Chapter 18
Using Climate Information for Building Smallholder Resilience in India

Madhavan Manjula, Raj Rengalakshmi, and Murugaiah Devaraj

Key Messages

- User-specific, relevant seasonal climate forecast (SCF) information has the potential to induce risk-reducing decisions for players across the agricultural value chain.
- The lead time and forecast requirement for SCF are diverse across the value chain and might induce competitive/complementary decisions across the value chain.
- SCF needs to be bundled with institutional support for better uptake and competitive advantage to the smallholder farmers.

M. Manjula (✉)
School of Development, Azim Premji University, Bengaluru, India
e-mail: manjula.m@apu.edu.in

R. Rengalakshmi · M. Devaraj
JRD Tata Ecotechnology Centre, M. S. Swaminathan Research Foundation, Chennai, India

R. Rengalakshmi
e-mail: rengalakshmi@mssrf.res.in

M. Devaraj
e-mail: devaraj@mssrf.res.in

Haque et al. (eds.), *Climate Change and Community Resilience*,
https://doi.org/10.1007/978-981-16-0680-9_18

18.1 Introduction

Shifting rainfall patterns, increasing rate of extreme events changing temperature regimes are some of the outcomes of climate variability and climate change influencing agricultural production. While all the factors pose threat to crop cultivation, climate variability during the crop season is a major source of agriculture production risk (Legler et al., 1999; Paz et al., 2006) in rainfed systems. The impact of climate variability on agricultural productivity is manifested through crop loss due to floods or seasonal droughts induced by excessive or insufficient rains during the crop season. Variability in temperature and relative humidity during the growing season triggers sporadic pest and disease outbreaks resulting in massive crop losses (Jones et al., 2017; Tanyi et al., 2018). The impact of climate variability on the farming system has a multiplier effect on the other players across the agricultural value chain ultimately posing a challenge to the local agricultural economy and food security (Lipper et al., 2014; Wheeler & Von Braun, 2013).

Knowledge of climate variability prior to crop season and its incorporation in management decisions across the value chain is touted as the key adaptation strategy for intra-seasonal climate variability. In India, in addition to the existing short and medium range weather forecasts disseminated by the Indian Meteorological Department (IMD), access to reliable intra-seasonal and seasonal climate forecasts (month to multi-month time frames) could induce a set of adaptive responses that might help to reduce production risks posed by climate variability (Meinke et al., 2006). Sivakumar (2006) reported that access to forecasts of meteorological risks and timely agro-meteorological advisories can assist farmers to take appropriate strategic and tactical decisions to cope with changing climate. Climate consortiums in South America, Africa and West Asia have in the past attempted to generate and disseminate seasonal climate forecast (SCF) (Hansen & Sivakumar, 2006; Pulwarty, 2007). But these attempts have not yielded the desired results due to various reasons (Bruno Soares & Dessai, 2016; Hansen et al., 2011; Rickards et al., 2014)

The reasons range from low predictive skill of the forecasts at finer spatial and temporal scales, lack of easy access to SCF, challenges in interpreting probabilistic SCF and inability of the end user to take up adaptive responses based on SCF, and attitude and psychology to taking risks (McCrea et al., 2005; Vogel & O'Brien, 2007). The other challenge is communicating probability-based climate forecasts to the end users. Several studies on application of SCF information indicate the risk of a deterministic interpretation of probabilistic forecast information and the use of empirical approaches in explaining the probabilistic nature of SCF (Hansen et al., 2007; Suarez & Patt, 2004). Communication tools which adopt a participatory approach in disseminating SCF have been reported to be effective in Africa and India (Hansen et al., 2007; Meinke et al., 2006). Another challenge is meeting the diverse seasonal climate information needs of different actors involved in the crop value chains. To improve the relevance of climate forecasts, it is imperative to identify the decision-relevant attributes of forecast information for specific activities and actors and incorporate that into the forecasts (Stern & Easterling, 1999).

Experiences from across the globe show that SCF information should have reasonably good predictive skill, be locale specific, be tailor-made to end user requirement and be communicated through a participatory approach using customised communication tools to have better uptake (Vogel & O'Brien, 2007). This is particularly useful to know as pointed out by Bahinipathi and Patnaik (2021, Chap. 4 of this volume) when they examined the factors that determine farmer adaptation behaviour.

