1) Project Title

Management responses to seasonal climate forecasts in cropping systems of South Asia's semi-arid tropics

2) Amount Requested: $85,000 US for one year

3) Detailed Proposal

Background

The demand for secure and sustainable food production in developing countries continues to increase. The challenge is particularly great in rainfed production systems in the semi-arid tropics (SAT) of India and Africa, where Green Revolution technologies have had relatively little impact. Much of the challenge relates to the inability of farmers or policy makers to anticipate and make proactive adjustments to climate variability. Experiences in Australia, the USA and South America have shown that the emerging capacity to forecast future rainfall and temperature distributions can substantially contribute to increased agricultural productivity and farmer livelihood, underpinned by more appropriate natural resource management.

> **Throughout this proposal we will refer to actions that will take place within the one-year funding requested from APN as 'project'**. The proposed follow-on activities, which aim to develop a blueprint for true 'end-to-end' delivery will be referred to as '**program'**.

APN support is sought to initiate a multidisciplinary program that can eventually be used to deliver an internationally-recognised framework for effective delivery of seasonal climate forecasts in rainfed systems of the SAT. The APN component of this program is designed as a scoping study and constitutes a stepping stone towards a well-integrated research and delivery program that will address more comprehensively those aspects of climate risk that currently impede agricultural production in developing countries.

Using locations in southern Asia as case studies, this project aims to demonstrate the utility and feasibility of combining seasonal climate forecasting with a structured, agricultural systems research approach.. Although we recognise the site-specific nature of agriculture, elements of the systems framework that has proven successful in rainfed cropping systems in northeastern Australia and elsewhere, are quite general, and can be adapted to local circumstances. We intend to extend the effort to sites in Southern India and Pakistan in order to ensure that the overall systems approach is regionally applicable. We also recognise that cultural or institutional impediments might further limit the effectiveness of this approach. Hence, the human dimension will form a key element in this and subsequent proposals. The Indian collaborators (Drs. Sulochana Gadgil and Selvaraju) have identified the Tamil Nadu and Bangalore sites where climate variability significantly impacts agricultural production. Likewise, the Pakistan collaborator (Dr. A. Rehman Khan) will identify sites in Pakistan where comparable activity can be initiated. The project will provide the means to assess the potential value of seasonal climate forecasting to agricultural producers in the Asia-Pacific region.

Aims

The project will demonstrate the value of seasonal climate forecasts (scf) for agricultural decision making in the developing world with the help of well-focused case studies. Two key target audiences need to be considered in terms of project delivery:

(a) the international scientific community in agriculture and climate science (including their affiliated national and international government organisations), and
(b) participants in the case studies, which are often, but not exclusively farmers.

The former need to be convinced of the value of the approach, while the latter must ultimately reap the benefits. The overall aims of a comprehensive demonstration program are to:

- Quantify and communicate the value of agricultural management responses to climate and seasonal forecast information in two regions of southern India (Tamil Nadu and Bangalore) and sites to be determined in Pakistan

- Develop appropriate methods to connect dynamic climate models and seasonal climate forecasts with agricultural systems analysis and decision making at the farm or policy level
- Develop well-focused , regional partnerships across national boundaries

While these longer-term objectives will require additional funding from other sources, APN could facilitate the initial establishment of such a program. Although the outcomes of the project proposed here are an essential stepping stone towards the more comprehensive program, they are not contingent on the successful establishment of such a program. This scoping study will make a valuable contribution to APN's objectives in their own right. Specific objectives of the proposed research are to:

1. Document the current skill of predictability of relevant climate variables as a basis for understanding biological cropping system response to predictable components of climate.
2. Demonstrate via systems analysis how this predictability could alter management decisions to improve crop yields, stabilise livelihood, and enhanced sustainability of resources.
3. Identify other partners throughout the Asia-Pacific region and gain support for this initiative. The partners will include scientific institutions and existing farmer networks, and provide the scientific linkages necessary to ensure a successful end-to-end delivery program across national boundaries. This process, to be conducted in close consultation with APN and START, will identify other potential regional sites and researchers where CLIMAG-related activities could be fostered in future years.
4. Design and gain additional funding for the comprehensive program.

These objectives fulfil the requirements and follow the guidelines for a CLIMAG demonstration project (Manton et al., 1999; Selvaraju et al., 1999; see also Appendix 4). To achieve these objectives it would be helpful if, in addition to the APN support requested here, a START fellowship could be obtained for the senior Indian scientist to participate for one year in an Australian partner project. ('Using Seasonal Climate Forecasts For More Effective Grain-Cotton Production Systems'). This would allow on-the-ground staff training in systems analytical approaches that have already been operationalised at APSRU.

The project will deliver a better understanding and appreciation by the various stakeholders of the value of seasonal climate forecasting (scf) for agricultural management and will therefore considerably strengthen the international capacity to deliver scf effectively. To do this requires clear identification of key decision points within this farming system in terms of their (a) technical possibility and (b) socio-economic feasibility. This iterative scientist-farmer interaction will be initiated as part of this project.

Methods

This project involves analysis of climate predictability, training/capacity building, systems simulation analysis, evaluation and feedback from stakeholders and networking/planning for future program activities.

The SOI phases system has already shown considerable skill for rainfall forecasts in this region (Appendix 4). While this will be the starting point for the systems analysis, other means of deriving analogue year sets (e.g. via SST systems or statistical downscaling) need to be investigated. IRI's guidance and expertise in this field will play a critical role in shaping the climatic research component of the project.

