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

A.K.S. Huda[1], R. Selvaraju[2], T.N. Balasubramanian[2], V. Geethalakshmi[2], D.A. George[3] and J.F. Clewett[3]

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.

[1]School 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
[2]Tamil Nadu Agricultural University, Coimbatore – 641 003, Tamil Nadu, India.
[3]Queensland Centre for Climate Applications, Department of Primary Industries, Tor Street, Toowoomba, Queensland 4350, Australia.

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

Using seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

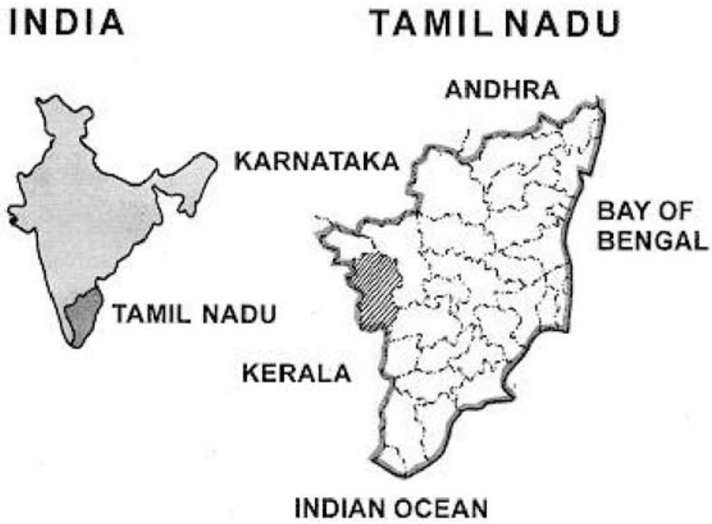


Figure 1. Location map of Coimbatore district of Tamil Nadu, India.

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

Using seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

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.

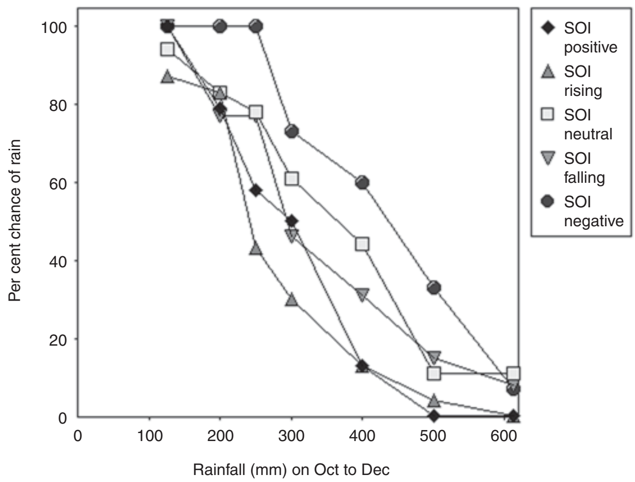
Impact of short-range weather forecasts

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.

Using seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

Methods used to communicate climate information

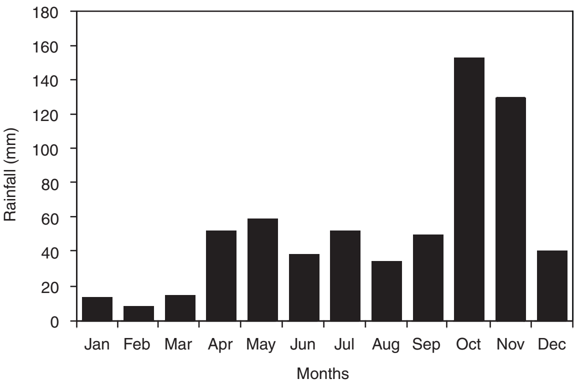
In the process of participative decision-making, the seasonal climate forecasting was explained to the farmers by conducting participatory workshops at regular intervals in the farmers' holdings, before the start of the season and through the northeast monsoon season. The sequence of the discussions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

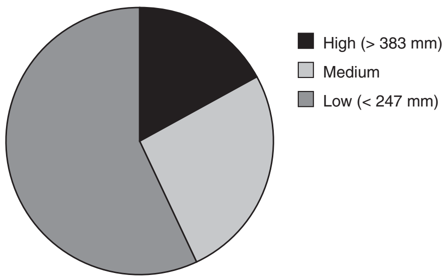
The expected probability of receiving a particular quantity of rainfall (information from the farmers) during the season (or a specific month) was explained to the farmers based on the seasonal climate forecast indicators like Southern Oscillation Index (SOI) in different formats (pie charts, cumulative 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.

(A)



(B)



(C)

Rainfall (mm)	SOI Falling	SOI Negative	SOI Neutral	SOI Rising	SOI Positive	All years
< 610	8	7	11	0	0	4
500	15	33	11	4	0	11
400	31	60	42	13	13	29
300	46	73	58	30	50	50
250	77	100	74	43	58	67
200	77	100	79	83	79	83
126	100	100	95	87	100	96
Median (> 301)	46	73	58	30	50	50

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 seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

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 discus 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). Implications 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 problamatic 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

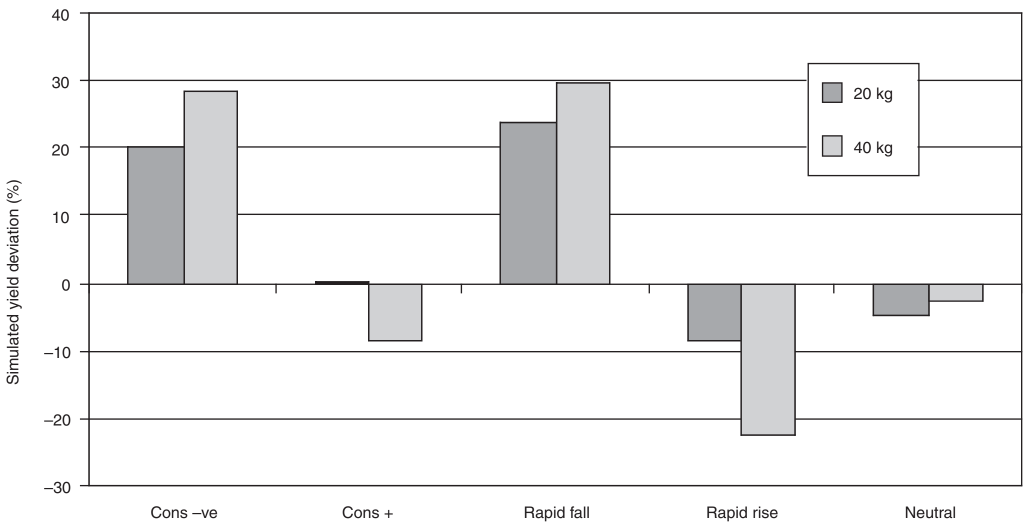


Figure. 4. Deviation of simulated sorghum yield level by SOI phases at Coimbatore, India under two levels of fertiliser.

Using seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

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 farmere 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 fallow 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. Considering 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 $A5000 and a gross margin of $A3000. 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

Using seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

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.

Using seasonal climate forecasting in agriculture: a participatory decision-making approach
edited by A.K.S. Huda and R.G. Packham
ACIAR Technical Reports No. 59
(printed version published in 2004)

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.