

International Training/Workshop on Climate Risk Management in Agriculture, India

Extended Range Forecast System for Climate Risk Management in Agriculture Project

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Overview

The Extended Range Forecast System for Climate Risk Management in Agriculture (ERFS) Project, supported by the DAC, Ministry of Agriculture, Government of India, seeks to improve capacity to forecast the Indian summer monsoon, and to demonstrate approaches to using forecasts and other climate information to benefit agriculture/rural livelihoods. It integrates risk management and climate science research, involving leading institutions in India and abroad in climate research and agricultural management. These include the Indian Institute of Technology Delhi (project nodal institution), the Indian Meteorological Department (IMD), National Center for Medium-Range Weather Forecasting (NCMRWF), the Indian Council of Agriculture Research (ICAR), state agriculture universities, International Research Institute for Climate and Society (lead international collaborator) and others. The project adopts a demonstration approach, focusing on select districts in ten states that face significant livelihood impacts due to variability in the southwest monsoon: Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Himachal Pradesh, Rajasthan, Tamil Nadu, and Uttarkhand.

From April 27-30, 2009, IRI and the Acharya N. G. Ranga Agricultural University (ANGRAU) co-led a workshop on agriculture risk management as part of the project, “Extended Range Forecast System for Climate Risk Management in Agriculture” (ERFS). Hosted at ANGRAU near Hyderabad in the state of Andhra Pradesh, participants included researchers from agriculture universities in nine states across India, who are leading demonstration efforts as part of the ERFS project, project partner institutions including IMD (Delhi and Pune), IIT-Delhi, IRI, and stakeholder institutions (See Appendix B for a complete participant list.). This four-day workshop had the following objectives:

- Understand the nature of agricultural risks faced by farmers, and the role of climate in those risks, particularly in the context of the nine demonstration sites
- Discuss and share practical approaches to analyzing these risks using methods and tools across different scales, and begin the task of capacity enhancement of project participants
- Identify types of strategic decisions that would benefit from integration of extended-range climate forecast and other information, and build understanding of the types of climate information that might be developed through the ERFS project
- Develop a broad plan of work to guide next steps in demonstration site research within the ERFS project

The workshop resulted in the development of a work plan to guide demonstration efforts including analysis of climate risks and crops in the chosen districts, development of climate risk management tools to help address these risks and development and dissemination of climate advisories, as part of the Indian Meteorological Department’s existing Agro-Met Advisory program.

Opening Session

The Director of Research at ANGRAU, Dr. G. Lakshmi Kantha Reddy, initiated the proceedings, offering his hopes for a very productive workshop. Prof. U.C. Mohanty of the Indian Institute of Technology Delhi (IIT Delhi) provided an overview of the ERFs project and emphasized the linkages between understanding agriculture risk and identifying the specific types of forecast information needed to address them. Dr. L.S. Rathore, director of the Agro-Met Advisory System at IMD, offered a historical perspective and context for the work of the ERFs project, focusing on the use of long-range forecasts in the context of strategic decisions. Dr. Shiv Someshwar of the International Research Institute for Climate and Society (IRI) at Columbia University congratulated project partners on launching this crucial effort to develop practical climate risk management approaches for diverse contexts of Indian agriculture. The workshop was then formally opened by Dr. P. Raghava Reddy, Vice-Chancellor of Acharya N.G. Ranga Agriculture University (ANGRAU), who spoke eloquently about the importance of this effort for the state of Andhra Pradesh and India as a whole, emphasizing the potential utility of forecast information to better prepare for drought situations, and to also support increased crop productivity. All commended Dr. D. Raji Reddy, Principal Scientist (Agromet) and Head Agrometeorology-Cell at ANGRAU, and his team for hosting the workshop, and welcomed participants from the IRI.

During the session, the workshop objectives were outlined (as listed above) and the following additional points were raised during the discussion:

- The current Agro-Met Advisory system provides information in the short and medium-term; this project will focus on longer-range forecast and climate information, which may relate to a broader range of agricultural risks and decisions
- The ERFs project brings together the agriculture and climate science communities, enabling the project to focus on developing climate information that is really targeted toward strategic decisions farmers and policymakers make to manage risk
- The project therefore takes a risk management approach in that it focuses on strategic decisions, and on making the most of positive opportunities as well as managing negative risks
- In addition to farmers, it is also important to understand the role of district and local government agencies, NGOs, and other stakeholders, and to target the development of climate information to integrate into their decision processes
- The workshop is intended to be highly interactive, fostering a broad discussion on various perspectives about agricultural risks and the integration of climate information to benefit farmers

Session I: Overview of Climate Risk from the Perspective of Farming Communities

This session focused on building an understanding of the agriculture risk aspects of the ERFSS project. Dr. Rathore of IMD offered his remarks on key risks in Indian agriculture, and laid out three key components to guide analysis of climate risks in the ERFSS Project. These include:

1. **Risk zoning:** this refers to identifying risks within specific temporal ranges, particularly in the context of extended range forecasts. This is to be undertaken using agro-climatic data, and also based on past experience and in the context of using extended range forecasts.
2. **Determining optimal forecast information:** based on the kinds of risks, identify the forecast information required. While the forecasting community may not be able to give the exact forecasts as required, it was important to define the operational components of receiving the forecast, such as the format, time intervals, channels of communication, etc.
3. **Identifying range of factors influencing farmer decisions:** in order to develop risk management strategies and properly integrate climate information, a complete understanding about the various external factors influencing farmers' decisions is needed. This includes:
 - a. Comprehension of extreme events and climate variability and their implications on crop and animal production systems
 - b. Understanding of farm operations, and using current analytical tools to integrate climate knowledge
 - c. Helping farmers themselves relate an understanding of climate to their decision making

