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Agricultural Systems Research for Developing Countries

Proceedings of an international workshop held at Hawkesbury Agricultural College Richmond, N.S.W., Australia 12-15 May 1985

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Foreword

Farming systems research means many things to many people. In this volume some of the heterogeneity of the farming systems approach to research is reviewed and considered. ACIAR sponsored this workshop to help identify those approaches in which Australian scientists might have some comparative advantage that could complement the approaches being taken in developing countries.

The papers presented at the Workshop are an important record of a unique meeting of farming systems researchers from Southeast Asia, Papua New Guinea and Australia. They form a reference volume on FSR approaches in neighbouring countries, areas of systems research concentration in Australia, the relationship between FSR and rapid rural appraisal techniques, and studies of problems and pitfalls in adapting FSR approaches from developed to developing country agriculture. They should, therefore, not only assist ACIAR in its future activities in FSR, but also inform and guide those who are planning or conducting research in this area.

ACIAR would like to thank all the participants in the workshop for their respective contributions, Hawkesbury Agriculture College for providing the venue, the Workshop coordinating committee, Mr Reg MacIntyre, on secondment to ACIAR from IDRC in Canada, for his assistance in bringing the volume to publication so promptly and efficiently, Ms Sylvia Hibberd and Mrs Maureen Kenning for their untiring assistance in preparing for the Workshop, arranging travel and handling all administrative details so efficiently, and the Workshop convenor and volume editor, Dr Joe Remenyi.

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Opportunities for Farming Systems Research Collaboration: Issues and Recommendations

J. V. Remenyi

THE papers in this volume were prepared for an ACIAR-sponsored workshop on farming systems research (FSR). The purposes of the workshop were principally to identify areas of FSR where Australia can be said to have a comparative advantage, and on the basis of this identify a strategy for collaborative research between Australian and developing country researchers. To these ends the workshop brought together leaders in FSR from Australia and overseas.

The Australian participants were selected on the basis of replies to a survey of farming systems researchers in Australia, and were chosen from among respondents so as to ensure a representative spread across institutions and disciplines involved in FSR. Hence, there was a preponderance of agronomists and agricultural economists. It is these two disciplines that dominate the community of farming systems researchers both in Australia and elsewhere.

The overseas participants came largely from Southeast Asia and the Pacific. All are active in FSR, and several are directors of FSR centres or institutes. Certain of the overseas and Australian participants are acknowledged global experts in FSR in both theory and practice. They brought to the workshop a degree of authority and current awareness that kept discussion focused on the cutting edge of FSR. They also added a healthy scepticism that ensured that the workshop did not lose sight of the critical challenge — to specify how Australia's unique skills in FSR can contribute to increasing the productivity and income of small farmers in developing countries.

What is FSR to ACIAR?

One problem that plagues all gatherings to discuss FSR is the variety of meanings that individuals attribute to the process described as FSR. It almost seems that there are as many notions of what FSR is as there are researchers who do on-farm research or apply their skills to farm problems. However, the result of accepting such a wide definition is to rob the concept of any utility and uniqueness. It was essential, therefore, that a clear statement of ACIAR's perception of FSR be presented to the workshop.

FSR is one of twelve program areas that ACIAR's Policy Advisory Council and Board of Management have identified for development. In order to act on this mandate and establish some visible presence as soon as was practicable, steps were taken to mount research projects in this area prior to the workshop. By May 1985 ACIAR had four FSR projects in its portfolio.* These represent the obvious opportunities for an Australian contribution to collaborative research in the farming systems arena. They also provide practical examples of what FSR has

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*These are: Project 8205 'Smallholder Farming Systems in the South Pacific : Constraints to Development'; Project 8326 'Improvement of Dryland Crop and Forage Production in African Semi-arid Tropics'; Project 8330 'A Regional Analysis of the Transfer and Performance of New Technologies in Rice-based Farming Systems in Sri Lanka and the Philippines'; and 8369 'Environmental Constraints to Increased Productivity of Rainfed, Rice-based Farming Systems in Sri Lanka and the Philippines'.

meant to ACIAR as well as a guideline that was to prove valuable in charting a path through the diffuse discussions about the definition of FSR.