This paper is drawn from a multi-country multidisciplinary project that aims to investigate the use of SCF in enhancing food security in South Asia. The project also aimed to develop a blueprint for improved seasonal climate information across case study regions in the Indian Ocean Rim Countries. The paper details the project experience in the state of Tamil Nadu, India.

18.2 Study Area and Methods

The study was conducted in Dindigul district, located in south-western Tamil Nadu and geographically spread over 6266.64 km^2. The economy is predominantly agrarian. The major crops are maize and other cereals, vegetables, pulses, cotton, oilseeds, paddy and sugarcane. Agriculture is predominantly rainfed, and the main agriculture season is from October to December. The district receives a mean annual rainfall of 845.6 mm. The region benefits more from north-east monsoon (53%), and the maximum rainfall is between October and December. January and February are the months, which receive minimum (49.6 mm) rainfall. The coefficient of variation in the inter-annual period is around 30%. The farmers in this region have a strong perception of climate variability and relate it to the frequent water-deficit years, premature end, late onset and uneven distribution of rains (Fig. 18.1).

The study adopted a value chain approach and included on-farm and off-farm players across the agricultural value chain of the major crops cultivated in that region. Mixed methods were used to elicit information on existing climate risk management, nature of climate information needed, and dissemination networks. Semi-structured interviews were conducted to collect quantitative information from farmers. Samples were drawn using stratified sampling technique. A total of 242 marginal and small farmers were surveyed. Participatory appraisal tools such as resource mapping, social mapping, seasonal calendar, trend analysis, time use studies and gender analysis were used to elicit qualitative information. The off-farm players were engaged in the study through consultative workshops and one-on-one interviews. Reflective learning methods like decision analysis were used to communicate SCF information.

Fig. 18.1 Location of the study area. *Source* M. S. Swaminathan Research Foundation

18.3 Results and Discussion

18.3.1 Stakeholder Perception of Climate Risks

Rainfall was the major climate risk articulated by players across the value chain. However, there were striking differences in the aspect of rainfall that was considered critical for farming and business by the respective stakeholders. Extreme weather events like droughts and floods were cited as climate risks that were impacting at a regional level. Farming was sensitive to late/early onset of monsoon, unequal intra-seasonal distribution of rainfall, extended dry spell after sowing, extended dry spell/excess rainfall during flowering, excess rainfall at harvest, untimely and inadequate rain during the season (Table 18.1).

Table 18.1 Climate risks experienced by farmers in the last three agricultural seasons

Climate risk	Number of farmers articulating respective climate risks
Late/early onset of monsoon	108
Unequal distribution of rainfall in the season	51
Extended dry spell after sowing	55
Excess rainfall in peak flowering/harvesting season	122
Untimely rains	53
In adequate amount of rainfall during the season	79

Source Field Data
Note Total will not add up to 242 as there are multiple responses from each respondent

18.3.2 Key Decisions and Climate Information of Relevance

The key decisions and the climate variable that would influence these decisions for farmers and extension agents who provide crop management advisories to farmers are detailed in Table 18.2.

Table 18.2 Key on-farm decisions and influence of climate information

Key decisions	Key climate variable that informs the decisions
Time of sowing	Onset of monsoon
Choosing of crops/crop variety	Total rainfall and its intra-seasonal distribution
Irrigation management—timing of irrigation and quantity of water to be applied	Total rainfall and its intra-seasonal distribution
Resource use allocation—labour and finance	Total rainfall and its intra-seasonal distribution
Fertiliser application—quantity, type and stage of application	Distribution of rainfall across the crop growth stages
Timing of pesticide application	Wind direction and speed; rainfall distribution across crop growth stages
Time of harvest	Distribution of rainfall during the crop maturation stages

Source Field Data

Aspects like total amount of rainfall during the season, onset of monsoon and intra-seasonal distribution of rainfall are said to influence the business decisions of input dealers. The major business decisions affected by climate/weather parameters for an input dealer are as given below:

- Stocking of inputs (seeds/fertilisers/pesticides)—quantity, type and time
- Transport of inputs (seeds/fertilisers/pesticides)—time
- Supply of inputs (seeds/fertilisers/pesticides)—quantity, type and time.