Following this, Dr. Someshwar of IRI provided an overview of the agenda key themes to be covered in the coming three days. These include:

- Nature of agriculture risks, including climate and non-climate risks
- Issues of variability and uncertainty
- Levels of analysis and currently available tools (de-trending tool, Weather Manager etc)
- Defining “Good” year and “Bad” years
- Mapping of agricultural dynamism, and of institutions and policies and their role in risk management.
- An introduction to some climate risk management tools
- Discussions to develop a workplan for the agriculture risk components of ERFSS

Dr. D. R. Reddy of ANGRAU spoke at length on the need for improving crop productivity for farmers, and the crucial role of interaction between the agriculture and climate science communities in order to conduct research and develop appropriate tools. In the Indian context, for a majority of crops there has been some stagnation in productivity. New technologies to improve productivity are not fully tested as to their ability to resist new and existing stresses. Just as the farmer-scientist interaction had to increase, so the collaboration between climate scientists and agriculture scientists needs to increase as well, in order to develop practical strategies to understand current risks. The 2002 droughts illustrated some of the serious costs of a lack of coordination. Working with local government and civil society will be crucial.

Sheshagiri Rao, member of the IRI research team, and Dr. Amor Ines, agricultural scientist from IRI, both offered further comments on the utility of research for farming communities, emphasizing the need for inter-disciplinary, context and problem-specific work in order to translate climate knowledge into variables that are meaningful to farmers and relevant to their decisions. For example, farmer decisions will be different based on soils, crops, pests and diseases, topography, etc. They will also differ based on the local socio-economic and policy contexts. Also mentioned was the need to address climate impacts on livestock, natural resource dynamics (particularly ground water), and the role of economic instruments such as crop insurance etc.

It was emphasized in the discussion that all of these factors will play a role in determining what kind of climate information will be most needed in particular contexts. It is likely that, in addition to forecasts of average rainfall, climate information about rainfall onset dates, likelihood of dry and wet spells, etc., will be needed in order to address farmers concerns over what and when to plant, conducting land preparation, irrigating, etc. The need for such information will need to be balanced with the current ability to produce reliable forecasts at the appropriate temporal and spatial scales, which the ERFs project hopes to improve.

Session II: Presentations by PIs of participating state agriculture universities

This session was dedicated to overviews from the Principal Investigators from each of the participating state agriculture universities on the key climate-related risks in their demonstration sites, and their on-going and past work relevant to the ERFs project. The following presentations were made:

- Dr. D. Raji Reddy, Acharya N. G. Ranga Agricultural University (ANGRAU), Andhra Pradesh
- Dr. V. Geethalakshmi, Tamil Nadu Agricultural University (TNAU), Tamil Nadu
- Dr. R. S. Rana, Himachal Pradesh Krishi Vishwa Vidyalaya (HPKV), Himachal Pradesh
- Dr. A. S. Rao, Central Arid Zone Research Institute (CAZRI), Rajasthan
- Dr. K. K. Agarwal, Jawaharlal Nehru Krishi Vishwavidyalaya (JNKVV), Madhya Pradesh
- Dr. A. R. Tupe, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PKV), Maharashtra
- Dr. H. S. Khuswaha, Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T), Uttarakhand
- Dr. S. N. Pashupalak, Orissa University of Agriculture and Technology (OUAT), Orissa
- Dr. Vyas Pandey, Anand Agriculture University (AAU), Gujarat

Appendix A of this report summarizes key information from each presentation regarding the chosen demonstration site in each of the nine states. For further details, the Powerpoint presentations are available among workshop documents (distributed via CD to all participants, and available upon request).

Following the presentations, Dr. Rathore of IMD offered a summary of key points. He observed that there is a wide range of data being employed using a number of modeling tools, such as crop, disease, and irrigation management models. Moving forward, additional efforts will be focused on data collection, and improved approaches to using climate indicators in understanding climate-related stresses and sensitivity of crops and livestock. The workshop is to build upon this base to