Biophysical systems analysis via simulation modelling is the only feasible way to objectively evaluate alternative management options and their interaction with climate variability. Field experimentation is needed to develop such a simulation environment in the first instance, and, once developed, to add credence by demonstrating its capabilities of reproducing experimental results. However, the time scale at which climate variability impacts on agricultural production (i.e. seasons to decades) prohibits a field experimental approach for hypothesis testing in relation to scf. Only a well-tested simulation approach can overcome this constraint. Although the proposed project can draw on the considerable experience and tools developed within ICASA generally and through APSRU specifically (see section 5 on 'collaboration'), some local testing and modification will be necessary. Although this has been done before in other projects, for example in India and Africa, it is a non-trivial task that requires adequate resources. Ultimately, the biophysical simulation needs to link closely with whole-farm economic analyses on one hand and social science research activities regarding farmer decision making on the other. This project will outline these needs in detail and suggest a development pathway by which this can be achieved.

Program and project concepts are outlined in Fig. 1, indicating scope and linkages between disciplines and identifying strengths and weaknesses of the current capabilities. For the proposed start-up phase (highlighted area in Fig. 1) to be successful requires

- an initial, two week project team meeting at TNAU (Meinke, Hansen, Selvaraju, Gadgil, Hammer, and others as identified at the inaugural planning meeting hosted by IRI in conjunction with their International Forum in April 2000) to conduct or initiate the following tasks:
    - familiarise project team with TNAU and IIS facilities and staff
    - analyse predictability of rainfall associated with ENSO phases
    - conduct farm surveys to obtain background data for systems analysis and to gain stakeholder support for activities
    - gather necessary agronomic information for systems analysis
    - identify range of possible management options
    - document necessary stakeholder linkages and possible contributions from various individuals and institutions.

  (*Due to political constraints we do not anticipate that Dr. Khan will be able to travel to TNAU. He will be fully consulted through electronic communication.)*
- follow-up visit by Hansen, Selvaraju and Gadgil to Toowoomba (2 weeks) to
    - train staff in cropping systems simulation and analyses
    - complete data analyses of climate predictability and crop impacts and
    - plan and initiate project systems analyses. This will also include evaluation of some of the technically possible management options in terms of systems performance (yield/profit/risk/sustainability). The opportunity exists for one or two scientists from other countries in the region to participate in this training program. Additional funds required for these regional participants would be at least $10,000 (travel and subsistence). This modest cost is reflected in the overall total cost of this proposal.
- based on the data collected and tasks initiated at the Toowoomba meeting, conduct simulation studies that will highlight the leverage points in terms of systems management.
- at an appropriate venue, present results to stakeholders (including farmers), obtain their feedback, and jointly formulate plans for their participation in a follow-on program
- specify actions required to deliver overall program outcomes and gain support from a range of international research fund providers for this program.

Tangible outcomes from this project will be:

- a well documented proposal to possible funding providers for a 4-year program to develop a blueprint for true end-to-end application of seasonal climate forecasting in agricultural systems in the SAT
- an agronomic and climatological systems analysis of cropping systems in Southern India including clear recommendations on where additional research efforts are needed according to the general framework presented in Fig. 1. This will include quantification of strategic management opportunities in these cropping systems and testing of existing analytical models.

To achieve outcomes, two research associates will be appointed in India to (a) conduct the necessary farm survey work and analyse results and (b) to provide technical and computing assistance for systems analysis. A further 50% of a technical officer is required for simulation support in Toowoomba. In addition to these APN funded position, collaboration organisations will contribute staff time to the project (see spreadsheet on budget details, Appendix 4).

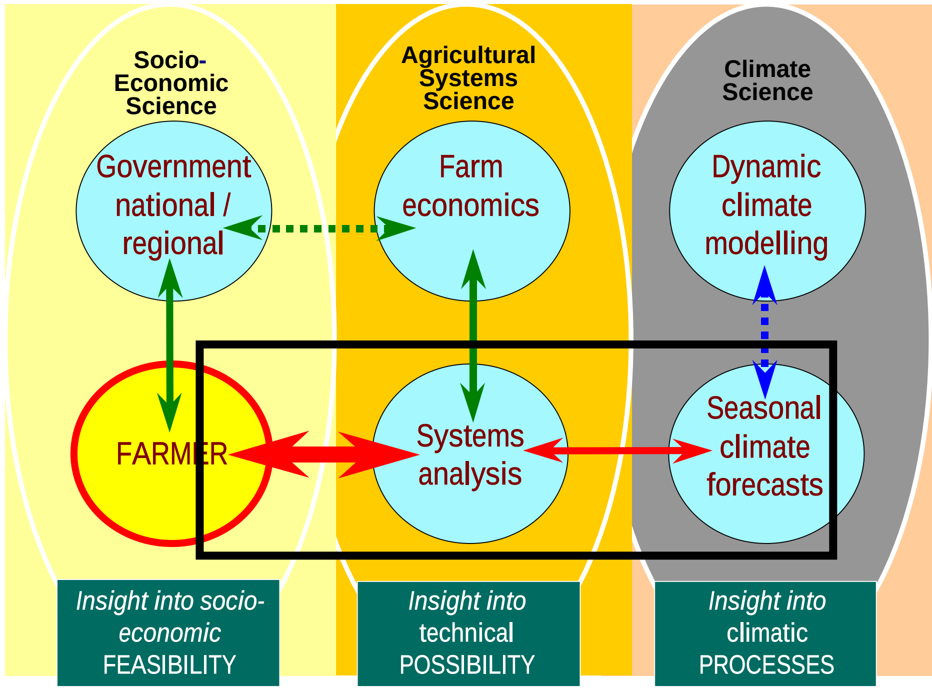

Figure 1: Program concept – disciplines, relationships and linkages for end-to-end delivery. Issues within the marked box are the components for which funds are requested from APN. It is anticipated that full program activities can commence by mid 2001, once funds have been secured. Operational links are indicated by the solid arrows in Fig. 1. Dashed arrows indicate areas where an operational connection does not yet exist and where the larger program needs to develop components for true end-to-end applications.