18.3.3 Current Source of Climate Information Across Stakeholders and Its Utility

The stakeholders have access to nowcast (very short term, up to 2 h), and short and medium range forecasts given by the Indian Meteorological Department (IMD). The forecasts are received through television, radio, newspapers and mobile phones. In addition to these public sources, farmers in the study area receive medium range weather forecast information through the Village Knowledge Centre (VKC) and Farmer Producer Company (FPC) network. Majority of farmers also rely on traditional knowledge for climate information. This is evident from the use of proverbs and folk songs that refers to climate parameters like rainfall, wind direction and wind speed in this region. The major sources of traditional knowledge are the older farmers, local astrologers and the almanac. However, traditional knowledge was said to be losing its relevance in a changing climate. The medium-range forecasts given by IMD for Dindigul district are based on the readings from Agro-Meteorological Field Unit (AMFU) located within Reddiarchatram block within the district. Hence, the forecasts and the advisories based on these forecasts come with 70–80% accuracy and are said to be useful and reliable for decision-making. Interestingly, the VKC-FPC network is also a major source of non-climatic information related to agriculture and allied sectors in the region. The FPO also plays the role of input supplier and produce aggregator to its shareholders. For shareholding members, the FPO is the nodal agency for accessing locale-specific information, technology and inputs and output markets. Thus, the VKC-FPC network supports the farmers to act on the climate information-based agro-advisories.

18.3.4 Strengthening Reach of Existing Climate Information

At present, weather/climate information is being communicated through mass media like television, radio and newspaper. Among these channels, television has the highest reach. But the weather bulletins disseminated through television are usually given at the end of the news bulletin and mostly go unnoticed. Measures like telecasting the weather report at the beginning of the news bulletin, having a dedicated weather channel and running scrolling text on district-specific climate information at frequent intervals throughout the day, were articulated as strategies to increase the reach of weather/climate information through television.

Communicating weather/climate information through mobiles was felt to be more effective since mobile technology had better reach in the region. It was suggested that the government should make it mandatory for all service providers to disseminate weather information through mobiles and emphasise this as a criterion for granting licence for operation.

18.3.5 Seasonal Forecast Requirement (Parameters and Lead Times) Across Stakeholders

Different stakeholders articulated different requirements for the seasonal forecast information (Table 18.3). The climatic parameters demanded by farmers are total rainfall, onset and distribution of total rainfall across the season. Of this, distribution of rainfall across seasons was articulated as important climate information by about 66% of respondents. Climate forecasts with a maximum of one-month lead time were thought to help in strategic on-farm decisions with more than 50% respondents echoing this. Seasonal climate forecasts with longer (2–6 months) lead times were said to have no relevance for farmers in the region.

On the other hand, off-farm players like input dealers, insurance agents and credit institutions required information with 3–6-months lead time to make strategic decisions. Input companies and district-level wholesale dealers of inputs saw a lot of potential for strategic business planning and risk reduction if forecasts are given 6 months before the start of the season. The sub-dealers at the block level demanded forecast information with a lead time of 1–2 months. The local village-level traders required information on total rainfall and its distribution with a one-month lead time.

Table 18.3 Forecast and lead time requirements expressed by farmers

Forecast requirement	No. of farmers articulating
Total rain for the season	68
Onset of rain for the season	78
Distribution of rain (intra-seasonal)	160
Lead time in months/days before sowing	No. of farmers articulating
One	135
Two	40
Three	3
3–4 days before sowing	81

Source Field Data
Note Total may not add up to 242 as there are multiple responses

Seasonal forecasts specific to a region were found to be of less significance for players beyond farmgate such as district-level traders in agricultural commodities. Their scale of operation was much beyond the region, and hence, climate variability in one region would not affect their business.

