanding is that the cause precedes the effect. In fact, the rain causes separation of charge in the storm, which is the cause of the thunder and lightning; we just see and hear the effect before the cause. This linking of cause and effect, which is often reinforced by chance, is the basis of some of the beliefs which may serve to limit the uptake of evidence-based predictors. An individual who has personally participated in the formation of their own system and has confidence in a particular predictor will be reluctant to follow evidence-based predictions. There may be a sound basis for these

predictors, and even if there is not, there has been some reinforcing of them by chance, which is also true of evidence-based predictors. The difference is that science has standard methods for dealing with the effect of chance, while ordinary people usually do not have them. Discussion of the weather is our most common social lubricant. Everybody can participate in a weather discussion but nothing spoils a good discussion like somebody who actually knows what they are talking about.

People close to the land are often close observers of the weather, of the animals and plants, and of atmospheric phenomena. The changes in the behaviour of animals, birds and insects and atmospheric phenomena are often linked with expected changes in the weather and they are then used as predictors. Ant activity, the wheeling and crying of the native parrots, curlews calling at night, insects swarming to night lights, the flights of migratory birds, circles around the sun or moon, phases of the moon, cloud effects at sundown and the persistence of aircraft vapour trails are examples. The people who want the information have made the observations, assessed the information and drawn the conclusions. What is lacking is the ability to objectively assess the relationships. People become firm believers in their predictors and sceptical of other predictors where they were not participants. Participative learning requires that people put their practices, assumptions and ideas to the test (McTaggart, 1989). It is the lack of testing processes which allow unreliable predictors to persist or excellent predictors to be disregarded. The attractiveness of some of the wisdom of the elders is in the very fact that they cannot be tested easily. The author's grandfather would pronounce gravely that if there were four frosts in a row then it would rain 100 days later to the day. Testable, but who would bother?

How much information?

In the winter of 1997 the Southern Oscillation Index (SOI) had moved into a strongly negative phase. There was much media discussion but little information. Contradictory statements from prominent people were common. Information that was readily available was expressed in terms that were confusing and probably deliberately vague. The author had studied the phenomena at that time and understood the principles of the Walker system, the implications for sea surface temperature changes, the language and the possible application of the principles. The Rainman computer program was used to calculate the probabilities of rain during the coming critical spring season. The author had studied the local climate for many years and knew what the baseline was, and, as a farmer, understood the local farming systems and the people involved. This was known to

many of the local farmers and the author was asked questions that could only be answered in terms of their probability outcomes.

The dilemma was to find the best way to communicate probability outcomes to people who needed to know exactly what was going to happen. Decisions that get to the very basis of what a person is and how they see themselves in the world had to be made by people who were ill-equipped to do so. The consequences of getting it wrong were too serious to bear thinking about. The farmer can draw on the current knowledge of the effect of the SOI, Indian Ocean sea surface temperatures and whatever else is available. From there the deviation from the norm can be calculated. Can the effect of the pressure and stress on the farmer during that time be calculated? They know that it may not rain as the probability suggests. There is, perhaps, a high probability that it will all turn out well, but who knows the probability outcomes for the person? A farmer's biggest fear is not of the drought or losing all the assets, but the fear that may not be up to the task ahead. What if the decision is made that there is a terrible drought looming and appropriate measures are taken? The stock are sold for very little money, fertiliser is withheld from the crops and then ... it rains. Getting it wrong when you predict a drought is almost as bad as getting it right.

Who will farmers blame if it all goes wrong? They will blame themselves, but they will probably also blame the adviser. Advice given at a critical time in the lives of farming people should not be given lightly. We should also ask if people really benefit from knowing the future. Some could not have faced the future if they knew just what some seasons were going to be like. It is precisely because farmers did not know that they had hope — hope that it may not turn out too badly, hope that it may rain next week. It is hope that sustained them and enabled them to face another day.

How much information and how will it be given?

There will always be a high probability of being wrong in forecasting. Ideally the farmer would assess and interpret the information themselves and thereby have ownership of the decision. If the farmers make the forecast themselves they will know the basis of the decision. It is unlikely that the majority of farmers will be in a position to assemble and assess the information that is required. Even if it were possible for a farmer to do all of that, there is probably a 30% chance of getting it right simply by guessing. If there is too much information in a form which is too difficult to access at a time of stress, guessing would be a better option. Guessing means no additional knowledge to be acquired and assessed

and no additional stress on the person. Too little information and the odds of getting it right fall away because the basis of the prediction is not sound and guessing again becomes a sound option. The alternative is information processed but deliberately left partially uninterrupted so that the person has to assess, interpret and gain ownership of the situation by participating in the process.

To put these principles into practice the author determined to attempt to do two tasks. First, he attempted to educate the farmers on the current understanding of sea surface temperature changes and the SOI/El Niño phenomena, in the belief that knowledge is strength and comfort. There was at the time much discussion in the media, much of which was ill-informed opinion. The author reviewed his knowledge of the phenomena, prepared a talk and had basic information printed.

Second, data from the local area was collected and set out in a way that is easily interpreted (Table 1). It is set up so that a farmer can easily review all past events that relate to the movement in the SOI and make a probability judgement on the present situation. The time was July 1997, and the information for the months of June and July is set out and spring outcomes for the high and low SOI seasons are shown separately. The yield outcomes are calculated using a simple water use/yield model (French and Schultz, 1984).

The seasons where the SOI was above 10 and rising are shown in standard type, those where it was below 10, and rising/falling are shown in bold. Exceptionally good or bad seasons that do not fit this bracket are not shown. Comments are based on a subjective analysis of the daily rainfall chart for each season. The subjective analysis differs substantially from the model in some seasons because of unfortunate timing of the rainfall. This is a problem for any simple model, such as that used to calculate the potential yield. The years 1882 and 1886 are examples of seasons that are somewhat similar in total spring rainfall but had entirely different crop outcomes. Scan this information and assess what degree of risk you would take with wheat crop production.

Interpreting Table 1 requires some work. The relationship between SOI and spring rainfall is not concise. The simple task of interpreting leads to some ownership of the conclusion

Having done the exercise ask yourself how you would feel if the year was 1882 and every other farmer was harvesting a bumper crop, but because you did not have the best available knowledge you were not. How would you be feeling in 1982 if you applied your normal winter fertiliser, hoping that the rains would come in spite of the predictions?

This was an exercise in bringing complex information to people who needed answers to immediate

Table 1. The relationship between the SOI, spring rainfall and potential yield of wheat (Bullenbong Recording Station).

Year	SOI in June	SOI in July	Rainfall for spring (mm) (Aug–Nov)	Subjective assessment of yield potential	Potential yield (tonnes/ha)
1882	-10	-19	201	Good	4.00
1888	-14	-15	83	Poor	1.70
1896	-27	-19	154	Drought	3.40
1901	16	13	215		3.10
1905	-27	-19	124	Good	3.80
1911	-10	-11	106	Average	3.50
1914	-15	-17	36	Drought	0.20
1917	17	26	274		6.20
1938	14	17	110		2.20
1940	-17	-14	47	Drought	0.20
1941	-13	-19	71	Average	1.40
1950	22	19	224		5.00
1955	12	16	226		5.20
1956	10	11	183		6.90
1965	-10	-21	177	Good	2.40
1972	-10	-17	152	Average	2.10
1974	1	11	280		6.80
1975	12	19	216		3.40
1976	0	-11	199	Drought	2.10
1977	-15	-13	37	Poor	1.40
1979	4	13	206		3.20
1982	-17	-17	48	Drought	0.50
1987	-17	-17	45		3.00
1994	-9	-16	80	Drought	1.40
		Average	167		3.50

questions. How well did the exercise work? There was no formal evaluation but many people said it helped. Most of the farmers, including the author, were too busy coping with the extra work and pressure.