4) Relationship to priority topics in the APN Research Framework

The primary priority topic that this proposal addresses is Climate System Change and Variability, as it relates to both the El Nino-Southern Oscillation and the Asian Monsoon. Because it deals with agricultural management responses to predictable components of climate variability, it also relates to Terrestrial Ecosystem Change and Impacts: Forests, Grasslands, and Agricultural Land.

5) Regional Collaboration

The project brings together scientists belonging to a range of national and international research organisations and universities. Its interdisciplinary approach will foster 'systems thinking beyond disciplinary boundaries' – an essential skill for anyone involved in applied scf. This clearly addresses the capacity-building objective of the APN. Although largely based in Southern India and Pakistan, the project will help to establish well-focused regional partnerships within the Asia-Pacific region. This will be achieved through existing synergies with partner projects such as a current ACIAR project which will provide links to other countries in SE Asia (e.g. Indonesia). New partnerships will be developed with other researchers in the APN region through training institutes such as currently proposed by Dr. Eileen Shea. Drs Meinke and Gadgil are proposed as co-leaders of the third week of this Training Institute which will be devoted to CLIMAG methodologies regarding the use of scf's, crop models, and methods to integrate the local farming community in the information and decision support system. Participants to the workshop will be selected by open competitive process throughout the Asia-Pacific region; selection criteria include broad regional participation. These participants will then be candidates for pilot or second stage CLIMAG projects in the Asia-Pacific region. It is anticipated that additional funds will be sought over time via, for instance, the START fellowships program and ACIAR.

For climate research, the project brings together organisations such as IRI, CLIPS, BoM Australia and the Indian Met Service. The IR serves as a link to climate models and the climate prediction community, and actively seeks to advance applications of climate prediction to agriculture. The IRI has endorsed this project, and funded a coordination meeting in November 1999.

Within the agricultural disciplines, the ICASA initiative draws together the worlds major groups involved in agricultural systems analysis and modelling. ICASA's board includes Wageningen Agricultural University (WAU) and partners, many American scientists such as Dr Jim Jones at the University of Florida and Dr Cynthia Rosenzweig at GISS (NASA), and APSRU in Australia representing one federal (CSIRO) and two State Government Research Organisations (DPI and DNR). ICASA will provide additional links to some of the existing systems analysis capacity in India. ICASA has also endorsed this proposal in principle. APSRU will also provide valuable linkages to world-leading climate research conducted by the Queensland Centre for Climate Applications (QCCA) by involving scientists such as Dr Graeme Hammer (QCCA/APSRU) and Dr Roger Stone (QCCA) as consultants to the project.

APSRU will bring its considerable expertise based on many years of project activities at ICRISAT (India) to the project, including an active network of Australian and Indian scientists. It will further provide a link to an extension research/delivery-focused project funded by ACIAR. This project is led by Dr S. Huda from the University of Western Sydney and also connected to QCCA via Dr Jeff Clewett, Program Leader, QCCA. Dr Selvaraju is already participating in this project, which aims to work closely with farmer groups in southern India to discuss possible uses of scf. This ACIAR project has also links to other parts of SE Asia (e.g. Indonesia). It will provide a convenient communication and delivery mechanism for the project proposed here.

6) Capacity Building

Participation in planning, conducting and reporting collaborative project research will enhance technical capacity among project scientist. Training activities in Toowoomba and funding for an Indian post-doctoral associate located at TNAU are designed explicitly to improve technical expertise and competence. Considerable capacity building will be achieved through targeted training workshops, learning and networking resulting from collaborative project activities and through post-doctoral associate, possibly further enhanced by a START fellowship.

7) Links to Policy

Because of its limited scope, the current project has no direct policy implications. However, this is intended to be the initial phase of a more comprehensive project that will have implications for how the Indian Meteorological Service, Universities, extension organsisations and farmer networks function together. The project will provide useful feedback for efforts to develop and disseminate seasonal climate forecasts tailored to the agricultural sector in India.

8) Relationship to Global Change Research Programs

Although the proposed research focuses on climate variability and its predictability at a seasonal time scale, two general issues link it directly to global change. First, population growth and resource degradation (including urbanisation of agricultural land) are expected to increase society's vulnerability to episodic food shortages associated with climate fluctuations in the coming decades. This is particularly true for populations that depend on rainfed production, especially in the SAT. India's rainfed agricultural area is important to global food security by virtue of its size. Second, preparation for the uncertainties associated with global climate change requires an analytical framework and institutional mechanisms for anticipating and adapting to climatic fluctuations. Some studies suggest that climate change will increase interannual climate variability in many regions. As a CLIMAG demonstration project, the proposed research contributes directly to the global research programs – START, IGBP, IHDP, WCRP – that sponsor CLIMAG.

9) Related Research Work

Several major research efforts in other regions (e.g., Australia, Argentina, Uruguay, USA, South Africa) are devoted to using a similar systems analytical framework for applying seasonal climate prediction to management of crop production systems. APSRU is ideally placed to capitalise on these efforts through their existing project links with these countries as well as their considerable expertise in cropping systems analysis and climate applications. The proposed research will cooperate with, and build upon, ongoing efforts by Sulochana Gadgil (IIS) to apply scf to management of groundnut production in Andhra Pradesh. The project and its planned expansion in subsequent years is one of a global network of CLIMAG demonstration projects under development. CLIMAG provides a mechanism for coordinating regional scf application projects, and for sharing approaches, tools and lessons learned. The project will provide a context for the IRI to address methodological research issues, including climate information format and delivery, and the linkage between climate model outputs and crop model requirements.