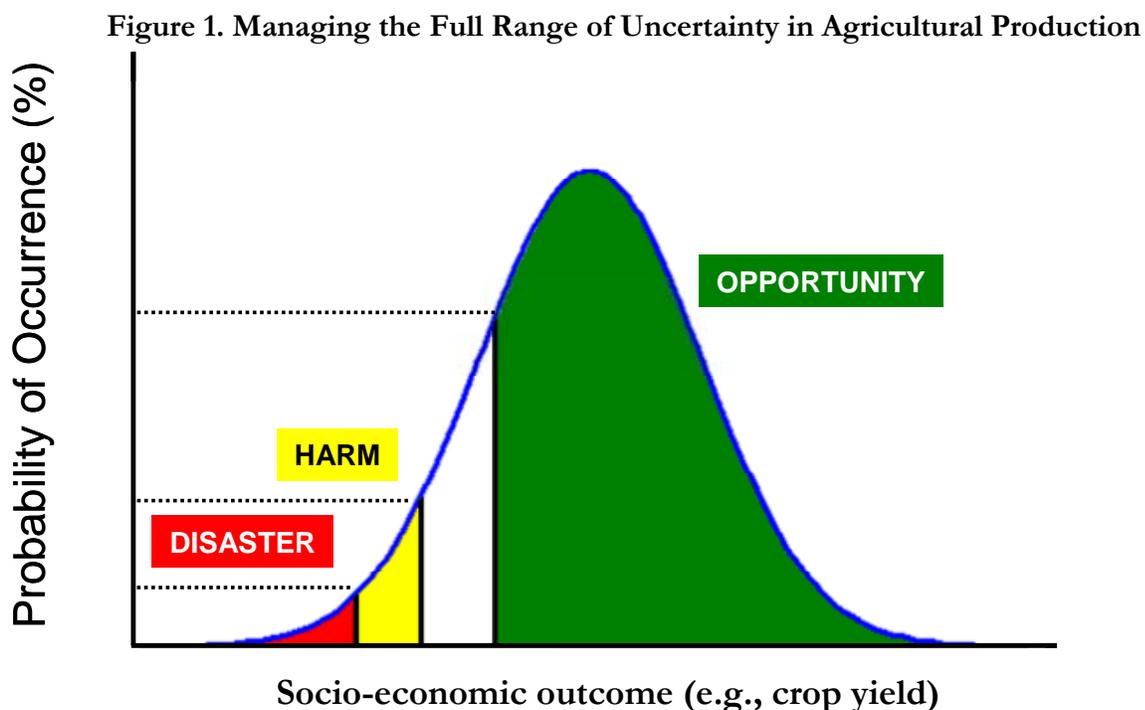
discuss issues of agriculture risk management, and an exploration of available tools and approaches. Following two days of training, the final sessions of the workshop would focus upon development of workplans for each demonstration area.

Session III: Climate and Agricultural Risk

This session focused upon understanding and analyzing the role of climate in agricultural risk, in the context of a wide range of non-climate risk factors. Decisions by farmers can be informed by climate information, but they must also weigh other factors, such as seed and other input prices and subsidies, soil types, local pests, and more. Drs. Reddy (ANGRAU), Amor Ines (IRI) and Sheshagiri Rao (IRI) jointly led this session, covering the following broad outline of topics and providing training in specific tools and techniques.

- 1. Drivers of agriculture risk (climate and non-climate):** it is critical to recognize that agriculture risk derives from multiple sources, including climate and non-climatic factors. The interactions between these must be understood in order to understand and manage agricultural risk. The following broad types of risk were mentioned:
 - Climate (temperature/rainfall extremes)
 - Prices (of seeds/inputs, mandi prices)
 - Institutions (banks and access to credit, community support groups, etc)
 - Policies (subsidies, government relief programs, water/land access rights, etc)
- 2. Analyzing variability at different spatial and temporal scales:** at smaller spatial scales, variability tends to increase. For example, when the coefficient of variation is calculated for a crop's yield at a global level, it is much lower than when a district-level analysis is conducted, in part because of averaging of yield data across scale. Rainfall variability behaves similarly; one will find significant variability at the station level, but this decreases at larger scales. This is crucial to understand, since often, climate analysis may not be conducted at the same scale as agricultural analysis and hence tailoring climate information to the needs of the analysis is important.
- 3. Climate and non-climate factors in yield: de-trending techniques.** In order to detect the role of climate in crop yield or production, it is often necessary to “de-trend” a time series of data, which separates low-frequency (e.g., adoption of new technologies) from high-frequency (e.g., year-to-year climate variability) influences. For example, overall crop productivity in India has increased substantially over time. Considerable agricultural research has demonstrated that factors such as technology, better seeds, etc. are largely responsible for such upward trends. In order to analyze the relationship between crop production and year-to-year climate variability, long-term trends such as this need to be filtered. Commonly used tools, such as Fourier-based low-pass smoothing, were presented in detail, using an example of a re-constructed time series of crop yields in Mahabubnagar (the demonstration site in Andhra Pradesh). It was emphasized that a long time series of data is needed to employ such methods.
- 4. Implications of variability for decision making:** in analyzing the role of information about variability in making decisions, two key points must be recognized: 1) decisions are dynamic, made within a particular context that changes over time; and 2) use of average values has limitations. An example was presented comparing two different representations of variability in

5. **Levels of spatial analysis and options for climate risk management:** climate risk management encompasses the full range of possible outcomes farmers face each season. Figure 1 illustrates this range, and is an important reminder that strategies that use climate information to better prepare for opportunities are just as important as preparing for adverse outcomes.



It is also critical to recognize that decisions are made at a range of time horizons and spatial scales, and therefore, analysis at these scales is needed in order to identify appropriate climate risk management options. Table 1 presents temporal and spatial scales of analysis that may be associated with various CRM options. At the farmer level, choices about crops, fertilizers, and other inputs; at the enterprise level, decisions about combinations of crops; and at the district level, decisions relate to subsidies, crop insurance, loan waivers, etc. Outcomes of decisions at one level may affect decisions at other levels.

Diversification was emphasized as a strategy for reducing risk. Tools were discussed that could assist in planning such strategies, such as a simple optimizer that analyzes risks of various decision options. Diversification strategies combine options with negatively correlated risks, such as combining crops with non-overlapping critical periods. At the enterprise level, diversification could involve combinations of crops and livestock.