Conclusion

For farmers to have ownership of the processes in climate decision-making, to collect the records, (which most farmers do for rainfall anyway) and to analyse those records (which they will probably need help with) will probably be enough to ensure that ownership. For the majority of farmers, participative learning will be concentrated at the times when climate information is most critical, notably when drought appears to be looming. It is necessary to increase its use as a basis for planning for the poor seasons and to maximise the better seasons. We should never forget that we are dealing with a human activity, that the people involved are diverse and are personally and emotionally part of the situation. Those of us who can improve the situation for farmers by bringing knowledge and data to assist in managing climatic variability should at least attempt to understand how it feels to lay awake at night and hear a hot dry wind blowing away your last hopes.

References

- Daley, D. 1994. Wet as a shag, dry as a bone. Drought in a variable climate. Queensland Department of Primary Industries, Brisbane.
- French, R.J. and Schultz, J.E. 1984. Water use efficiency of wheat in a Mediterranean type environment I. The relation between yield, water use and climate. Australian Journal of Agricultural Research.
- Gillespie, G.W. and Buttel, F.H. 1989. Farmer ambivalence towards agricultural research: An empirical assessment. *Rural Sociology*, 54(3), 382–408.
- Makeham, J.P. and Malcom, L.R. 1981. *The Farming Game*. Gill Publications: Armidale.
- McTaggart, R. 1989. Principles for participatory research. Deakin University. *The Third World Encounter on Participatory Research*. 1989.
- Meinke, H. 2001. Understanding climatic variability to improve agricultural decision making. 10th Australian Agronomy Conference.
- Meinke, H., Hammer, G., Stone, R., Power, S., Allen, R., Potgeiter, A. and Howden, M. 2000. Anticipating climatic variability to improve agricultural decision-making. *Climanage 2000* (Conference on Australian Climate Variability).
- Vanclay, F. 1997. The sociological context of environmental management in agriculture. *Critical Landcare*. eds. S. Lockie and F. Vanclay. 9–28. Centre for Rural Social Studies, Charles Sturt University, Wagga Wagga.

A background to participative approaches for research and application of climate science

R.G. Packham¹

Abstract

This chapter provides a background to the use of participative processes in the research and application of Seasonal Climate Forecasting (SCF). It notes that SCF needs to be useful for small-scale and subsistence agriculture, as well as industrial, export-oriented agriculture, and therefore the policy implications of the application of SCF must be considered. The chapter goes on to show how modern agricultural extension requires true participation. As SCF is a complex, dynamic system, the principles of complexity science and chaos theory need to be understood and used. The application of these principles is underpinned by a participative approach. Participative approaches embody the values of sharing power and decision-making, and of respecting the views and knowledge of all stakeholders; as such, they are based on a rights-based, rather than a utilitarian, approach to values. Participation represents a shift from *teaching* to *learning*, with a particular focus on experiential learning — finding out and taking action. Participation proceeds through dialogue, and relies on commitment rather than coercion. Thus, there is a need to build effective partnerships amongst the stakeholders involved, and this often requires some form of institutional reform. Participation is not a once-only input, but rather an ongoing process throughout the life of a project.

SEASONAL climate forecasting (SCF) is aimed at improving agricultural production through improved decision-making by farmers. Thus the technology needs to be of use to, and used by, these farmers. Participative approaches to research and application can overcome some of the problematic issues encountered in the past with the implementation of new technologies. For example, the green revolution with its package of technologies utilising hybrid seeds, chemical fertilisers, pesticides and weedicides, as well as large-scale irrigation, resulted in tremendous gains in food production. However, there are still nearly 800 million people in the developing world affected by hunger and malnutrition. This is not due to a lack of world food production, but to more complex human issues relating to questions such as: *Who grows the food? How and where it is grown? How it is distributed? Who has access to it?*

The current problems of world hunger are not a function of demand outstripping supply. They are a problem of access to food and food-producing resources. The green revolution was hailed as a ‘miracle’, yet this view concentrates only on the outcome of increased yields, while ignoring the social and ecological costs.

Seasonal climate forecasting needs to be aware of policy implications, as well as technological implications, if it is to be successful in improving yield and food security. Many people now believe that any technological policy for rural and agricultural development must be judged, among other factors, on whether it increases or decreases *inequity* in the distribution of and access to resources and food, and whether it ensures the sustainability of resource use. This applies as much to western industrialised agriculture as it does to the agriculture of developing countries. Currently, in developed countries, there is acknowledged evidence of inequity and decline in rural communities, both socially and environmentally, while in developing countries, there is strong evidence that the green revolution has similarly increased inequity, and that the large-scale use of

¹School of Environment and Agriculture, University of Western Sydney, Hawkesbury Campus, Locked Bag 1797, Penrith South DC, NSW 1797, Australia. e-mail: R.Packham@uws.edu.au

fertilisers, particularly, is adversely affecting soils and is leading to a decline in total yields (Altieri, Rosset and Thrupp 2000; Simms 1999; Shiva 1999).

For the developing world, there is increasing recognition of a need to support a viable low-input, small-farm agriculture that will, overall, be more productive and be of greater benefit to the alleviation of hunger than the current focus on industrial-agriculture, monocropping, and export-orientated farming systems. Seasonal climate forecasting has a key role to play in this. It has also been suggested that such low-input, small-scale agriculture needs to apply the principles of *agroecology*, which integrates indigenous knowledge (something the green revolution totally ignored) with current technical knowledge, encompassing not only production goals, but also considerations of social equity and ecological sustainability. This also applies to season climate forecasting. These approaches can best be developed participatively, since they rely on local farming knowledge and techniques that are adjusted to different local conditions, the management of diverse on-farm resources and inputs, as well as the incorporation of contemporary scientific understanding.

Participation and agricultural extension

Traditional extension assumes that innovations based on the products of agricultural science research, such as knowledge of better climate forecasting and its incorporation into quantitative prediction models, are improvements and that any problems arising can be solved with more science. This uncritical acceptance can result in detrimental social and ecological impacts. Extension differentially reaches those farmers who are better educated and economically better off. It applies to production agriculture, rather than subsistence agriculture or conservation technologies, particularly where these may have an economic cost in the short term. Traditional extension approaches tend to trivialise and marginalise local or indigenous knowledge, ignoring generally the contribution farmers might make about agricultural technology development. Extension has also tended to ignore the political and cultural contexts within which technical developments are to occur (Vanclay and Lawrence 1994).

From a farmer's perspective, innovations are less likely to be adopted if they do not conform to a number of criteria. These criteria include:

- If their degree of complexity makes them hard to understand and requires greater management skills, this could be an issue with climate models.
- If they are indivisible, where partial adoption of an innovation package is not possible, so SCF needs to avoid this pitfall.
- If they are incongruent with farm and person objectives, so SCF needs to be flexible and adaptable to local needs and concerns.
- If they are not economically beneficial, particularly over the short rather than long term, so SCF needs to be able to demonstrate its efficacy.
- If risk and uncertainty is high, so these need to be clearly stated in ways the farmer can understand.
- If there is conflicting information about the innovation, so a common approach needs to be taken when taking messages to farming communities.
- If the required cost or capital outlay is high, and this should not be a major issue with SCF.
- If the intellectual outlay is high, meaning that the complexities of the science have to be translated into meaningful 'rules of thumb' if farmers are to adopt the ideas.
- If there is a loss of flexibility, which should not be an issue for SCF directly.
- If the physical and social infrastructure is not present; for example, marketing infrastructure or cultural norms about an innovation that make it acceptable to a particular farming group. Here participative approaches will assist the acceptance of SCF.