10) Appendix 1. Major Collaborators and linkages

PI's:
Holger Meinke, APSRU, Australia (project coordination)
James Hansen, IRI, USA
Ramasamy Selvaraju, Tamil Nadu Agricultural University, India
Sulochana Gadgil, Indian Institute of Science, India
Dr. A. Rahman Khan, Pakistan Agricultural Research Council, Pakistan

The project coordinator and all sub-project leaders are very experienced scientists with active project involvement in many other countries. This expertise will be invaluable to the project proposed here.

Dr Meinke will provide connection to APSRU/ICASA to facilitate access and technical support in relation to simulation capacity of APSIM and decision analysis procedures. He will further provide important links to QCCA via his supervisor, Dr Graeme Hammer, Program Leader, QCCA/APSRU. Dr Hanson as the IRI representative of the project will provide guidance and support for the development of improved climate forecasting approaches. Dr Selvaraju at Tamil Nadu Agricultural University (TNAU) and Dr Gadgil at the Indian Institute of Science (IIS) will provide the local agricultural modelling expertise. Dr Krishna Kumar at Pune could be connected to the project to provide climate forecasting input relevant to India. Dr. A. Rehman Khan will provide technical expertise on agricultural practices in Pakistan so that as the program develops it incorporates the perspectives of other developing countries in the region. This will greatly assist the utility of the CLIMAG approach over time.

Dr Selvaraju of Tamil Nadu University has considerable background in agricultural modelling and systems analysis. By connecting his expertise with that at the IRI (climate forecasting), WMO (CLIPS, climate information and prediction) and ICASA (agricultural modelling and decision analysis; climate forecasting) it is possible to develop a sound approach to applications in southern India that could eventually be modified and applied to other regions in Asia and, in fact, anywhere where the Manton et al. (1999) requirements are met. While the IRI and WMO will connect and coordinate many of the climate related activities, ICASA via its partners will provide a similar, global network for agricultural systems analysis.

Dr Gadgil has many years of experience across disciplines. This provides a cost effective and robust way to test the approaches developed. She has already established a farmer network that can be accessed by the research team as soon as project activities commence. Her groundbreaking work will be supplemented and value added through some of the already existing project activities. APSRU and QCCA have already formal links to TNAU via two ACIAR projects. A scientist, Mr Madhiyazhagn, is already using APSRU's systems model APSIM linked to on-farm trials. His objective is to see how simulations can be used for discussions with farmers to gain mutual advances. A further ACIAR funded project coordinated by Dr Samsul Huda (University of Western Sydney, UWS) already addresses some of the extension and communication component and should be linked closely with the activities proposed here. Dr. A. Rahman Khan is a noted agronomist in Pakistan with extensive modelling experience in the region.

Strong synergies exist with other APN initiatives, such as the training institute proposed by Dr. Eileen Shea (Training Institute on climate variability and society in the Asia-Pacific region). Drs Meinke and Gadgil are proposed as co-leaders of the third week of this Training Institute which will be devoted to CLIMAG issues in the Asia-Pacific region. This collaboration will draw suitable participants at the training institute into CLIMAG demonstration projects and further assist in identifying future partners.

11) Appendix 2. Curriculum Vitae

Curriculum Vitae – Holger Meinke

Contact Details

Dr Holger Meinke, Agricultural Production Systems Research Unit (APSRU), Department of Primary Industries, PO Box 102, Toowoomba Qld 4105, AUSTRALIA
Tel: +61 – (0)7 4688 1378 (work)
+61 – (0)7 4639 1107 (a/h)
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Fax: +61 – (0)7 4688 1193
Email: meinkeh@dpi.qld.gov.au

Personal Details

Date and Place of Birth	12 April 1957, Heidelberg, Germany
Nationality:	Australian
Languages:	English, German, Latin, basic knowledge of French

Recent Employment History

January 1988 to present

Queensland Department of Primary Industries, Toowoomba, Australia, Agricultural Productions Systems Research Unit (APSRU); **Senior Research Scientist**

APSRU is a joint research unit between the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Queensland Department of Natural Resources (DNR) and the Queensland Department of Primary Industries (DPI). APSRU conducts agricultural systems research to improve production systems and their management, focusing on sustainability and profitability. APSRU is a multidisciplinary unit with over 50 professionals ranging from crop and soil scientists to climatologists, computer scientists, software engineers, software developers and general support staff. Currently, I am one of five members of the APSRU management committee (AMC) and thus responsible for the strategic directions and performance evaluation of the group. I am representing the interests of DPI on the committee. The AMC decides resource allocation, sets research priorities and is responsible for general staff management. As a senior scientist of APSRU, I am also responsible for the conduct and progress of a range of major research projects funded by various R&D agencies (details available on request). The emphasis of my research is on the development and delivery of agricultural systems analysis, applied seasonal climate forecasting and climate variability assessments. This involves the development and application of appropriate dynamic simulation models and climatic databases. I have published over 50 papers on these issues, 20 of those in international, scientific journals (see attached selection). In addition, I regularly publish articles in the rural press and producer-oriented magazines. Much of my work involves working directly with clients (producers, agribusiness, policy makers and other scientists). Frequently, I present seminars at grower meetings, industry and scientific conferences and give invited lectures (eg. Queensland University; Wageningen Agricultural University, The Netherlands; University of Buenos Aires, Argentina; University of Sao Paulo, Brazil; UN-WMO meetings in Ecuador, Switzerland and Japan; Chinese Academy of Meteorological Sciences, Beijing; European Society of Agronomy, Spain).

University Education:

PhD in Agriculture and Environmental Science, January 1993 to June 1996
Wageningen Agricultural University, The Netherlands, Department of Theoretical Production Ecology (TPE), *Supervisors*: Prof. R. Rabbinge, Prof. H. van Keulen and Dr G.L. Hammer; *Thesis*: Improving wheat simulation capabilities in Australia from a cropping systems perspective (ISBN 90-5485-511-8, copy available on request).