18.3.6 Communicating Seasonal Climate Forecasts: Role of Decision Analysis

Communicating SCF is a challenge since the forecast is probabilistic in nature. In SCF when one says there will be 40% chance of a normal rainfall season, one needs to understand that there is 60% chance of this not happening. Conventional methods of forecast communication like weather bulletins through mass media are largely in deterministic mode (provides quantitative value or range of weather parameters expected for a given time and an area). A different mode of communication is needed to communicate SCF given as tercile probabilities, which is an estimate of the likelihood of the rainfall that may occur within the given lead time. A decision analysis framework is more useful to communicate probabilistic SCF, as it is developed based on the principle of reflective learning. The decision analysis framework serves as a decision support tool in assessing the value of seasonal climate forecasts against multiple criteria. It is useful in working out trade-offs between competing objectives and helps to compare relative profitability of the probable decisions/choices that the respondents make based on the forecasts (Carberry et al., 2000). The framework was applied to on-farm decisions with farmers and off-farm decisions with members of the FPC.

Decision support tools like decision tree, decision graph and wonder bean were used to communicate SCF to farmers (Harrison & Williams, 2008; Liguton & Hayman, 2010). These tools help the end user to visualise the outcomes of each decision vis-a-vis the associated resource cost and the economic implication of decisions. The decision tree also allows for adding complexities to the decision process. Climatically risky decisions at on-farm and off-farm level were integrated and analysed using the tool. The tool helps visualise the possible scenarios and the outcomes and relate it to their own farming situations. The participants were asked to articulate their assumption on the potential yield and economic returns given the SCF scenarios of normal, above normal and below normal rainfall.

Capacity of the participants on deciphering probabilistic seasonal climate forecasts was built through representing different probabilities of rainfall for the season. The process started from a climatology scenario of equal chances of normal, dry and wet season and varying the probabilities to a great degree among the different options. In order to define the normal season, farmers were asked to share their perceptions based on practical experiences. According to them, normal rainfall amounted to 15 plough rainfall which is 375 mm on the metric scale (one plough rainfall is 25 mm). This corroborated with the 30-year historic average monthly rainfall data for the region during September/October to December.

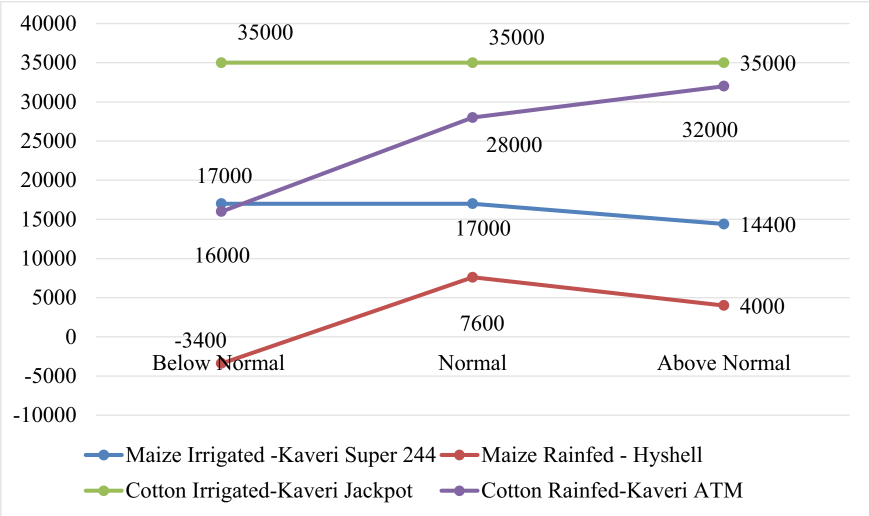

Fig. 18.2 Gross margins of crops and crop varieties across different forecast scenarios. *Source* Field Data

Decision tree framework which was used to compare the economics of different decisions was explained using excel sheets. They were given a probability forecast of 60% chance of a normal season, 20% of a dry season and 20% of a wet season. These forecast values were provided by the climate scientists. Given this scenario, the farmers were asked to articulate their crop choices as a first step and the varietal choices for the crops chosen as an added complexity in the second step. The outcome of the exercise is shown in Fig. 18.2. Irrigated cotton variety Kaveri jackpot was the best choice given the relative profitability of the crop across the SCF scenarios.