It is impossible for scientists to fully understand all these issues from a farmer's perspective when trying to develop an innovation in isolation. It is only by participating in the development of an innovation *with* the farmer or farming community that these concerns can be holistically addressed. There needs to be a shift in research and development practice away from an elitist 'trickle-down' approach, to the facilitation of group interaction and problem solving at the local level — participative decision-making with farmers.

SCF as a complex dynamic system

Many everyday situations are *inherently unpredictable*. Unlike what science often tries to have us believe, the behaviour of complex systems, such as climate science and SCF, is not based on a linear transformation of inputs into outputs. This unpredictability does not mean that these situations are unintelligible, but it does mean that prediction in a complex system will only ever hold for a short time in a local context, even if precise mathematical descriptions are known. Such complex dynamic systems are very sensitive, so that even an infinitely small change in the starting conditions of a new process can result in drastically different future developments — the so-called Lorenzi butterfly effect. The reason that short-term predictions hold is that it takes time for the consequences of small changes to build up. The long-term behaviour cannot

be predicted by experts, and can only be allowed to emerge, but it does so according to family-like resemblances. For example, we cannot predict the exact shape of a particular snowflake, but it will still be clearly a snowflake.

Climate science and forecasting has many of the features of complexity and chaos, a relatively new and unfolding field of science. In complexity and chaos theory, reducing does not simplify (as it does in experimental science), since interaction is important, and this means inseparability. A pattern feature of this inseparability is known as a *fractal*, which, simply put, is an entity with characteristics that are simultaneously apparent at many *scales of focus*. Looking at one fractal level enables the inquirer to make generalisations about other fractal levels at different scales. The deeper the understanding of a complex system the more meaningful nuances can be discovered, but it is never simplified by reduction into parts since the parts retain the complexity of the whole.

Complex dynamic systems give birth to forces of *self-organisation*, which appear to arise spontaneously from apparently disordered conditions, not driven by known physical laws. This occurs when amplifying (or positive) feedback loops drive a non-linear system towards instability and away from stable equilibrium, which is governed by negative, or damping, feedback loops. There is a border between stability and instability where feedback flips autonomously between the amplifying and the damping to produce chaotic behaviour — a paradoxical state that combines stability and instability. It is at this *Edge of Chaos* that complex new orders emerge. The two conditions required for such self-organisation to emerge are a permanency of motion (as found at the edge of chaos), and an intensity of interactions between the varieties of parts that gave rise to the complexity. The term *attractor* is used to describe such things in motion being pulled toward a definite point or region during the cycles of amplification and damping. These are of three types, known as *point*, *closed loop* and *strange* attractors.

Complexity theorists use all these ideas in social situations to seek increased understanding in order to participate personally, critically and meaningfully in complex, yet commonplace, situations such as climate forecasting. Participation here is based less on the need for understanding for improvement, intervention and control, but rather on understanding leading to increased choice for future, personally meaningful action in an ever-changing world. This is the situation of using climate science to help farmers improve their agricultural outputs in a sustainable way. While the laws of science are deterministic, social practices, being complex and chaotic, are *agreed upon* by people, either consciously or not,

and are modified over time through adaptation. Thus, participative approaches are required when applying scientific findings to complex social systems, but they can only lead to short-term control in local contexts. Processes need to be established to deal with the continually emerging complex issues, such as the ongoing use of seasonal climate forecasting by farmers. Stacey (1992) suggests that the following steps need to be included in any such participative process:

- Develop new perspectives on the meaning of control, where a (local) group itself discovers its intention and exercises control.
- Encourage self-organising groups that discover their own challenges, goals and objectives.
- Design the use of power to allow for open questioning and public testing of assertions.
- Provoke multiple cultures and new perspectives.
- Present ambiguous challenges instead of clear, long-term objectives or visions.
- Devote explicit attention to improving group learning skills.
- Invest in management resources to allow this to happen.

These ideas of complexity and chaos bring new perspectives to participative approaches to the application of climate science with farmers, adding to those that arise only from trying to improve situations through the use of experimental science, economics or extension. They provide an additional rationale for the use of participative methods, since farmers are trying to manage complex systems, as well as the climate being a complex system.

The participatory approach and values

The word *value* has several meanings, but currently has come to be dominated by its economic sense of the *quality of being most useful*, giving rise to judgements of worth, a fair equivalent for something, or a thing's (or person's) usefulness or importance. However, this is only a part of its fuller meaning as a *principle, standard or quality* considered worthwhile or desirable. Here, the *usefulness* of something is only one of many ways of making a value judgement. It is in this sense that values, together with their associated beliefs, affect the learned behaviours that give rise to a particular community's culture. Thus if only scientific or economic values are used to make judgements, they may not always find acceptance in many communities.

A participatory approach to seasonal climate forecasting itself contains a set of values, and people using this approach add others as well which are relevant to a particular context. As is discussed below, a participative approach has embedded in it the

values of *sharing power and decision-making* across all stakeholders, and of *respecting the views and knowledge* of all stakeholders. It is moving beyond the idea of making tradeoffs between competing objectives, as is the case with the utilitarian approach of much of modern economic development, or of only accepting experimental science as the arbiter of what is right, as much of agricultural decision-making does in a development context. Participation is underpinned with a more *rights-based* (or deontological) approach that is incompatible with the utilitarian (or teleological) trade-off rationality.

There are certain things particular communities will accept, and certain things they will not freely accede to, such as in cases when there is a contravention of their value and belief systems. In participative approaches, it is the *means* that are important, allowing the *ends* to emerge from this application of a valued process. A participatory approach may well also embrace other general values than the two already mentioned, as often those working with a participatory approach also subscribe to broad human values, such as Love, Peace, Truth, Right Action and Non-Violence, which they bring to any participative process they engage in. It is this concern with, and incorporation of, underlying values that differentiates a true participative approach in its genuine, sincere form.

An example is given by Midgley (2000) of how methods will fail to achieve participation if they come from a group holding a utilitarian or purely scientific set of (teleological) values, which then tries (often unwittingly) to impose these on a community group holding rights-based (deontological) values. If the group insists on using its teleological values, it can then only succeed by domination of its views at the expense of respect for the values held by other stakeholders. An understanding of some of the philosophical issues involved is thus necessary for making an appropriate selection of a particular methodology to be used in a local context where participation is a goal.

All methods implicitly embody certain rationalities and values that will impinge differently on various stakeholder. Participation requires a critical awareness of these methods to emerge through *dialogue* amongst stakeholders, particularly about the values that must be upheld. It is the values that the various stakeholders hold that will underpin their judgements about if and when an improvement has occurred in a particular context. This contrasts with approaches based on experimental science, where the desired outcome is often established before any intervention — participatory or otherwise — commences. What constitutes an improvement is thus a topic for consideration and dialogue amongst the

stakeholders of an issue (or context) throughout any intervention, with such dialogue allowing the values held by different groups to emerge and be recognised.

Participation represents a shift from teaching to learning

All that has been said so far has a clear focus on *learning*, and this leads to another innovation required to improve aspects of the complexity of agro-environmental issues — a move away from a focus on *teaching* in the sense of *telling* about these issues and how to improve them, to *learning* with stakeholders about these issues and how to improve them. By this is meant to be a move away from a belief that knowledge can be ‘injected’ into others in some way, and that knowledge by itself can lead to understanding and thus improvement. There is a need to recognise and acknowledge the vital learning link between *finding out* about issues, and *taking action* to improve these issues in some way. The finding out and taking action also needs to go on in the actual (experiential) context that is giving rise to the issues of agro-environmental concern, and not be confined to simulations and experiments within the confines of the research laboratory or research station. As far as possible, the learning and research needs to be issue-based in actual agricultural contexts, and it is from this basis that other issues of a more discipline-of-science kind can be addressed. The actual contexts are always complex and messy to deal with (not neat like the adapted questions that science addresses), and it is here that participative and systemic ideas come to the fore.