Table 1. Linking Levels of Analysis with CRM Options

Spatial level	Decision by	CRM OPTIONS	OPPORTUNITIES (good events)
Plot	Family	Choice of variety, fertilizer dosage, irrigation	Increase in cropping intensity
Family / farm	Family	Crop, enterprise choice	Mix of enterprises, livestock, trees
Community	Families/ local institutions	Use of CPRs, watersheds	Improvements in CPRs
Region (Sub district)	Govt. banks, and other institutions	Subsidies, crop insurance, Govt. Schemes	Improvements in CPRs
District	Govt. banks, and other institutions	Subsidies, dev. Schemes, Local self Govt.	Policy- Watersheds, improved farming
State/National	Govt. banks, and other institutions, Policy	Loan waiver, crop insurance, credit policy, REGS, Drought relief measures	Policy- efficient irrigation, prices, nutrient use, farming methods, trade

6. **Identifying “good” and “bad” years:** in conducting analyses of agricultural risks, a critical step is identifying which years are “good” or “bad”, according to what measure. Two approaches were discussed: a) calculation of a “Z-score”; b) calculation according to exceedance of a certain percentile threshold (i.e, a year is among the lowest 20% in rainfall, or crop production).
7. **Tools to analyze weather data:** there are many challenges involved in analyzing weather data. Two tools were presented and discussed that can help in this:

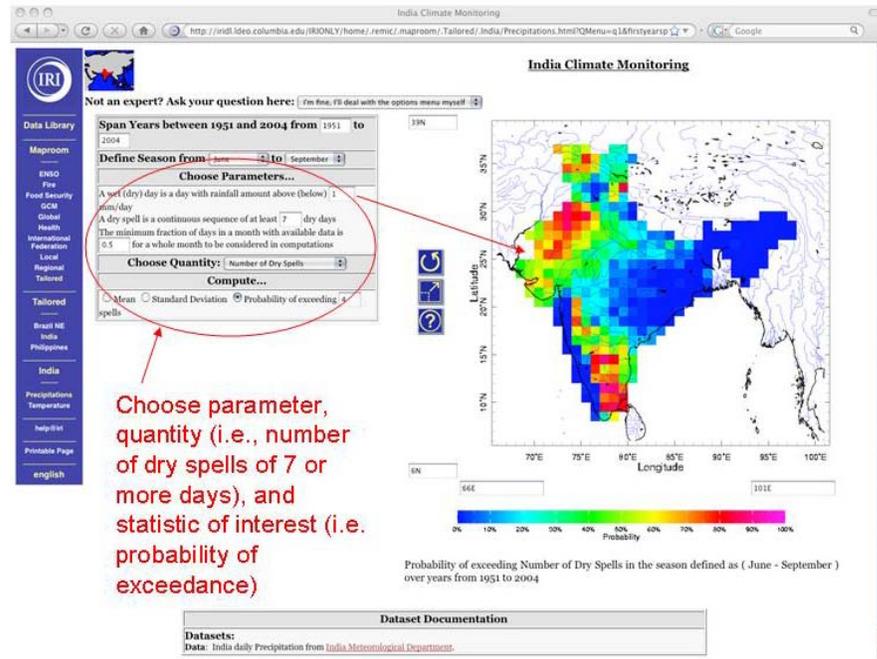
Prototype tool in IRI Data Library Maproom: IRI has developed a prototype online tool to map and analyze weather data to suit user needs. This tool uses IMD’s 1-degree gridded data, which has been made available for use in the ERFs project. The tool was created in a password-protected area of IRI’s online Data Library.¹ It was agreed that this data, and the tool, could be made accessible to all nine principal investigators for the ERFs demonstration areas.

The tool analyzes historical data according to user-defined parameters. For example, if a user is interested in understanding patterns of dry spells in a region, one can choose the length of a dry spell, start and end dates for a particular period, and the statistic of interest (such as probability of exceeding a certain threshold). The tool then generates maps and graphs accordingly. Figure 2 provides an illustration of the interface. It was agreed that such statistics could be of great value

¹ IRI’s Data Library is a freely available online tool that enables users to access and spatially analyze a wide range of publicly available climate, environmental and other datasets. The tool can be accessed at: <http://iridl.ldeo.columbia.edu/index.html>.

in characterizing the climate variability in a particular region, and could help generate climate information that is useful for decision-makers. It was also agreed that running this tool with higher resolution day data would be extremely useful.

Figure 2. Prototype tool to analyze and map historical climate data over India.



Weather Manager (“Weatherman”): this is a program developed by Dr. Jim Hansen and others as a research tool to store, organize, and analyze weather data. Dr. Amor Ines from IRI led an in-depth training session in using the tool. The software and manual were included on the CD of materials provided to participants at the end of the workshop.

During this session, Madan Mohan Reddy, Director of the Confederation of Kisan Organizations, offered some remarks on the importance of managing climate variability in agriculture. He spoke about the differing risks faced by farmers and the importance of livestock in periods of drought in Mahabubnagar, one of the demonstration areas.

Session IV: Agricultural Dynamism and Decision Making Under Uncertainty

During this session, a series of presentations, discussion and training led by Dr. Amor Ines and Sheshagiri Rao of IRI and Dr. D. R. Reddy of ANGRAU focused on approaches to analyzing decision options in the context of uncertainty. The session was organized into two parts:

1. Decision-making under uncertainty: Dr. Amor Ines led a discussion on concepts of risk aversion and optimization. Many farmers are risk-averse, meaning that given a choice between higher returns but some uncertainty, and an outcome with certain but slightly lower return, many

would choose certainty and lower returns. The certainty equivalent is the point at which the decision-maker is indifferent between a certain and an uncertain option. It was emphasized that a risk management perspective on decision-making can only be undertaken if farmers have the capacity to face risks (that is, to take action based on uncertain information). Not all farmers have this option.