M.Sc.Agr. in International Agricultural Development, October 1983 to February 1986
Technical University Berlin, Germany, Faculty of International Agricultural Development; *Thesis*: Influence of air temperature and soil temperature on grafted and self-rooted *Passiflora* hybrids (1st class honours).

B.Sc.Agr. in General Agriculture, October 1980 to September 1983
University of Hohenheim, Germany, Department of General Agriculture

Professional Memberships

Australian Institute of Agricultural Science and Technology, CPAg; European Society for Agronomy (ESA); Editorial Board, European Journal of Agronomy (EJA)

Selected Publications

Carberry, P., Hammer, G.L., Meinke, H. and Bange, M., 2000. The potential value of seasonal climate forecasting in managing cropping systems. In: G.L. Hammer, N. Nicholls, and C. Mitchell (eds.), Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems – The Australian Experience. Kluwer Academic, The Netherlands, in press.

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Wang, E., Ryley M.J., and Meinke H., 2000. Frequency of potential events of sorghum Downy Mildew in Australia. Plant Pathology, in press.

Reyenga, R.J., Howden, S.M., Meinke, H., McKeon, G.M., 1999. Modelling global change impacts on wheat cropping in south-east Queensland, Australia. Environmental Software, 14: 297-306.

Keating, B.A. and Meinke, H. 1998. Assessing exceptional drought with a cropping systems simulator: a case study for grain production in north-east Australia. Agricultural Systems, 57: 315-332.

Meinke, H., Hammer, G.L., van Keulen, H. and Rabbinge, R., 1998. Improving wheat simulation capabilities in Australia from a cropping systems perspective. III. The integrated wheat model (I_WHEAT). Europ. J. Agron., 8: 101-116.

Meinke, H. and Stone, R.C., 1997. On tactical crop management using seasonal climate forecasts and simulation modelling - a case study for wheat. Scientia Agricola, 54: 121-129.

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Meinke, H., Stone, R.C. and Hammer, G.L. 1996. Using SOI phases to forecast climatic risk to peanut production: a case study for northern Australia. International J. of Climatology, 16: 783-789.

Meinke, H. and Hammer, G.L. 1995. A peanut simulation model. II. Assessing regional production potential. Agronomy J., 87:1093-1099.

Meinke, H. and Hammer, G.L. 1995. Climatic risk to peanut production: a simulation study for northern Australia. Aust. J. Exp. Agric., 35: 777-780.

Meinke, H., Carberry, P.S., McCaskill, M.R., Hills, M. and I. McLeod 1995. Evaluation of radiation and temperature data generators in the Australian tropics and sub-tropics using crop simulation models. Agricultural and Forest Meteorology, 72: 295-316.

Meinke, H. 1994. Peanuts - potential to grow? Rural Research 163: 18.

Meinke, H., Hammer, G.L. and Chapman, S.C. 1993. A crop simulation model for sunflower. II. Simulation analysis of production risk in a variable sub-tropical environment. Agronomy J., 85: 735-742.

Meinke, H., Hammer, G.L. and Want, P. 1993. Potential soil water extraction by sunflower on a range of soils. Field Crops Res., 32: 59-81.

Curriculum Vitae - James W. Hansen

Associate Research Scientist
International Research Institute for Climate Prediction
LDEO - Columbia University
P.O. Box 1000
Palisades, NY 10964-8000

Education

Ph.D. in Agricultural and Biological Engineering, University of Florida, 1996
M.S. in Agronomy and Soil Science, University of Hawaii, Manoa, 1989
B.S. in General Tropical Agriculture, University of Hawaii, Manoa, 1985

Professional Experience

1999 - present	Associate Research Scientist, International Research Institute for Climate Prediction
1999	Assistant Scientist, Agricultural and Biological Engineering Department, University of Florida.
1996-1998	Visiting Assistant, Agricultural and Biological Engineering Department, University of Florida.
1990-91 & 1988-89	Research Associate, Department of Agronomy and Soil Science, University of Hawaii.
1989-1990	Agriculturalist, Mindanao Baptist Rural Life Center, Philippine Baptist Mission, Davao del Sur, Philippines.

Research Interests

Agricultural applications of seasonal climate prediction. Agricultural systems analysis and modeling, and their applications to optimal use of climate forecast information, farm household risk and sustainability analysis, and land use evaluation. Weather data management. Stochastic weather generation.

Selected Refereed Publications (20 total)

Hammer, G., J.W. Hansen,, J. Phillips, J.W., Mjelde, H.S.J. Hill, and A. Potgieter. Advances in application of climate prediction in agriculture. Paper presented at Systems Approaches for Sustainable Agricultural Development: Methodologies for Interdisciplinary, Multiscale Perspectives, Lima, Peru, 8-10 November 1999. (To be published in a refereed workshop proceeding).

Jones, J.W., J.W. Hansen, F.S. Royce, and C.D. Messina. Potential benefits of climate forecasting to agriculture. Submitted to Agriculture, Ecosystems and Environment.

Messina, C.D., J.W. Hansen, and A.J. Hall. 1999. Land allocation conditioned on ENSO phases in the Pampas of Argentina. Agricultural Systems 60:197-212.

Hansen, J.W., J.W. Jones, C.F. Kiker, and A.H. Hodges. 1999. El Niño-Southern Oscillation impacts on winter vegetable production in Florida. Journal of Climate 12:92-102.