Experiential learning has been described elsewhere (for example, Kolb 1984; Packham, Roberts and Bawden 1989; Bawden 1995), but the basis of such learning is that it is made up of four sets of questions: *What is there? What does it mean? What might be done? How will we do it? How will we know when we have done it?* Thus, while incorporating theory and practice, experiential learning is more than either or both of these — experiential learning is *not* just learning in a practical situation.

When using this approach with SCF, these questions need initially to address the issue(s) of concern. They also need to address the methods chosen to answer these immediate questions, and to examine and question the assumptions held in deciding on the selection of the methods used to answer these questions — the assumptions that help us make meaning, give rise to the values we hold, and that are underpinned by different ways of knowing (epistemologies) and worldviews (Bawden and Packham 1993).

Thus there are three *levels* of learning going on in experiential learning.

This linking of theory with practice and values in a recursive way is termed *praxis*. The key to this innovation is that praxis is grounded in real contextual issues as the main focus and thrust of learning. The role of the researcher here then becomes much more that of a *facilitator of learning*, rather than simply an expert disseminator of knowledge. It requires different inter-personal and communication skills, both of the researcher and the stakeholders. Again such issues have been well described elsewhere (for example, Packham et al. 1989; Bawden 1992; Bawden and Packham 1993). The 'teaching' becomes much more learner-centred and self-directed, rather than teacher-directed.

Others support these ideas, particularly in the context of developing a more sustainable agriculture. For example, Pretty (1998) believes that the central concept of sustainable agriculture is that it must enshrine new ways of learning about the world, and that such learning must not be confused with teaching. Teaching implies a transfer of knowledge and understanding, he notes, from someone who knows to someone who does not know. Ison (1990) also noted that where teaching does not include a focus on self-development enhancing the ability to learn, then teaching threatens sustainable agriculture. Both note that this has profound implications for agricultural development. The focus is less on *what* we learn and more on *how* we learn and *with whom* — a much greater focus on participation than is necessary with teaching. Pretty (1998) suggests that this implies new roles for development professionals, leading to a whole new professionalism with new concepts, values, methods and behaviour, characteristics that he goes on to describe more fully

What is participation?

What has been argued here is that if research and application of climate science is to lead to the improvement of an agricultural or environmental issue, it will not be achieved through the simple uniform delivery of a service or package of information. Such delivery usually assumes a need, that this need comes from a homogenous and definable group, and that these needs can be defined and understood by people external to the situation. Effectiveness of delivery then comprises the development of necessary technology, and then offering this as a service, usually through a centralised system, for adoption and implementation. This is a detached, positivist and technocentric view. As has been suggested by Sriskandarajah et al. (1993), an alternative view can be taken that can optimise the adoption of seasonal

climate forecasting, in which the complex and heterogeneous needs of the people involved are first explored and defined through participation and dialogue. Providers and recipients then plan mechanisms of effective delivery in a co-learning way. This is the approach required if the benefits of climate science research are to be useful to rural communities.

Effective participatory systems depend upon commitment rather than coercion. These systems cannot be programmed or tightly controlled. They have leadership requirements for building effective partnerships, which traditionally-designed technical agencies often lack, although, at least in developing countries, indigenous and voluntary agencies are more likely to have these leadership requirements. Thus when adopting a participatory approach, there often needs to be a degree of institutional reform before such approaches will be fully understood and adopted. However, even in institutions that accept the need for a participative approach, issues about the nature of participation in terms of extent and quality, and questions about just who should participate in projects, often remain problematic. Sriskandarajah, Fisher and Packham (1996) identified key themes in participative projects as being:

- The importance of the scope for genuine participation in decision-making if 'community participation' is to be meaningful.
- The need to see participation as a continuing process of negotiation and decision-making, rather than a once only input into project planning.
- The need for clear identification of interested parties as the first step in establishing community-based resource management programmes.
- The need to recognise and build upon local knowledge and existing local resource management and institutional support practices.

A major criticism of the participatory approaches in widespread use today is that they are used to extract information in a ritualistic manner in project planning, rather than being used to empower the local people. This is not an issue with the methods themselves, but in how the methods are being used. In this regard, Pretty (1998) while noting the long history of participation in agricultural development, suggested that two overlapping schools of thought and practice have evolved. One views participation as a means to increase efficiency, with the central notion that when people are involved, they are more likely to agree with and support the new development or service. The other view sees participation as a fundamental right, in which the main aim is to initiate mobilisation for collective action, empowerment and institution building.

It must be re-emphasised here, as discussed earlier in this chapter, that participatory approaches are learning approaches, and the process of learning has already been outlined above. Pretty (1998) supports this view, and goes on to suggest six common features of these learning approaches to participatory development. These are:

- A defined methodology (principles for action) and a systemic learning process.
- Multiple perspectives — a central objective to seek diversity, rather than characterise complexity in terms of average values.
- Group learning processes that involve the recognition that the complexity of the world will only be revealed through group inquiry and interaction.
- Context specific.
- Facilitating experts and stakeholders. The role of the 'expert' is best thought of as one of helping people in their situation to carry out their own study and to achieve something.
- Leading to sustained action — the learning process leads to debate about change and debate changes to the perceptions of the actors and their readiness to contemplate action (praxis).

Participatory Action Research

This final section is included to provide researchers with an introduction to a methodology that enables them to incorporate the themes discussed so far. Participatory Action Research (PAR) is a form of a wider methodology simply called Action Research. Action research combines a *research* activity with *action* to improve the context within which the research is located. PAR goes further, in that it enacts the values of participation — particularly the sharing of power and decision-making, and respecting the views and knowledge of all stakeholders. Thus a key evaluative criterion for PAR has been stated by McTaggart (1989) to be: *has it improved the lives of those who have participated?* If not, PAR would reflect on: *why not?* and *what action can now be taken to achieve this?* This is the *participative action* sense of PAR. In addition, however, it is in essence a coalition of practical and theoretical traditions, such that action and new knowledge are both expected and aimed-for outcomes. Thus it is *research* because there is an intensive study of a situation that aims for the production of knowledge, while also including the idea of *informed practice*.

Action research is a group activity, and PAR tries to reveal the power issues involved in most group work through explicitly striving to share the way research is conceptualised, practised, and conducted. The group of people, including the community and

the people wishing to help the community, are all involved in conducting the research for themselves, and all have control over the use of outcomes and the whole research process (Tandon 1988).

Action research proceeds in a spiral of steps, each of which is composed of planning, action and the evaluation of the results of that action. It begins with a general idea that some kind of improvement or change is desirable. The group then decides where to begin in making improvements. Action plans are developed, but they need to be flexible and responsive, due to the complexity of real social situations — a *blueprint* approach as used in experimental science is not appropriate in these situations, because of their complexity (see earlier section). Participation in and learning about such complexity allows for emergence and self-organisation. It is the cyclical nature of the action research process that allows for this flexibility, through reflection on action, replanning, followed by further action, reflection, and so on. The group is continually learning from its own experience, and it is the group that has the primary responsibility for deciding on courses of critically informed action which they believe seem most likely to lead to improvements in their situation. The group also has the responsibility for evaluating the results of strategies it decides to implement (Kemmis and McTaggart 1988; Greenwood and Levin 1998; Kemmis and McTaggart 2000; Dick 2001).

Conclusion

This chapter has explored the meaning of, and current interest in, participatory approaches to research in agriculture and rural development with regard to participatory decision-making with farmers to utilise the insights being gained from climate science research and seasonal climate forecasting. A number of themes were developed and explored. This has been a mainly theoretical approach, as this chapter is intended to provide a background, a philosophical and methodological basis, for the ideas presented in the rest of this book. The themes are expanded upon to different degrees through the case study chapters. These theoretical ideas will also give people criteria with which to judge their own and others' participative approaches.