Optimization is an analysis that calculates the best/optimal possible decision amongst a range of choices, given available information and resource constraints. An example of optimizing maize production in Kenya was used to illustrate that decisions that are optimized based on average information (for example, rainfall averages) are usually not optimal in practice. Climate forecasts can help inform decisions to be closer to optimal, if uncertainties are properly understood.

2. Mapping out risk management approaches: Sheshagiri Rao of the IRI team discussed approaches to analyzing climate risks and risk management approaches at the community and village level. Drawing upon the example of Srirangapur Village in Mahabubnagar, a methodology was illustrated for mapping key decision points, relevant climate information for that decision, lead time required, and costs and benefits of different possible outcomes. Table 2 provides an example of the approach, which highlights the type of information needed in order to evaluate possible CRM options. Factors such as the cost of action and possible benefits or costs of outcomes play a role in determining what degree of uncertainty in climate information farmers will be able to tolerate.

Table 2. Sample table to aid in mapping out possible CRM options in Srirangapur Village, Mahabubnagar District.

Decision on	Climate & other information (minimum)	Lead time	Additional cost	Additional benefit (forecast is borne out)	Penalty (forecast not borne out)
Choice of crop- maize or cotton?	Seasonal total. Long dry spell timing	Before sowing	None	30-60% higher yield	Lose benefit
Best sowing window in – June 1 wk to Aug 1 wk	Distribution of wet/dry spells, Crop simulation runs	Before sowing	None	20-80 % higher yield	Lose benefit / can not sow the crop
Moisture stress management for the crop	Dry spell at silk formation stage (60-70 days)	7-10 days ahead	Irrigation	30-60% higher yield	Cost
Aphids management	Wet spells in Vegetative growth, silk formation	7-10 days ahead	Plant protection	10-30% higher yield	Cost

A second example was presented from Anantapur District, Karnataka, illustrating the role of factors such as diversification of livelihood sources (agriculture, livestock), access to credit and size of debt,

dependence upon common land for fodder, and others in understanding existing strategies to cope with climate risk. A mapping of such strategies is important for targeting our research efforts.

3. Using climate information in managing crop mixes: Dr. D. Raji Reddy of ANGRAU shared outcomes from preliminary research and analysis undertaken in 2 select districts, one with high and one with low rainfall. His results shed light on how combinations of soil type, rainfall levels, timing of monsoon arrival, wet and dry spell patterns, and other factors play a role in determining farmers' planting decisions. For example, while cotton was the first choice for black soil, given an early onset of monsoon, maize is the preferred crop if onset was delayed. Other factors, such as dry and wet spells affected whether or not farmers applied nitrogen, or employed additional irrigation to protect against sucking pests. The presentation highlighted approaches to analyze these factors for identifying how climate information can be used to support management of crop mixes.

Joining the discussion during this session were Dr. Y. S. Ramakrishna, former Director of the Central Research Institute for Dryland Agriculture (CRIDA), and Dr. P.S.N. Sastry, formerly of the Indian Agricultural Research Institute. Dr. Sastry provided remarks at the end of the session, observing that while it may not be possible to produce forecasts with 100% accuracy, the key point was to gradually reduce error from 50% to 30%. Also, it was important to realize that farmers are not seeking *daily* forecast information, and that focus is needed on their specific needs, particularly critical periods in their cropping calendars.

Session V: Group Work and Presentations on Demonstration Efforts

In this session, PIs from the nine state agriculture universities worked in three groups, each discussing their common priorities for work in their demonstration districts. It had been agreed that in most cases, one district would be taken up for demonstration. Within this district, there would be a focus on one village and two crops facing different kinds of climate risks. In each, agriculture, horticulture, and livestock aspects were to be considered.

Each group focused its discussion around the following three components of the project:

1. **Data , risk analysis and preparation of knowledge base:** identification of key risks, drawing upon climate data, environmental monitoring, soil moisture, pests and diseases, and livelihood contexts in each demonstration site
2. **CRM Tools:** approaches to analyzing data to identify possible strategies to manage risks (i.e., analysis of key decision points, climate information required, costs and benefits of response strategies).
3. **Advisory preparation and dissemination:** discussion of what advisories are required, channels of communication, feedback mechanisms, etc.

Each group reported back to all on their discussions. Several key points included:

- **Quantification of climate risk:** while many PIs have a good sense of these risks, it can be challenging to quantify it. One promising approach may be to analyze past climate data to identify some key statistics, such as probabilities of dry or wet spells. These can then be

- **Understanding needs of farmers:** a survey can be conducted to understand the information farmers actually need, and what management practices they have undertaken in the past to deal with certain climate problems. Key information that seems to be most needed is timing of monsoon onset, information on dry/wet spells, and forecasts at the 15-30 day range.
- **New possibilities to consider:** it may be useful to analyze issues at the watershed level, in addition to districts, and to integrate water management issues where possible. New tools such as weather-based insurance may be possible to integrate.