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Professional Societies
American Society of Agronomy; American Society of Agricultural Engineers; International Consortium for Agricultural Systems Applications

Curriculum Vitae - SULOCHANA GADGIL

Date and place of birth 7 June 1944, Pune, India

Education

MSc Poona University Applied Mathematics 1965
PhD Harvard University Applied Mathematics 1970

Positions held

1970-71	Research Fellow, MIT, Cambridge, Mass., USA
1971-73	CSIR Pool Officer, Indian Institute of Tropical Meteorology, Pune
1973-81	Assistant Professor, Indian Institute of Science
1981-86	Associate Professor, Indian Institute of Science
1986-	Professor, Indian Institute of Science
1989-96	Chairman, Centre for Atmospheric Sciences, IISc

Membership of Professional bodies

Fellow, Indian Academy of Sciences
Fellow, Indian National Science Academy
Member and officer, Joint Scientific Committee of World Climate Research Program 1990-97
Member of the bureau of the Standing Committee of the Global Change
Programme for Systems Analysis, Training and Research (START) 1994-97
Member, Council for Meteorology and Atmospheric Sciences
Member, Advisory Committee on Space Sciences
Member, Advisory Committee of National Centre for Medium Range Weather Forecasting
Member, Governing Council of the Indian Institute of Tropical Meteorology
Member, Research Advisory Committee, Centre Research Institute for Dryland Agriculture (CRIDA)

Selected Publications

Krishnamurti T N, Sulochana Gadgil 1985 On the structure of the 30 to 50 day mode over the globe during FGGE. Tellus 37A:336-360.

Gadgil Sulochana, Malati Hegde, R Gowri 1986 Agricultural zones of Karnataka. In: Karnataka State of Environment report. 85-86.

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Contributions of Sulochana Gadgil

Sulochana Gadgil is a distinguished meteologist who has made important contributions to the understanding of monsoon dynamics, tropical convection and coupling of the tropical atmosphere to the oceans. She discovered a new feature of the variation of the monsoon cloud band during the summer viz. northward propagation of the band at intervals of 30-50 days in an analysis of daily satellite imagery. This 30-50 day mode plays an important role in the active-break cycle of the monsoon. The mechanism underlying this subseasonal variation has been unravelled by development and analysis of a simple climate model. There has been considerable debate about whether the monsoon is merely a planetary scale version of land-sea breeze or a manifestation of the seasonal migration of the tropical convergence zone which girdles the earth in the equatorial region. Her studies of the subseasonal variation of the monsoon using satellite imagery provided clear evidence in support of the latter hypothesis. Her studies of the variation of satellite-derived cloudiness intensity with sea surface temperature (SST) over the north Indian Ocean elucidated the nature of dependence of tropical convection on SST for the first time, and showed the presence of a threshold SST of about 28 deg C. A large number of studies over the past ten years using different indices of tropical convection have shown that the same relationship holds for all the tropical oceans. In a recent study a theoretical framework has been proposed for understanding this nonlinear relationship between tropical convection and SST. She has also done an in-depth analysis of the space-time variation of rainfall over the Indian region to address problems of importance to applications-particularly agriculture. It is necessary to determine regions which are homogeneous with respect to climatic patterns for using the agricultural strategies derived at specific stations. Sulochana Gadgil determined such climatic clusters for the Indian region which are not only homogeneous with respect to the total rainfall in a year but its distribution within the year as well. For analysis of the variability of the monsoon rainfall, she has delineated the coherent rainfall zones of the Indian region with an algorithm specifically developed for the purpose. She has recently demonstrated that the northward propagating rainbelts imply predictability of weekly rainfall, one or two weeks ahead over the peninsula. She has also embarked on interdisciplinary studies aimed at identifying the climate component of agricultural productivity. She has developed a theoretical framework for using information on climate variability and meteorological forecasts (if applicable) to decide between alternative management strategies so as to maximize the long-term average returns and illustrated its application for the case of groundnut farming in semi-arid parts of Karnataka. This is important for deriving the optimum cropping and management strategies for different agroclimatic zones as well as for development of realistic models for the impact of climate variability/change on this critical resource. Along with leading scientists from Indian Agricultural Research Institute and Indian Institute of Tropical Meteorology she organized the first south Asian workshop on climate variability and agriculture in February 1995. She has analysed the performance of atmospheric models over the Indian monsoon zone and the available studies of climate impact on agriculture to suggest the priorities for research and development in this critical area from an Indian perspective. A program of addressing this challenging area by interdisciplinary groups is now being launched.

Curriculum Vitae - R. Selvaraju

I. Personal details

Name	**R.Selvaraju**
Address for correspondence	Department of Agricultural Meteorology Tamil Nadu Agricultural University Coimbatore – 641 003 Tamil Nadu, INDIA Phone : 91-422-431222 : 91-422-431672 E-mail : selvaraju_r@hotmail.com
Date of birth	05.02.1967 (5th February 1967) Age : 32 years
Sex	Male
Citizenship	INDIAN
Present occupation	Assistant Professor
Employer	Registrar Tamil Nadu Agricultural University Coimbatore – 641 003 Tamil Nadu, INDIA

II. Academic qualifications

1. Academic Degree

Sep 1984 - June 1988	Tamil Nadu Agricultural Uni.	Agriculture	B.Sc.(Ag.)	1988
Sep 1988 - June 1990	Tamil Nadu Agricultural Uni.	Agronomy	M.Sc(Ag.)	1990
April 1991 - June 1994	Tamil Nadu Agricultural Uni.	Agronomy	Ph.D.	1994

2. Academic awards

- Jawaharlal Nehru Award for out standing Agricultural Research in Soil Science and Agronomy (Indian Council of Agricultural Research National Award 1995) (Citation, Certificate, Gold medal and Cash prize)
- Foreign examiners donation prize and award for the best Ph.D student in Agronomy (1995 Tamil Nadu Agricultural University, Coimbatore)