The next chapter describes a workshop, which, amongst a number of aims, looked at the understanding of 'participative decision-making with farmers' by a group of climate researchers, and others involved in the application of SCF to farmers. The workshop adds to the other chapters of this book in elaborating and describing how the idea can be put into practice in the area of SCF.

References

- Altieri, M., Rosset, P. and Thrupp, L.A. (2000). The Potential of Agroecology to Combat Hunger in the Developing World. *Third World Resurgence*, Issue 118–119, June–July 2000.
- Bawden, R. (1992). Systems Approaches to Agricultural Development: The Hawkesbury Experience. *Agricultural Systems* 40:153–176.
- Bawden, R. (1995). Systemic Development: A Learning Approach to Change. Occasional Paper No. 1, Centre for Systemic Development, University of Western Sydney, Richmond, NSW, Australia.
- Bawden, R. (1999). The Community Challenge: The Learning Response. *New Horizons in Education* No. 99, October 1999, Sydney, Australia.
- Bawden R. and Packham, R. (1993). Systems Praxis in the Education of the Agricultural Practitioner. *Systems Practice* 6:151–162.
- Dick, R. (2001). <http://www.scu.edu.au/schools/gcm/ar/areol/areolhome.html>
- Greenwood, J. and Levin, M. (1998) *Introduction to Action Research: Social Research for Social Change*. Sage, London.
- Ison, R. (1990). *Teaching Threatens Sustainable Agriculture* Gatekeeper Series SA 21, IIED, London. Deakin University Press.
- Kolb, D. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall, New Jersey, USA.
- McTaggart, R. (1989). Principles for Participatory Action Research. Paper presented to the Third Encuentro Mundial Investigacion Participativa (The Third World Encounter on Participatory Research), Managua, Nicaragua, September 3–9, 1989.
- Midgley, G. (2000). *Systemic Intervention: Philosophy, Methodology and Practice*. Kluwer Academic Publishers, The Netherlands.
- Packham, R., Roberts, R. and Bawden, R. (1989). Our faculty goes experiential. In: Weil, S. and McGill, I. (eds.), *Making Sense of Experiential Learning*. Open University Press, Milton Keynes, UK.
- Pretty, J. (1998). Participatory Learning for Integrated Farming. Proc. Internet Conference on Integrated Bio-Systems (eds. Eng-Leong Foo and T.D. Senta), Institute of Advanced Studies, UN University. <http://www.ias.unu.edu/proceedings/icibs>
- Shiva, V. (1999). *Betting on Biodiversity: Why genetic engineering will not feed the hungry or save the planet*. Research Foundation for Science, Technology and Ecology, New Delhi, India.
- Simms, A. (1999). *Selling Suicide: Farming, false promises and genetic engineering in developing countries*. Christian Aid, London.
- Smith, Huston (2nd ed.) (1989). *Beyond the Post-Modern Mind*. Quest Books, Ill, USA.
- Skiskandarajah, N., Fisher, R.J. and Packham, R.G. (1996). Community Participation in Natural Resource Management: Lessons from Field Experience. Paper presented at the regional seminar 'Ecotone V' on community participation in conservation, sustainable use and rehabilitation of mangroves in Southeast Asia. 8–12 January 1996, Ho Chi Minh City, Vietnam. Mangrove Ecosystem Research Centre, Vietnam National University, Hanoi, Vietnam.
- Skiskandarajah, N., Packham, R.G. and Fisher, R.J. (1993). Learning Systems: A Participatory Route to Needs Assessment, Service Delivery and Enhancement of Smallholder Welfare. Daniels, P.W., Holden, S., Lewin, E. and Sri Dadi (eds). *Livestock Services for Smallholders: A Critical Evaluation*. Indonesia International Animal Sciences Research and Development Foundation, Bogor, Indonesia.
- Stacey, R. (1992). *Managing Chaos: Dynamic Business Strategies in an Unpredictable World*. Kogan Page, London.
- Stoorvogel, J.J., Bourma, J. and Orlich, A. (2004). Participative Research for Systems Analysis: Prototyping for a Costa Rican Nanana Plantation. *Agronomy Journal* 96 (2), 323–336.
- Tandon, R. (1988). Social transformation and participatory research. *Convergence* 21 (2/3): 5–14.
- Vanclay, F. and Lawrence, G. (1994). Farmer rationality and the adoption of environmentally sound practices: a critique of the assumptions of traditional agricultural extension. *Journal of Agricultural Education and Extension* 1 (1).

Workshop

A.K.S. Huda¹, R.G. Packham¹, R.D. Macadam² and B. McKenzie³

Context of the Workshop

THE FOCUS of the workshop was to bring together participants from the various components of the ACIAR-funded climate project to share their experiences of using seasonal climate forecast information in making improved agricultural decisions. This workshop provided an opportunity to the participants through a number of activities to review their understanding of group processes and to develop ideas to achieve the project outcomes. The workshop participants included the following ACIAR project teams: Seasonal climate forecasting science in Australia, India, Indonesia and Zimbabwe; Water management in Lombok Island of Indonesia; Grazing management in Zimbabwe; Participative farm decision-making in eastern Australia and Tamil Nadu, India.

The aim of the Workshop was to learn from our experience of participative decision-making with farmers so that we can reposition ourselves and our organisations to more effectively utilise participative processes to upgrade farmers' and researchers' skills in climatic risk/opportunity management. Highlights of the activities are summarised below.

Identifying participative techniques and required competencies

The participants were grouped at random, and each group was asked to identify projects within their organisations where the aim is to work participatively with client groups. They then identified techniques used for facilitating participative decision-making, and the competencies required for their effective use. Some of the process methodology with associated competencies (shown in parentheses) for successful group work are as follows:

- Motivating individuals and groups to come together (networking and issue promotion).

- Developing trust, confidence and group 'rules' (letting go of own position and agenda, sharing knowledge around).
- Developing open communication (encouraging opinion and comment).
- Empowering members (making power relations explicit).
- Developing common purpose and plans, and maintaining group cohesion (using facilitation skills).

Most groups presented separate lists of techniques and competencies. *Key Techniques* are those that engender power-sharing, involve local leaders, develop trust and common ownership, generate fun and foster a consultative process. *Specific* techniques mentioned included focus groups, semi-structured interviews, historical analysis of activities, mind-mapping and group facilitation skills.

Competencies required include: a balance of technical knowledge and extension skills; good interpersonal skills; the belief that what you are doing inspires others; the ability to be a good listener and someone who knows the audience; the ability to promote shared values and real needs, and to communicate integrity and respect for the wide range of people who make up the system.

Developing future scenarios: eliciting and mapping issues of concern

Four sub-groups were established and asked to write on adhesive-backed cards (stickies) a comprehensive list of issues surrounding the development of participative decision-making with farmers for climate risk management.

The cards were placed on a graph drawn on a single large sheet of newsprint with the level of uncertainty associated with the issue (low to high level of unpredictability) on the vertical axis, and on the horizontal axis the importance of the issue in terms of potential to impact on the development of participative decision-making with farmers (low to high). The facilitators then led a process of grouping the cards and categorising the grouped cards as critical concerns.