18.3.7 Decision Tree Analysis: Off-Farm Level

The off-farm actor considered here is the Reddiarchatram Sustainable Agriculture Producer Company Limited (RESAPCOL)—a farmer producer company based in Kannivadi, Reddiarchatram block. Input supply (seeds, fertilisers and pesticides) is one of the key essential services offered by the company to its members at the off-farm level. Here, managing the necessary seed stock by networking with private seed dealers is crucial. The demand side decision of critical concern is advance booking of seeds for the forthcoming cropping season with the private dealers by RESAPCOL. Amount of seeds of the different crops and the varieties to be stocked, phasing out distribution and the nature of transaction (cash/credit) to be extended to sub-dealers are the key supply side decisions. Table 18.4 gives the outcomes of the off-farm decision analysis.

Table 18.4 Outcome of decision analysis exercise with farmer producer company

Rainfall scenario	Probability (%)	Advance booking: seed quantity (ton)	Contingency arrangement			Quantity purchased 2 months before the season	Quantity distributed to sub-dealers	Mode and time of payment
Below normal	20	3.5	50% maize	45% cotton	5% ladies finger	0.9	25% of demand	Cash on delivery
Normal	60	5	60% maize	30% cotton	10% ladies finger	3	60% of demand	Credit
Above normal	20	7	55% maize	35% cotton	10% ladies finger	5	70% of demand	Credit

Source Field Data

18.3.8 Relevance of SCF and the Communication Tool for Strategic Planning Across Stakeholders

The importance of non-climatic factors on strategic decisions was emphasised by most of the players. In the case of farmers, it was the resourcefulness of the individual farmer and their coping capacity that were key drivers of crop choice or varietal choice decisions. The farmers articulated that the production decisions and outcomes are determined by climate variables as well as agronomic and economic factors such as labour, animal traction and credit. The communication cum planning tool used does not account for the non-climatic factors. Hence, the decisions/outcomes of these exercises may not be pertinent to and often are disconnected from the real-life agricultural decisions.

While facilitating the session, it was observed that farmers felt difficulty in articulating their strategic decisions with respect to committed and non-committed costs. This was because farmers normally based their committed and non-committed cost decisions on observation and assessment of actual climatic occurrences in the field. The climate information given to them (probability of a normal/below normal/above normal rainfall year) did not tell them anything about the intra-seasonal distribution and variations. Several of the non-committed cost decisions like intercultural operations, plant protection and top dressing are taken based on the intra-seasonal distribution and variation of rainfall.

Further, it emerges that the majority of key farm decisions are taken in very short lead times. Irrespective of any forecast (scientific or traditional), farmers prepare the land in anticipation of the season. Given the edaphic conditions, choice of the crop as well as variety is based on the onset of the rainfall prior to sowing. With respect to crop choices under rainfed situations, they take up either cotton or maize and the determining factors articulated are a) market price of the previous year/season and b) availability of groundwater to give one or two critical rounds of irrigation.

With respect to sowing decisions, if the onset is normal—i.e. receiving at least 50 mm of rainfall within 3–5 days in late September or early October—farmers start purchasing seeds, mostly hybrid seeds. These seeds are available in the market for immediate cash payment as well as credit. Planning for intercultural operations, top dressing and harvesting are purely based on how the season progresses. Such decisions do not require prior preparation and are taken based on actual occurrences.

For the off-farm player—the Farmer Producer Company and multinational input companies—strategic planning was done on the basis of their historic sales data, the standard acreage under each crop in the region, the ground-level data supplied by their field assistants and data on the existing market share of their competitors. The wholesale dealers will not incur heavy losses even if the forecast information goes wrong because bookings and commitments are initiated before the beginning of the season. Actual transaction of commodities happens after the commencement of the season or just about when it starts.

Table 18.5 Probable decisions based on SCF for different players

Off-farm player	Probable decision based on SCF
Input wholesalers	Stocking rate (managing inventory)
Producer (farmer)	Land allocation and crop choice
Produce aggregator (cotton)	Plan/influence produce turnover volumes
Produce aggregator (vegetables)	Forecast volume of incoming stock
Processor (cotton)	Help predict cotton quality
Financial institution (banks)	Decide on lending ceilings for different crops
Wholesale marketing	Not useful