Dr. Rathore of IMD summarized the **key outcomes and next steps** emerging from this session, including:

- **Data:** additional sharing of data is required in the following areas:
 - Meteorological data: while most groups already have 30 years of data, additional data is available from IMD. Dr. KK Singh of IMD will work with PIs to make available analyses based on IMD data for all nine districts. In addition, some districts are located far from weather stations, so spatial models are needed to interpolate the data. IRI can assist with techniques to do this.
 - Soil and crop data: most PIs have this data, but a common minimum set of data should be defined, and a composite list will be prepared (Dr. Reddy of ANGRAU to contribute to this).
 - Data on pests and diseases: these are very specific and must be undertaken by each PI. It will be helpful if notes on this are shared amongst the group.
 - Satellite and radar data: this has enormous potential, and follow-up is needed to ensure that this is available for all nine districts.
- **Climate risks:** the following concrete steps were discussed:
 - Prepare a common minimum list of what is required to assess climate risks, keeping in mind the need to quantify these risks
 - We need to understand farmers' perceptions of risks, and their current coping mechanisms and institutional context. IRI's institutions and policies group may be able to assist in preparing a common questionnaire to accomplish this.
 - A road map is needed to undertake the approach described earlier to superimpose climate parameters (dry/wet spells) on crop calendars. GIS may be required for this.
 - A common list of CRM analysis tools would be useful
- **Forecasts:** each PI needs to identify what kinds of climate information are required to address climate risks in the demonstration district. A consolidated document summarizing these needs could be generated and provided to the climate group, keeping in mind:
 - Forecasts of rainy season onset, dry/wet spells, and extreme temperature conditions are all very important.
 - Forecast verification is important, and we need to identify approaches for this
 - Forecasts are needed across a range of timescales (short, medium, and long-range), and inputs from a range of institutions may be important here.
- **Institutional linkages:** participants were encouraged to forge operational linkages with other departments and stakeholders undertaking similar projects and to combine efforts.

- **Information sharing:** to ensure easy flow of information between all the stakeholders of the project, a common web page would be hosted by IRI. A group email list may be useful. In addition to continuous sharing of knowledge and resources, PIs were advised to prepare a 6-monthly status report with updates, any persistent problems, results, successes, failures and other information. Dr. K. K. Singh offered to prepare a format for an annual progress report which all PIs could use.

The session was concluded with a brief presentation by Dr. Samui, IMD Center in Pune, on IMD's efforts to integrate data across multiple centers. These data resources will be very useful for the ERFs project. In addition, IRI, IMD and IIT Delhi have been discussing the development of a version of the IRI Data Library for the project, to be based at IMD. It may also be possible to incorporate this into IMD's existing data integration efforts.

Session VI: The Way Forward and Closing

The closing session summarized the key outcomes of the workshop, and highlighted the overall importance of the ERFs project in supporting India's farmers in better managing climate risks.

ANGRAU Vice-Chancellor Dr. P. Raghava Reddy initiated the closing session, commenting on the very useful discussions at the workshop, which will be crucial for developing strategies to address risks faced by farmers who depend upon rain-fed agriculture in Andhra Pradesh and other parts of India.

Dr. Rathore of IMD presented outcomes of the workshop in the form of a Workplan for the agricultural risk management component of the ERFs project. He thanked all participants and contributors, including eight state agriculture universities, two ICAR institutes, ICRISAT, IMD, IIT Delhi, IIT Hyderabad, farmers' representatives, ANGRAU faculty, and IRI.

Key elements of the workplan as presented by Dr. Rathore included:

- **Climate risks in nine demonstration districts:** in each district, there would be a focus on one village and two crops facing different kinds of climate risks. In each, agriculture, horticulture, and livestock aspects were to be considered. Principal investigators for each demonstration had identified the district of focus, key crops, key climate risks to be addressed, and data currently available as well as required. These are presented in **Appendix A** of this report.
- **Data requirements:** an indent to be prepared for the types of data required, some of which is already in the hands of PIs but others to be supplied from IMD and other sources. GIS and NDVI maps are also required. A version of the IRI Data Library is to be set up at IMD (New Delhi and Pune). IMD staff, and all PIs, will require access as well as training in using all data sources and the Data Library.
- **Forecast needs:** demonstration areas require downscaled forecasts of specific rainfall and temperature parameters of interest to the farmers, such as probabilities above and below

- **Climate risk analyses:** these may include climate risk maps, identification of typology of risks, key agro-climatic indices, critical temporal dimensions of risks and vulnerabilities to selected crop & livestock production, methods for quantification of climate risks, a questionnaire on farmers' perceptions about risk, and translation of climate risk in the context of agro-met advisories.
- **Climate risk management tools:** Sensitivity study on crop phenology; Analysis of DOS and harvesting and options; Thresholds of agro-meteorological risks; Portfolio of crops and livestock; Crop Calendars; Economic Impact Analysis; institutional mechanisms related to risk management strategies. Plans were discussed for a training for PIs in using such tools, to be held in Fall 2009 in Delhi.
- **Operational linkages:** Line function departments (agriculture, horticulture, poultry, animal husbandry etc.), the National Bank for Agriculture and Rural Development (NABARD), farmers' associations, and NGOs and CSOs are all critical agencies to engage in the project, in order to facilitate operational uptake of results.

Dr. Shiv Someshwar of IRI thanked ANGRAU for hosting the workshop, and all participants, who shared their deep knowledge of agro-climatic risks and contributed to the excellent and productive discussions during this workshop. IMD's leadership in the agro-met advisory system has been excellent and a model for other countries, and this project has the potential to add extended range forecasts to this system. IRI is very pleased to be engaged in this project, and plan to bring the best science, both from IRI and other Indian and international partners, to bear in this effort.

Dr. V. Geethalakshmi of Tamil Nadu Agricultural University (TNAU) spoke on behalf of the PIs participating in the workshop. The workshop has led to a concrete plan of action for the project, and gave an opportunity to take stock of current strengths and additional needs required to achieve good results. She noted that the IRI Data Library will be very valuable for this effort, and urged progress on this aspect as quickly as possible. The tools presented are also very valuable, and the PIs are looking forward to implementing these in their demonstration areas. Dr. S. N. Pasupalak of Orissa University of Agriculture and Technology (OUAT) added his remarks, confirming that the workshop led to a more concrete understanding of the project and the knowledge required.