¹ School of Environment and Agriculture, University of Western Sydney, Hawkesbury Campus, Locked Bag 1797, Penrith South D.C. NSW 1797, Australia.
e-mail: s.huda@uws.edu.au

² 34 Lee Road, Winmallee, NSW 2777, Australia

³ 135 Elizabeth Drive, Vincentia, NSW 2540, Australia

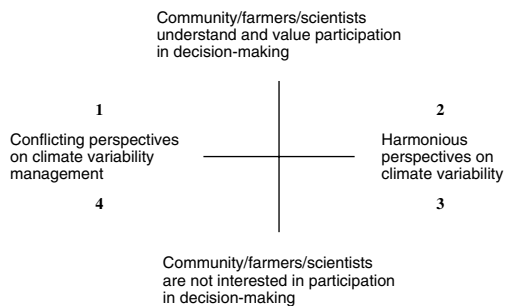
Approximately 90 issues were collated into 16 critical concerns. This data was used in the subsequent scenario-development activities.

Developing future scenarios: agreeing on two highly critical uncertainties

Each of the four sub-groups was asked to review the graph from the above activity and reduce the concerns plotted there into critical uncertainties. They were to reduce them to two highly critical uncertainties. The following explanatory example was given: if the issue at stake was the quality of life in 10–15 years, two highly critical uncertainties might be: first, social organisation — will it be rooted in the individual or group?; and second, social structure — will society be stable or fragmented?

The facilitators then led a process of reducing the critical uncertainties generated by the sub-groups to what the whole group regarded as the two underlying critical uncertainties, namely: the level of understanding and value placed on participation in decision-making by farmers/scientists/community; and the level of understanding and value placed on climate variability management by farmers/scientists/community.

The following four-quadrant matrix was then generated using the two critical uncertainties as axes.



Developing future scenarios: writing the story of a plausible scenario

Each sub-group was allocated one of the quadrants and asked to return to the concerns generated in activity 4, and to place in their allocated quadrant of the matrix those concerns that were relevant. They were then asked to write a story about what might feasibly unfold in the future, given the interplay between the concerns in the quadrant and the forces represented by the two axes.

Guidelines for story development included:

- Give the scenario a catchy, descriptive name.

- Brainstorm all the plausible events that could happen over the next 10 years given the interplay of concerns and forces in your quadrant.
- Select a logical trail of events and construct a time-line.
- Identify a dramatic point in the logic that captures the essence of the logic’s outcome.
- Build a story-line around the dramatic event identified in the logic.
- Write a narrative (mini-play) so that the story-line can be acted out.
- Rehearse presentation of the narrative and construct props, costume, etc.
- Present your scenario.

Reflecting on the experience using the 4 × Rs technique

Participants were asked to reflect privately for 15 minutes on the experience of the workshop, using the following questions to guide this process.

Recall the sequence of events: What did you do? When? Where? Why? How? With whom?

Relive the experience: What was it like? How did you feel? What were the highs and lows? How did it affect you?

Reinterpret the experience: What meaning do you now attach to what happened and how it affected you?

Respond to the reinterpretation: Is there anything you should do in response to what you have learned? What is it? Why is this appropriate?

When participants shared the outcomes in a subsequent plenary session, marked differences between two broad schools of thought were aired. Whereas most expressed satisfaction with what was done and what was learned, a significant minority said their expectations were not being met. The latter said they had assumed there would be more emphasis on technical aspects of the management of climate variability. After a period of robust discussion, a consensus was reached to proceed with the Day Two Program foreshadowed by the facilitators before the reflection session.

Developing future scenarios: sharing the future scenario stories

The four sub-groups completed development of, and presented as mini-plays, their scenario story narratives. (The stories are not included here as they depend on the context of the workshop experience for their relevance. They stretched the participants’ perspective on feasible futures, with the expectation that this would influence the subsequent ‘making sense’ and ‘planning action’ phases of the workshop.)

A focus conversation on what we need to do differently to promote a participative approach

Participants were asked to form sub-groups and respond to the focus question:

It seems to me now that the key to repositioning ourselves and our organisations to utilise participative processes more effectively to upgrade farmer skills in climatic risk/opportunity management is ...?

They were asked to follow the rules mentioned below for a focus conversation:

1. Individuals reflect privately on focus question.
2. Each person in turn shares his/her initial response to questions — others listen (no discussion — only questions of clarification allowed.)
3. After the initial round, conduct additional rounds during which individuals may alter their response to the question.
4. Recorder summarises outcomes and reports to plenary.

One of the four Australian groups reported the need to:

- make use of new information technologies to enable *mass* participation;
- integrate climate-variable data with other variables being managed by the end-user, for example markets and costs;
- promote interagency cooperation and transparent relationships;
- enhance awareness of the significance of climate variability in farmer goal attainment;
- present forecasts in terms of options for farmers (rather than the current technical style and content);
- avoid over-selling the product and losing credibility.

Other groups highlighted the need to research and develop an appreciation of the value of a participatory approach among stakeholders and to develop the required attitudes and skills.

One of the groups from Tamil Nadu Agricultural University in India (TNAU) responded by identifying changes they should promote through their ACIAR-supported project:

- scientists must upgrade skills in communication science and participatory decision-making;
- identify all actors in the project and involve them early;
- extend the project to other campuses of TNAU with World Bank support;
- appreciate that capacity-building is related to (but not the same as) participative processes, and keep both in mind;
- be clear about what we want to achieve — in terms of our outputs and those of farmers;

- utilise good communication processes to build trust and confidence among ourselves and with farmers;
- use imaginative approaches to develop and trial information farmers can understand;
- document work/methods/results;
- identify case studies to use as examples (positive and negative);
- utilise relevant adult learning packages to increase knowledge and skills of farmers;
- hold regular team reflections on what we do and outcomes;
- make frequent visits to farmers' fields to develop understanding of needs and decision-making processes;
- conduct on-farm experiments and on-campus training;
- use simple models to explain complex issues;
- develop a wider range of management techniques for different farms and climate situations;
- use PRA to understand the farmers' system and give something back in return;
- discuss how these initiatives can be incorporated into our project given ACIAR constraints.

Planning of strategic initiatives

TNAU (Tamil Nadu Agricultural University)

Group 1. The group selected as a high priority initiative an effort to bridge the gap on the acceptance of climate science between farmers and scientists. This will be done by utilising a participative approach to develop an understanding of what farmers do and why, while respecting indigenous knowledge about climate.

The underlying assumption is that farmers and the nation are foregoing productivity gains because farmers are unable to understand the scientists' perspective and language, and vice versa.

Strengths and opportunities to build on are: TNAU's strong research and extension linkages and widely distributed field stations; a significant number of staff with well-developed facilitation skills; and TNAU's national and international credibility and the resultant access to resources and training.

Relevant weaknesses and threats are: intellectual conflict between staff in different disciplines; and the dilution of effort caused by the expectation that all staff will be involved in research, extension and teaching.

TNAU will marry its facilitation expertise and knowledge of scientific climate forecasting to run participative workshops to find out what farmers know and need to know, and relate this to scientific climate forecasting in terms of what each group can

learn from the other. It will run inter-disciplinary workshops on climatic risk management for staff, and work to reallocate staff resources to more effectively achieve the institutional mandate for teaching, research and facilitation.

Key performance indicators (KPI) will be:

- the level of adoption of advice by farmers and the resultant farm productivity;
- assessment of the competency of staff to fulfil the TNAU mandate.

(The facilitators observed that these were outcome indicators, whereas KPIs were measures of whether the intended program implementation was proceeding as planned.)

TNAU Group 2. The selected initiative was to develop the climatic modelling capacity of TNAU throughout the statewide system of TNAU campuses and research stations to provide local climate predictions. It was based on the premise that this capacity was currently confined to headquarters and that there was limited acceptance elsewhere. The need was for locality-specific forecasting systems that enabled 'climate response farming'.

Opportunities/Strengths to build on were: availability of scientific manpower; strong research-extension linkages; and good leadership/motivation within TNAU.

Weaknesses/Threats were: a shrinking level of government financial support; and dependence at local level on models predicted elsewhere.

The intention is to seek international support to invest in development through participatory approaches of local models that incorporate indigenous expectations.