3. Fellowships

- Award of Senior Research Fellowship from Council of Scientific and Industrial Research (CSIR), Government of India
- Merit scholarship from Tamil Nadu Agricultural University for Ph.D

4. Distinctions

Selected in national eligibility test (NET) conducted by ICAR for lectureship and Assistant Professorship

III. Professional Experience

1. Employment details

Dates of employment	***Position***	***Employer***
July 1994 to Feb. 1995	Scientist, Agricultural Research Service, ICAR	President, ICAR
Feb. 1995 to Till date	Assistant Professor and Registrar	Tamil Nadu Agr. University

2. Teaching

Programme	***Courses Offered***
Principles of Crop Production	Irrigation Management;
Agricultural Meteorology	Agronomy of pulses, green manures and forages

Post Graduate		Dry Farming; Advances in Crop Weather Modelling

3. Research area and period

Water & Nutrient management in maize (M.Sc.(Ag.))		1988-1990
Crop Modelling and Tillage in intercropping systems (Ph.D.)	1991-1994
Climate forecast, modelling and agricultural management	1995 onwards

4. Training attended

1. Foundation course on Agricultural Research Management - 6 months
2. Advances in weather forecasting and dryland management – 20 days
3. Training on Hybrid rice production technology – one week
4. Crop modelling – one month
4. Seasonal climate forecasting and garicultural Management – three weeks

5. Publications specific to systems analysis

Selvaraju,R., and C.Ramaswami. 1997. Evaluation of fallow management practices in a rainfed vertisol of peninsular India. Soil Tillage Research. 43: 319-333

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Ramaswami, C., and R.Selvaraju. 1995. Simple crop water and mechanistic simulation models for cowpea under moisture limited environments. Second International symposium on systems approaches for Agricultural Development (SAAD2) 6-8 Dec.(1995) held at IRRI, Philippines. 140p.

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Selvaraju,R. 2000. Development and application of dynamic tillage model (TILLSIM) to evaluate fallow management practices in dryland vertisols. ISTRO-2000, Blackland Road, Temple TX, USA.

Selvaraju, R. 1998. Modelling growth and yield of cowpea (Vigna unguiculata (L) Walp) to assess interannual yield variability in a semi-arid environment. (Journal of Agronomy and Crop Science).

Selvaraju, R. 1998. An analysis of rice ecosystems in India. In: Trainig on Advances in rice production technology, Tamil Nadu Agricultural University, August 2-28, 1998.

Selvaraju, R.1994. Influence of irrigation and nitrogen on plant water status and thermal response of Maize (Zea mays). Indian J.Agron.39(2) :225-228

Ramaswami, C., and R.Selvaraju. 1993. Estimation of leaf area and specific leaf area of lab lab (Dolichos lablab L.). South Indian Horticulture 41(2):117-118.

Cirriculum Vitae of Dr. A. Rahman Khan

Dr. A. Rahman Khan
Senior Scientific Officer
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Islamabad, PAKISTAN

18 years experience in agronomy and agronomic modelling

12) Appendix 3. Budget overview

In addition to the inaugural team meeting hosted by the IRI in April 2000, the project team will need to meet at least twice and some technical support costs have to be met. Except for the farm survey work, the project will be a computing/desk study that connects to existing delivery and agricultural research projects. Access to APSIM and training in its use will also require support resourcing. One airfare plus living expenses have been earmarked specifically for a visiting scientist of another Asian-Pacific nation to participate in the Toowoomba workshop. This will foster new partnerships and assist in the process of developing similar demonstration projects elsewhere.

Funds are needed to facilitate ‘capacity building’. This is best done within active projects and can be achieved, for instance, by offering visiting scientists to get involved in existing project activities at APSRU.

Table 1: Funds required for project activity

Type	**Item**	**Details**	**US $ (K)**
meetings and workshops	two project meetings (India and Australia)	15,000 (7 int. airfares) 17,000 local travel, per diem and accommodation (at cost), 3,000 report preparation and program submission, 5,000 travel associated with next phase of project	40,000
technical support	• farm survey work • technical analysis • network building • data gathering • APSRU technical assistance, software development and support	20,000 research associates (2) for farm survey and technical analysis 5,000 computers (2) 20,000 APSRU technical assistance, software development and support	45,000

13) Appendix 4. Budget details and spreadsheet

In addition to the $85,000 requested from APN, participating organisations will contribute operating funds for travel plus staff time estimated at US $138,000 and hence the overall APN share of project cost will be 38% (see attached spreadsheet for details). Salaries of staff time contributed by other organisations were multiplied by 2.6 to account for overheads and on-costs.

14) Appendix 5. Chart of milestones and evaluation criteria

The attached spreadsheet contains a detailed list of proposed milestones, their evaluation criteria and delivery date.

15) Appendix 6. Systems analysis for the Tamil Nadu region – background (Meinke et al., 1999)

The following analysis was conducted as part of an IRI/WMO sponsored training workshop held in Toowoomba in February 1999:

Agricultural production in the Indian state of Tamil Nadu experiences problems due to erratic monsoon seasons, crop failures and improper resource management. Average annual rainfall is 640 mm with most rainfall received during two monsoon seasons, namely the south-west monsoon (172 mm; June to September) and north-east monsoon (321 mm; October to December). During the Toowoomba workshop a range of seasonal climate forecasting approaches were considered. For this part of India, the use of SOI phases has shown considerable skill. There is a significant relationship between seasonal rainfall and negative phases of SOI, with a stronger signal during the north-east monsoon (Table 2). In both seasons variability is less in negative SOI phases with chances of getting at least median rainfall considerably higher than in other years.