Several speakers devoted time to what FSR could or ought to be for ACIAR. Nonetheless, no consensus on a simple definition emerged. This lack of agreement is indicative of the powerful normative quality that besets much that is written by advocates of FSR, plus the unfortunate absence of a well known and decisive track record of FSR results and achievements. Consequently, while participants were unanimous about the value and importance of FSR in the developing country context of smallholder subsistence-oriented agriculture, they were unable to be firm and unequivocal in defining FSR.

It was finally agreed that there are varieties of FSR, not any of which is contrary or exclusive. Nevertheless, the very difficulty encountered in arriving at a consensus is indicative of a fundamental problem — too much may have been claimed for FSR, with the result that donor expectations of what FSR can achieve may be excessively optimistic. Moreover, there is a growing concern among donors that FSR has not provided a 'quick fix,' and that if FSR is not done well, it is not much better than more conventional disciplinary approaches to agricultural research. FSR is neither a short-term fix, nor a panacea for the chronic problems of smallholders in subsistence-oriented agriculture. There is a need for donors to acknowledge these facts, especially by adopting appropriate FSR project and program review and evaluation procedures. Equally, however, the advocates of FSR need to acknowledge the legitimate concern of donors that the Farming Systems approach is encountering problems in acceptance, and that these problems stem in part from the lack of competent people to develop the FSR approach effectively.

There are those who would argue that the systems approach to agricultural research is no more than a technique, but a very useful and effective one, to help ensure that: (i) applied agricultural research begins and ends with the farmer; (ii) explicit notice of the multidisciplinarity and complexity of poverty problems in agriculture is taken; and (iii) adequate feedback mechanisms exist between on-station research and on-farm problem identification and research.

Despite the difficulties encountered in agreeing on an acceptable definition of FSR, there was clear endorsement of what were presented as identifiable characteristics of an ACIAR farming systems research project. These characteristics reflect a combination of constraints imposed by ACIAR's mandate in research, and the general features of FSR methodology. Operationally, it is these characteristics that are crucial in marking out a particular piece of research as belonging in the FSR program rather than in plant improvement, livestock, socioeconomics or some other ACIAR program area.

There are five critical characteristics:

(i) The research relates to smallholder, subsistence-oriented agriculture because it is to farmers in this sector that ACIAR's principal FSR mandate refers;

(ii) The research project is multidisciplinary and holistic in perspective. This means that the goals of the project are not merely expressed in terms of current or future levels of productivity, but also in terms of the stability and sustainability of output, and the equity implications of recommended changes to the farming system. It is not necessarily the case, however, that the goals of the FSR project in question should embrace an 'increase' on all four of these fronts. In some cases the gains in productivity may be consciously 'traded' for some loss of stability in yields. In other cases, any shift away from the status quo in terms of equity may be acceptable so long as the plight of the poor is improved. Mostly, however, ACIAR's bias in favour of smallholder subsistence agriculture implies a flow of benefits from FSR that especially favours farmers at the lower end of the income and wealth scales;

(iii) The research involves the farmers in critical phases of the research project. Typically, therefore, the project begins by involving farmers in the diagnosis of the farming system, and ends by verifying recommended new practices or inputs using farmer-managed on-farm trials;

(iv) The research is applied rather than basic and is aimed at generating viable technologies. It also tends, therefore, to be near-term rather than long-term research;

(v) The research will involve one or all of four basic phases in the FSR process:
   (a) system description, diagnosis and problem specification;
   (b) on-station solution design;
   (c) on-station solution testing followed by on-farm solution verification;
   (d) extension of research results, training and policy formulation for extension support.

These phases are unlikely to be undertaken concurrently, so an individual project may concentrate on one or more phases in the sequence. This is especially so where the ACIAR involvement concerns the provision of skills needed at a particular stage in the research process but not at others.

Demand for FSR

Interest in FSR in developing countries has burgeoned in recent years. There are those who would say FSR is still 'the flavour of the month.' Throughout the early 1980s donors at both bilateral and multilateral levels have been keen to include FSR in their brace of weapons against agricultural stagnation or decline in developing countries. Similarly in aid-receiving nations, FSR groups are sprouting up like crocuses in the spring. Why is this so? Is it because FSR has something special to offer developing countries or is it merely a response to perceived donor bias?