KPIs will be: timely rainfall information; reliable (precision) forecasts; good feedback from farmers; higher levels of participation; flow of funds; availability of widely accepted indigenous models.

TNAU Group 3. The central issue is how to upgrade farmers decision-making skills to minimise climatic risks and maximise opportunities. The context for pursuing this was the three-year ACIAR project, which was then in its second year. The plan for the coming season was to evaluate the decision-making options taken by farmers, with development of a methodology for doing so being a precursor. A

second objective was to develop effective learning packages for farmers.

The KPIs will be:

- the number of decisions based on scientific computer forecasts made by a sample of farmers;
- an assessment of what farmers actually do in response to decision-making situations, and why.

Conclusions

Experiential learning was presented during the workshop as a collaborative process of finding out about and making sense of the problematic situation as a basis for action to improve it. The facilitators' task was to lead the group through this process and provide an opportunity for participants to reflect on what was happening during the workshop. The reflection sessions were a monitoring tool that also enabled participants to focus on and learn about the learning process. The workbook distributed to participants detailed possible workshop activities and the collection of readings provided reference material related to participative processes.

The learning process and development were presented as dynamic whereby learners (the sub-systems) take the lead in repositioning the groups and/or organisations they belong to (the system) to respond more effectively to changes in the environment (the supra-system). In the case of this workshop the facilitators saw the participants as the sub-systems, the organisations and groups they represented as the system and the wider environments in which they operated as the supra-system.

The workshop enabled some participants to reposition themselves and their organisations to more effectively utilise participative processes to upgrade their own and collaborative farmers' skills in climate risk/opportunity management. This facilitated expansion of a collaborative project with other institutions building on the skills and experiences from current research.

The outcomes included: building and strengthening a cooperative network to share future experiences and dilemmas; and designing this publication to benefit researchers, extension workers, farmers and other community workers to learn from selected case studies of the application of SCF in agricultural decision-making.

Conclusion

A.K.S. Huda¹ and R.G. Packham¹

RECENTLY a number of critiques have appeared based on the fact that the science behind Seasonal Climate Forecasting (SCF) is still unfolding. This debate questions the accuracy of climate forecasting and the usefulness of SCF as an aid to farmers' decision-making. However, it is the authors' view that SCF is such an important area for farmers that we cannot wait for the science to be fully elaborated. We need to use whatever tools we have in the best way we can in order to allow us to see whether it makes a real difference in practical situations. This means that it is incumbent on researchers and affiliated institutions to ensure that farmers are provided with all necessary information in an appropriate form, and that the ultimate decision-making rests with the end users. We believe this publication demonstrates the usefulness of the application of current knowledge and tools, and that this has resulted in improved outcomes for farmers over and above decisions based on 'guesstimates' or other indigenous techniques.

Another contribution of the project, of which this book is a part, has been to bring together professionals from different fields to interact in ways that have not happened before. For example, farmers, land managers, meteorologists, climate scientists, agronomists, engineers, extension workers and social scientists from different countries (Australia, India, Indonesia, Zimbabwe) are becoming more familiar with the limits of the SCF technology, and with its strengths, weakness, knowledge gaps and potential uses in the field. The 'mission' or systems approach taken appears to be a way forward, not only for SCF, but for all areas where science is used to overcome intractable practical situations. It is helping scientists understand the social, economic and cultural constraints of the adoption of the science of SCF knowledge.

Another issue that has emerged is one of communicating scientific knowledge to the users, particularly concepts such as the probability, reliability and accuracy of the science of SCF. Here we are not

dealing with simple cause-effect relationships in the kind of dose-response relationships that agronomists might be familiar with in such areas as fertiliser use. Instead, issues of complexity science come to the fore, as introduced in Chapter 5. This means that we can never be sure what the practical outcomes of recommendations will be; we can only move towards improved outcomes. This showed up very nicely in the case studies reported in earlier chapters, on balance with positive benefit. The authors believe there is room for considerable improvement in this area, and are working towards this. Some of the directions being taken for future research are as follows.

Future work

There are several concepts worthy of consideration for future projects. The following build on the outputs and outcomes that have been achieved in the project described in the introduction to this book, but they are not given in any order of priority.

The publication and distribution of the worthwhile Indian edition of *Will It Rain?* is likely to help build on the progress made. Similarly, it would be useful to create a publication from the chapters prepared for the participative problem-solving monograph. The final reports of this ACIAR project (Clewett, 2004) proposed several follow-on projects concerning the further development and application of seasonal forecast technologies.

Proposals for India

The involvement of the farming community in the Coimbatore area of Tamil Nadu in southern India occurred through identifying the socio-agricultural characteristics of the study area. These farmers, along with staff from TNAU, extension officers and agricultural development staff in the area, were involved in the participative workshops. A total of 80 workshops were conducted in the eight villages over a three-year period (2000–2002) so that each farmer was potentially involved in up to 10 workshops. A further two workshops were held at the University.

¹ School of Environment and Agriculture, University of Western Sydney, Hawkesbury Campus, Locked Bag 1797, Penrith South D.C. NSW 1797, Australia.
e-mail: s.huda@uws.edu.au

Throughout India, considerable progress was made in developing farm management responses to ENSO conditions, and the work from TNAU in combining climate science, applications modeling and farm management problem-solving is to be applauded. The difficulty exposed in this work was the high-risk decision-making for farmers when using ENSO-based seasonal forecasts because of the weak (for north-east monsoon) and complex ENSO signal. The major concern raised by this finding is that ENSO may have some general effects on rainfall and agriculture, but there is a real risk that there is just too much variation in the data for the ENSO information to play more than a minor role in decision-making. This concern needs to be addressed by future research.

There is now considerable momentum in the extension of ENSO information to the farming community in the Coimbatore region. Thus, in the authors' view, it would be prudent to continue studies that specifically seek to assess the statistical significance, spatial coherence and temporal consistency in the economic value of farm management options for responding to the ENSO signal. The extension program that is continuing in Tamil Nadu is at risk and should be backed by a matching and thorough modeling and systems analysis program to assess the economic value of agronomic practices. These studies should be done with multiple sets of climate data (30–40) to assess spatial coherence in the interior regions of Tamil Nadu so that strengths and weaknesses are clear.

A climate sample of just one location, such as Coimbatore, is not sufficient. The characteristics of the interior regions should be compared and contrasted with the spatial characteristics along the east coast of Tamil Nadu, where the statistical robustness of ENSO relationships with rainfall are much stronger.

Considerable effort was put into developing and documenting case studies of successful 'on-farm' use of ENSO information in the Coimbatore area. The studies are informative and very powerful when discussing issues with farmers, but are also limited because circumstances change from farm to farm and year to year. Thus, some way of systematically drawing the case studies together is needed so that the value of seasonal forecasts can be described in a more general way. There is a need to retain the value of local content while avoiding the risks of using anecdotal stories when good results occur and blaming probabilities when results are poor.

Proposal 1. Use of seasonal rainfall forecasts to increase and stabilise crop productivity through soil moisture management in selected parts of Tamil Nadu (India) and Australia. Key objectives of this

proposal are to further evaluate seasonal forecasting methods, assess the risks and opportunities of alternative agronomic options and evaluate socio-economic impacts and benefits.

Proposal 2. Improving rural livelihoods in the semi-arid tropics (SAT) watersheds through participatory approaches to enhance rainwater management and groundwater availability for sustainable use.

Proposal 3. Use of climate information to develop and apply decision-making tools to manage disease risks for improved crop production. The key objective here is to demonstrate benefits of the application of knowledge of climate and its variability to promote better disease risk management for improved economic and environmental performance of specific crop production systems. The proposed work aims to link with institutions in various parts of India.