The workshop was concluded with the remarks of the chief guest, Dr. Ajit Tyagi, Director General of IMD. He thanked the Ministry of Agriculture for conceiving and organizing this project, and offered special thanks to Dr. Reddy of ANGRAU for hosting this workshop. He noted that in addition to Ministry of Agriculture, IMD, and IIT Delhi, the IRI brings many strengths to this effort. By addressing risk in agricultural production, this project addresses a key missing link in efforts so far. We have excellent capacities in crop and climate modeling, but a risk management approach is critically important. He also noted that IMD was committed to ensuring that required data, via password protection, would be made available to all the PIs.

Extending full support to the ERFs project, Dr. Tyagi said, "This effort means a lot to this country, since agriculture is such a key factor in our development plans. These have been fruitful days of discussion, and represent a new beginning and the first step over a long journey ahead, toward a climate risk management approach."

APPENDIX A. Demonstration Districts, Key Crops, Climate Risks, and Available Data

<i>DISTRICT State</i>	<i>PI and affiliation</i>	<i>Crops to be studied</i>	<i>Pest and Disease</i>	<i>Available Weather Information</i>	<i>Available Crop Data</i>	<i>Risks Involved</i>
PALAMPUR AND KANGRA Himachal Pradesh	Dr. Ranbir Singh Rana, Associate Professor Dept. of Agronomy, CSK Himachal Pradesh Krishi Vishwa Vidyalaya	Wheat and Apple	Apple: Apple Scab, Sanjose Scale; Wheat: Smut	Palampur: 35 years (From 1975) ; Kullu: 27 years (From 1982)	25 years data for selected crops	Crucial sowing rain: 25 mm in the third week of Oct and second fortnight of May; Intermittent dry spell for more than 2 weeks during July, August; Minimum temp. for apple in Dec-Jan, Delay in Western Disturbances
UDDHAMSINGH NAGAR Uttarakhand	Dr. H. S. Khuswaha, Professor Dept. of Social Science, College of Agriculture, G.B. Pant University of Agr. & Technology	Rice and Wheat		Weather data for the chosen location is not available		Heavy rain, floods, fog and high temperature in March
ANAND AND KHEDA Gujarat	Dr. Vyas Pandey, Professor and Head Dept. of Agricultural Meteorology, B.A. College of Agriculture, Anand Agricultural University	Cotton and Groundnut	Cotton: Mealy Bug, Sucking Pest and Viral Disease, Alternia Leaf Spot, Grey Mildew; Groundnut: Leaf Miner, Thrips, Bud Necrosis	Minimum Weather Data for 30 years; Data on daily rainfall, temperature and humidity	Crop data: District/taluk level data on area, production and yield for 30 years	Erratic Rainfall, onset and intermittent dry spell
JODHPUR Rajasthan	Dr. A.S. Rao, Principle Scientist Agricultural Meteorology, Central Arid Zone Research Institute (CAZRI)	Pearl Millet and Cluster Bean: June-Sep Mustard and Cumin: Nov-Feb		Data for 37 years (From 1971)	30 years data for selected crops	Crucial sowing rain: 25 mm in the first week of July; Intermittent dry spell for more than 2 weeks in July and Aug; Delayed onset of SW monsoon beyond 25th July
KHURDA AND ANGOL Orissa	Dr. S.N. Pashupalak, Prof. & Head Dept. of Agrometeorology, Orissa University of Agriculture and Technology	Rice and Groundnut		Daily weather data from 1969 for Khurda; Daily weather data for last 10 years for Angol	Rice: Block level data from 1981 onwards; Groundnut: District level data for 10 years	Heat wave: April to June 15; Heavy rainfall leading to floods during monsoon; October - Dec rainfall for rabi crops; dry and wet spells
MAHABUBNAGAR Andhra Pradesh	Dr. D. Raji Reddy, Principal Scientist (Agromet) Agrometeorology-Cell, Agricultural Research Institute, Acharya N.G. Ranga Agricultural University	Cotton and Maize	Cotton: Mealy Bug, Sucking Pest and Viral Disease, Alternia Leaf Spot, Grey Mildew; Maize: Stem Borer, Sucking Pests, Charcol Rot, Helmenthosporium Leaf Blight	Minimum Weather Data for 30 years; Data on daily rainfall, temperature and humidity	Crop data: District/taluk level data on area, production and yield for 30 years	Erratic Rainfall, onset and intermittent dry spell

DISTRICT State	PI and affiliation	Crops to be studied	Pest and Disease	Available Weather Information	Available Crop Data	Risks Involved
COIMBATORE Tamil Nadu	Dr. V. Geethalakshmi, Professor Agro Climate Research Centre, Tamil Nadu Agricultural University	Rainfed Sorghum, Irrigated Maize and Irrigated Rice	Rice: BPH, Stem Borer and Blast; Maize: Sucking Pest	50 years (1961 onwards)	25-27 years data for all the key crops	Crucial sowing rain: 25 mm in the third week of Sept; Intermittent dry spell for more than 2 weeks during Nov.; Delayed onset of NE monsoon beyond 20th October
AKOLA Maharashtra	Dr. A. R. Tupe, Assitant Professor, Dept. of Agronomy, Panjabrao Deshmukh Krishi Vidyapeeth	Cotton and Soybean	Cotton: Mealy Bug, Sucking Pest and Viral Disease, Alternia Leaf Spot, Grey Mildew; Soybean: Pod Borer, Spodoptera, Stem Girdler	Minimum Weather Data for 30 years; Data on daily rainfall, temperature and humidity	Crop data: District/taluk level data on area, production and yield for 30 years	Erratic Rainfall, onset and intermittent dry spell
JABALPUR Madhya Pradesh	Dr. K.K. Agarwal, Senior Scientist, Dept. of Physics and Agrometeorology, College of Agr. Engg., J.N.Krishi Vishwa Vidyalaya	Rice during Kharif; Chickpea/Wh eat in Rabi		Weather data from 1968 onwards	For both Rice and Wheat: District-level data from 1968 onwards	Continuous rain in June; Dry spells in July and August; Early withdrawal of monsoon; Frost in Rabi crops; Biotic stresses