Source Field Data

18.3.9 Probable Decisions Based on SCF Across the Value Chain

Choice of crops and crop variety are the decisions that farmers would base on SCF information (Table 18.5). For the wholesale input dealer at the district level, SCF was more useful in determining the stock of seeds to be maintained before the beginning of the season. It helps them decide on the stock of crops, varieties within these crops and the proportion of different crops. It also helps them to decide the nature and volume of transactions with the sub-dealers. If SCF forecasts a good season, they would extend inputs on credit to the sub-dealers, and if a bad season is predicted, they would prefer a cash-and-carry method. The credit institutions would use the information to decide the target for crop loans for the region as well as loan ceiling for each crop. They will also use the information for withholding or pushing crop loans. Similar experiences have been reported from Brazil (Lemos et al., 2002) and Zimbabwe (Phillips et al., 2002). Likewise, the insurance agents will also use the information to plan their targets and compensation payouts. Several of these decisions by players at the higher end of the agricultural value chain are competitive and often end up being counterproductive to the interests of the resource poor small farmer.

18.3.10 Suggestions for Making SCF Relevant for Stakeholders

Improving the capacities of the end user to interpret and use SCF for decision-making is a primary requirement for the climate forecast to be relevant. Further, SCF with 6-month lead time needs to be followed up with shorter lead times ranging from 1 to 3 months. This will cater to the forecast requirement of the different stakeholders and increase its utility in planning and management decisions. Downscaling to block level would increase the confidence of the stakeholders on the forecast. SCF needs to be packaged as a seamless forecast that combines with the existing short, medium and extended range weather forecast. SCF models should incorporate dynamics of the microclimate of the region and changes in climate variables post-extreme climate events like flood and drought. SCF should combine traditional knowledge of the region with climate science for improving its communication. SCF should be given along with advisories that build mitigation aspects directed at climate risk reduction. This has been envisaged and integrated in the National Action Plan on Climate Change under the implementation section as part of institutional arrangements for managing climate change agenda (Rattani, 2018).

Resource capacity of the end user plays a major role in determining the utility and uptake of the extended range forecast information. SCF information needs to be backed up with necessary input, and infrastructural and logistic support for the farmers/users to translate to on-field risk reducing action. A strong institutional mechanism to disseminate and implement SCF will help achieve this. The FPO which serves as a nodal agency for shareholding farmers can provide institutional support in terms of input, credit, infrastructural and logistic support to utilise SCF for reducing risk in farming.

18.4 Conclusions

Seasonal climate forecasts help in inducing risk reducing decisions across the agricultural value chain. However, SCF is only one suite of information on climate and weather that players across the agricultural value chain might use to make decisions. Hence, SCF generated and disseminated for a region needs to be flexible in terms of lead times and complement the existing short and medium range weather forecasts. But incorporation of SCF in decision-making depends a lot on the capacity of the end users in accessing and understanding the forecasts. Further, field-level adaptation action based on these decisions is dependent on the resource capacity of the end users and the presence of an enabling environment (Hansen, 2002). To enhance the usefulness of climate forecast information and advisories, it is essential to identify the decision-relevant attributes of forecast information for specific activities and players in the value chain, and provide forecasts incorporating those attributes. Communication is another crucial element that decides the utility of SCF; hence, appropriate participatory methods need to be adopted to communicate SCF. Capacity building of the end user in understanding, interpreting and using the forecast information for decision-making needs to be taken up for realising better utility of SCF.

The flip side of SCF is that it might sometimes undermine food security in the region by adding to the vulnerability of the primary producers. The forecast information is being put to use for different purposes by players across the value chain. Some of these decisions may be complementary to the primary producer, while some can be competitive and counterproductive to the primary producer. For example, the credit agencies' decision to limit crop lending in anticipation of a forecasted bad season can be very detrimental to the primary producers. A case in point is the experience in Brazil and Zimbabwe of financial institutions engaged in extending agricultural credit tightening their credit lending in response to a forecast for increased probability of drought. Similarly, the decision not to promote crop insurance in anticipation of a forecasted bad season by an insurance company can be counterproductive to the primary producers. Hence, efforts for strengthening climate resilience at a regional level need to factor in all these complementary and competitive engagements among the different stakeholders to ensure a win-win situation for all the players across the agricultural value chain.

Acknowledgement The authors acknowledge research funding from Australian Agency for International Development (Grant No. 59553).

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