Proposals for Indonesia

There appear to be great prospects for the application of simple ENSO-based seasonal forecast technologies in Indonesia and countries of southeast Asia and the southwest Pacific. In these countries there is a strong ENSO signal, with up to four months of lead-time for the important October-December period regarding the amount and the timing of rainfall. Indonesian results (Abawi et al., 2002) identified large effects of ENSO on crop production, and the research by Ismail Yasin is revealing effective ways to adapt crop choices to changes in irrigation supply. Results from the IQQM model for Lombok would no doubt show large impacts on water supply if the climate data were available to do long-term simulations. However, in all systems there are difficulties. The survey by Dr Sayuti on Lombok Island (Chapter 3) showed that farmers were not knowledgeable about ENSO forecasts, but were responsive to advice by extension staff. Two problems in the Indonesian and related environments requiring further research are:

- lack of long-term daily rainfall data; and
- how to achieve widespread recognition, respect and adoption in the broader community for ENSO-based seasonal forecasts involving tens of thousands of people.

The extension methods need to generate broad community impacts and thus the participative problem-solving approach needs to occur at district community levels, and involve policy makers and other influential people. To achieve this outcome, continued support through the University of Mataram and other universities such as Bogor and Yogyakarta would be worthwhile.

Data sets with long-term records of daily rainfall are a prerequisite for studies seeking to assess

climatic risk. However, lack of long-term observations of rainfall and other climatic data is a common theme in all countries. While one solution to this problem is to invest large sums of money in retrieving and digitising data, alternative solutions to this problem need to be found. This is particularly so in the light of climate change that could alter the characteristics of rainfall. There is need to consider opportunities for downscaling rainfall data from GCM outputs.

Final comments

The three main benefits demonstrated by this publication are improved knowledge of: (i) climate and seasonal forecasts; (ii) the value of seasonal forecasts in agriculture; and (iii) how to develop skills in farmers, extension staff, planners and other resource managers to make good use of seasonal forecasts in managing climate variability. Development of the decision support tools relevant to many countries and communities will ensure that benefits continue to accrue long into the future. While evidence suggests there will be benefits from further R&D commitments in agricultural climatology, there is a continuing challenge to generate broad community outcomes as the future seasons unfold.

Participatory decision-making and the farmer surveys have conclusively demonstrated how improved knowledge and skills of the variable climate have helped farmers in decisions such as crop selection, time of sowing, irrigation, herbicide application, nursery preparation and management of water resources.

Use of the seasonal climate forecasts can benefit agricultural production and resource management, as shown through impact evaluation procedures that

highlight economic and social benefits. Scientists have learned to understand more fully the critical needs of farmers in making vitally important decisions on weather and climate-sensitive farm operations. The discussions that considered the choices, chances and consequences of any decision helped farmers and scientists put in perspective short- and long-term risks and benefits. This participative decision-making provided an opportunity to build confidence and trust among the farmers so that they can manage climate risk in a better way.

Participative research and decision-making has enabled a greater level of collaboration between researchers and farmers to make better decisions that apply climate information and forecasts to farm management decisions. Results support the idea that there is an opportunity to apply the substantial benefits of this work to other identified areas in the world, for example within Tamil Nadu and other states in India. This will enable the achievement of improved production and resource management decisions, and capture the benefits of seasonal climate forecasts for better agricultural management.

References

- Abawi, Y., Yasin, I., Dutta, S., Harris, T.R., Ma'shum, M., McClymont, D., Amien, I. and Sayuti, R. (2002). Final Report from Sub-project 2 — Water and crop management in Indonesia, for ACIAR project LWR 2/96/215. Capturing the benefits of seasonal climate forecasts in agricultural management. QCCA, Department of Natural Resources and Mines, Queensland, July 2002. 138 pp.
- Clewett, J.F. (2004). Capturing the benefits of seasonal climate forecasts in agricultural management. A final report to the Australian Centre for International Agricultural Research on project LWR 2/96/215. Department of Primary Industries, Queensland. 121 pp.

List of Participants

Sl.No	Name	Address
1	Dr V Geethalakshmi	Dept of Agricultural Meteorology Tamil Nadu Agricultural University Coimbatore 641 003 Tamil Nadu India
2	Dr R Selvaraju	Dept of Agricultural Meteorology Tamil Nadu Agricultural University Coimbatore 641 003 Tamil Nadu India
3	Dr BJ Pandian	Dept of Agronomy Tamil Nadu Agricultural University AC&RI, Killikulam India
4	Dr S Krishnasamy	Dept of Agronomy Tamil Nadu Agricultural University Madurai India
5	Dr A Balakrishnan	Tamil Nadu Agricultural University Periakulam India
6	Dr C Chinnusamy	Dept of Agronomy Tamil Nadu Agricultural University Coimbatore, 641 003 India
7	Dr VJF Kumar	College of Agricultural Engineering Tamil Nadu Agricultural University Coimbatore, 641 003 India
8	Dr G Gajendran	Dept of Agricultural Entomology Tamil Nadu Agricultural University Coimbatore, 641 003 India
9	Dr Sayuti Rosiady	University of Mataram Mataram Indonesia
10	Mr Kampion Shoko	Zimbabwe Meteorological Services Harare Zimbabwe

11	Dr Jeff Clewett	QCCA DPI PO Box 102 Toowoomba Qld 4350 Australia
12	Mr David George	QCCA DPI PO Box 102 Toowoomba Qld 4350 Australia
13	Dr Yahya Abawi	QCCA QDNRM PO Box 102 Toowoomba Qld 4350 Australia
14	Mr Ken Day	QDNRM Meiers Road Indooroopilly Qld 4068 Australia
15	Dr John McBride	Bureau of Meteorology PO Box 1289K Lonsdale Street Melbourne Victoria 3001 Australia
17	Assoc. Prof. Samsul Huda	University of Western Sydney Hawkesbury Locked Bag 1797 Penrith South DC NSW 1797 Australia
18	Prof. Peter Cornish	University of Western Sydney, Hawkesbury Locked Bag 1797 Penrith South DC NSW 1797 Australia
19	Assoc. Prof. Roger Packham	University of Western Sydney, Hawkesbury Locked Bag 1797 Penrith South DC NSW 1797 Australia

20	Mr Gary Wallace	University of Western Sydney, Hawkesbury Locked Bag 1797 Penrith South DC NSW 1797 Australia
21	Mr Jess Jennings	12 Charles St Forest Lodge NSW 2037 Australia
22	Mr Nick Christodolou	QDPI PO Box 310 St George Qld 4487 Australia
23	Assoc. Prof. Robert Mulley	University of Western Sydney, Hawkesbury Locked Bag 1797 Penrith South DC NSW 1797 Australia
24	Mr Tim Ellis	University of Western Sydney, Hawkesbury Locked Bag 1797 Penrith South DC NSW 1797 Australia
25	Mr Paul Carberry	NSW DPI RMB 944 Tamworth NSW 2340 Australia
26	Dr Graeme Tupper	161 Kite Street Orange NSW 2800 Australia
27	Mr Jeff Hoffmann	Ceranya Lockhart NSW 2656 Australia
28	Mr George Gundry	Tarago NSW 2580 Australia
29	Ms Libby Salmon	CSIRO Plant Industry GPO Box 1600 Canberra ACT 2601

- 30 Dr John Petheram Institute of Land and Food Resources
University of Melbourne, Creswick Campus
Vic. 3363
Australia
- 31 Dr Tony Fischer ACIAR
GPO Box 1571
Canberra
ACT 2601
Australia
- 32 Assoc. Prof. Bob Macadam 34 Lee Road
Winmalee
NSW 2777
Australia
- 33 Mr Bruce McKenzie 135 Elizabeth Drive
Vincentia
NSW 2540
Australia