APPENDIX B. Workshop Participants

ERFS Demonstrations: Principal Investigators

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APPENDIX C. Workshop Agenda

International Agriculture Risk Management Workshop
For Government of India ERFs Project
 At ANGRAU, 27-30 April 2009
Agenda

Time		Topic and speaker	Chair
27th April 2009			
9:00	10:00	Registration	
10:00	11:10	Welcome: <i>Dr Raji Reddy, ANGRAU</i> (10 minutes) Address: <i>Director of Research, ANGRAU</i> (10 minutes) ERFS Project, a brief overview: <i>Prof. Mohanty, IIT-D:</i> (10 minutes) Inauguration address: <i>VC ANGRAU:</i> (15 minutes) Remarks on risks in Indian Agriculture: <i>Dr. L.S. Rathore, IMD</i> (15 minutes) Vote of Thanks: <i>K.K. Singh, IMD</i> (5 minutes)	ANGRAU Official
11:10	11:40	Tea Break	
11:40	12:30	Agricultural Risk Project component: Overview <i>Dr. Rathore & Dr. Someswar</i> Views on utility of research for farming community <i>Drs. Raji Reddy, Dilip Singh, Sheshagiri, Amor</i>	Prof. Dash
12:30	13:30	Lunch & Departure of Distinguished Members	
WORKING SESSIONS BEGIN			
13:30	15:30	PIs presentations on relevant past/ongoing research (Ten presentations each for 10 minutes)	Dr. Rathore
15:30	16:00	Tea Break	
16:00	18:30	Climate & Ag. risk <i>ANGRAU Group, Drs. Sheshagiri and Amor</i> <u>Topics:</u> drivers of agricultural risk; variability and uncertainty; levels of analyses (crop, farm, and district levels); “good” and “bad” years. <u>Tool & activity:</u> De-trending, Weather manager <i>continued....</i>	Dr. Someswar
28th April 2009			
9:00	11:00	Climate & Ag. risk (<i>continued</i>)	Dr. Rathore

		Rainfall variability <u>Tool and activity:</u> Weather manager (tool to calculate key weather/climate statistics)	
11:00	11:20	Tea Break	
11:20	12:00	Climate & Ag. risk (<i>continued</i>) Levels of analyses	
12:00	13:00	Climate & Ag. risk (<i>continued</i>) “good” and “bad” years analyses from farmers’ perspective	
13:00	14:00	Lunch	
14:00	16:00	Mapping agricultural Dynamism <i>ANGRAU Group, Drs. Sheshagiri and Amor</i> <u>Topics:</u> implications of variability for agricultural decisions; decision-making under uncertainty at plot, farm and higher levels <u>Tools:</u> Decision analysis at the crop enterprise level: Enterprise budgeting, Suitable optimization methods, Risk efficiency analysis. Topics: Decision analysis at the farm/household level Tools: Linear programming, Non-linear extension and expected utility. <i>Continued...</i>	Ms. Conrad
16:00	16:20	Tea Break	
16:20	18:30	Mapping agricultural Dynamism (<i>continued</i>) Discussion	Dr. Someshwar
29th April 2009			
9:00	10:30	Assessing Institutions & Policies: <i>Drs. Someshwar, Conrad</i> <u>Topics:</u> role of institutions in risk management; assessing roles of relevant policies and stakeholders Discussion	Dr. Sheshagiri
10:30	10:50	Tea Break	
10:50	13:00	Group Work by ALL Participants on Climate risk & Dynamism in Demonstration sites Discussion	
13:00	14:00	Lunch	

15:30	16:00	Tea Break	Dr. Rathore
16:00	19:00	<p>CRM Tools and Approaches <i>PIs present select tools of use</i></p> <p>Discussion</p> <p><i>Drs. Amor & Sheshagiri</i></p> <p>Topics: Understanding and predicting crop response to weather/climate; and forecasting systems:</p> <p>Tools: Water requirements satisfaction, Crop simulation models, Linking crop models with seasonal forecasts through statistical methods; Linking crop models with seasonal forecasts through stochastic weather models</p>	
30th April 2009			
9:00	11:00	<p>CRM Tools and Approaches (continued)</p> <p>Discussion</p>	Dr. Someshwar
11:00	11:20	Tea Break	
11:20	11:40	Remarks by Dr. A. Tyagi, DG-IMD	ANGRAU Official
11:40	13:00	<p>CRM Tools and Approaches – Continued <i>Drs. Amor & Sheshagiri</i></p> <p>Discussion</p>	Dr. Rathore
13:00	14:00	Lunch	
14:00	15:00	<p>Way forward & Work Plan development: <i>Dr. Rathore</i></p> <p>Discussion</p>	Ms. Conrad
15:00	15:30	Wrap up	ANGRAU Official