Table 2: Probability of exceeding the long-term median rainfall during either the south-west monsoon (SWM) or the north-east monsoon (NEM) by the five SOI phases preceding these seasons.

SOI Phase	SWM	NEM
Falling	42	46
Negative	80	75
Neutral	30	58
Rising	35	30
Positive	55	47

Fig. 2 shows the rainfall probabilities of exceedence for the October to December season based on June/July SOI phase, i.e. 2 months prior to the on-set of this season. It shows, for instance, that under consistently negative SOI conditions, chances for exceeding 400mm are about 60%. This is reduced to only 15% when the SOI in June/July is either rapidly rising or positive.

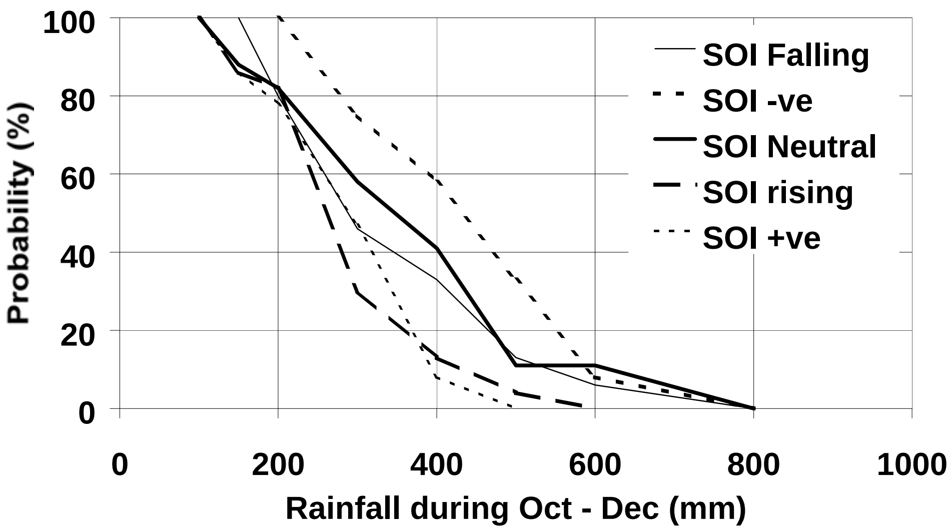

Figure 2: Rainfall probabilities for October to December rainfall based on June/July SOI phases.

However, the important question from a farm management perspective is not "how much rain am I likely to get?" but rather: "How does this rainfall variability impact on crop yields and how can I manage this cropping system better with this type of information?". The issue can be addressed using systems analysis and crop modelling:

The average dryland crop production in this region is about 0.6 t/ha. The key management decisions are selection of crop, dates of sowing, land management, fertiliser rates, intercultural operations and harvesting. Seasonal climate forecast could help to increase production by making better informed management decisions. For instance, preliminary simulation results indicated that if the median August – November rainfall probability is above 400 mm and the soil profile contains at least 50% of stored soil moisture on August 15th, it is advisable to plant cotton. If the condition is not satisfied it would be better to consider planting sorghum between September 15th and Oct 15th, provided the median September-December rainfall probability exceeds 300 mm and stored soil moisture is above 30%. Otherwise millets, sunflower and chickpea could be considered. Using the simulation platform APSIM (McCown et al., 1996), we conducted a simple economic analysis on the simulated results (Fig. 3).

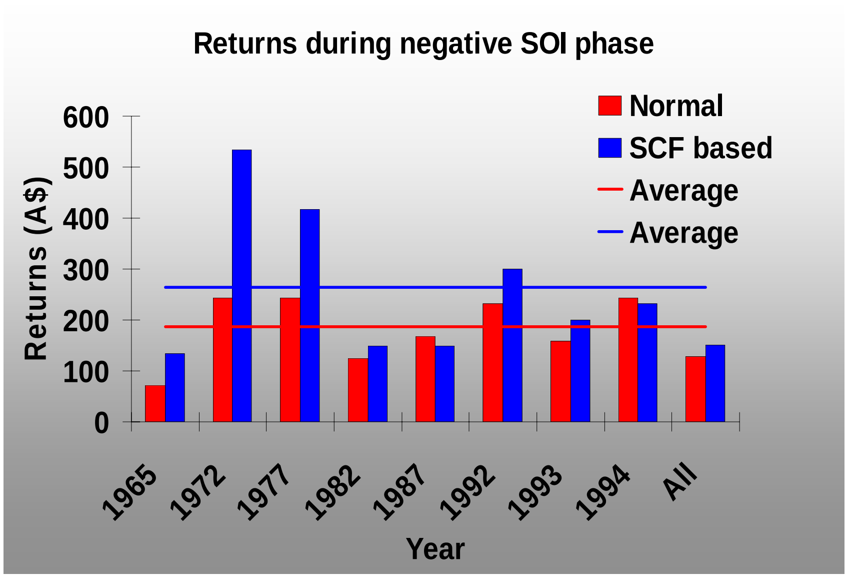

Figure 3: Simulated economic returns of the non-responsive management option versus a responsive management based on seasonal climate forecasts (scf).

The analysis showed that in seven out of nine years when the SOI was negative at the end of July, returns from the scf based system where higher than those for the non-responsive system. In two of the years simulated returns where marginally lower than for the non-responsive management.

This example shows how such a seasonal forecast combined with a sound modelling approach allows objective evaluation of alternative management options and quantification of associated production risks. While there is no doubt that the proposed management strategies are technically possible, the feasibility of these options still needs to be investigated. This requires an analysis of similar rigour to establish if within the existing socio-economic structures and production environment the proposed management adaptations are feasible and acceptable. As with the biophysical/economic systems analysis, entry points need to be identified that are likely to result in largest benefits to producers and policy makers.

16) Appendix 5. References

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