The influence of donor requirements on developing country priorities and institutional adaptation was confronted head-on at the workshop. Several developing country representatives expressed a need for a clearer statement of what FSR has to offer developing countries. Others cautioned against the assumption that FSR skills in countries like Australia will transfer into the humid and semi-arid tropics without difficulty. In the Australian case there was a need to recognise the crucial constraints posed by shortcomings in the level of institutional and logistical services; support that Australian researchers would take for granted in their home base. Also, while developed country agricultural scientists could assume a significant degree of common knowledge between themselves and the farmers their research is designed to benefit, this is not the case when they turn their skills to developing country problems. They have to be prepared to confront their stock responses and to ask even the most obvious of questions, intellectual pride notwithstanding.

ACIAR has received a variety of requests for assistance in collaborative FSR from scientists and institutions in Asia and the Pacific. Some of these enquiries have highlighted problems that arise because of ACIAR's newness and the general lack of familiarity with constraints that define the area and the ways in which ACIAR can respond to requests received for research support.

ACIAR is not a research funding agency in the normal sense of that description. ACIAR does not provide money for research as much as it provides 'human capital.' ACIAR's goal is to facilitate the mobilisation and application of agricultural research skills in which Australia has a 'comparative advantage,' to alleviate constraints facing improved agricultural productivity and levels of food consumption in developing countries. Hence, ACIAR uses its financial strength to support the involvement of Australian scientists in 'collaborative research' with colleagues in developing countries.

As a result, ACIAR normally does not adopt the role of a technical assistance agency, but seeks out research groups in the developing world that already have a capacity to do research. ACIAR's mandate is to facilitate a research partnership between these groups and Australians with unique skills that are complementary.

The workshop participants were quite unequivocal that in many cases ACIAR will find these complementarities in the specialist skills that are needed to complete existing FSR teams in developing countries. The principal areas of research in which these specialist skills are likely to exist were identified during the workshop and these are listed later.

A second misconception concerns the relationship between research and training. Formal degree, diploma or certificate training is not normally within ACIAR's brief. On-the-job training or short courses essential to a given research project (e.g. to train enumerators, survey data analysts, or technicians in the use of equipment), are a natural and legitimate part of research. ACIAR can provide for such training within research projects it supports. However, other forms of training are the responsibility of other agencies in the Australian foreign aid arena, especially the Australian Development Assistance Bureau (ADAB) and the International Development Program (IDP) of Australia's tertiary education institutions. A recent innovation is the ADAB-ACIAR postgraduate fellowship program, whereby a limited number of postgraduate research degree fellowships have been set aside by ADAB for award to developing country nationals associated with ACIAR research projects. In other respects, however, ACIAR's role in formal training is limited to cooperating with ADAB and IDP in ensuring that formal training required in research is brought to the attention of the appropriate authorities for action. ACIAR cannot fund such training in its own right without a deliberate shift in policy.

Workshop participants from overseas made a persistent call for research skills from Australia involving:

(a) the ability to define problems in terms that can be addressed in a research framework;
(b) aid with data analysis and interpretation;
(c) translation of research results into recommendations and agricultural practices that are meaningful for extension agents, policy-makers and, ultimately, farmers; and
(d) definition of cost-effective and rapid techniques of rural appraisal.

A majority of workshop participants argued that Australian researchers have a comparative advantage in offering skills of these types. Why? There was the oft-repeated belief that the broad disciplinary base of tertiary training in agricultural science in Australia has given many Australian agricultural researchers unique abilities in integrating research skills across disciplinary boundaries. The systems perspective comes more naturally, even within a discipline, because of this training, and may be one reason why so many discipline-based agricultural researchers in Australia see themselves as being involved in FSR of one sort or another.

The workshop benefited from the involvement of FSR leaders from Indonesia, Malaysia, Papua New Guinea, Philippines, and Thailand. They provided first-hand insights into the demand for FSR collaboration in their respective countries. Their country papers presented to the workshop are an important part of these proceedings. However, in the context of the workshop they were also asked to summarise briefly their perceptions of their local needs in FSR. The results of their submissions are summarised in the accompanying table of 'priority demands for FSR collaboration.'

It should be noted that developing country representatives at the workshop were not forewarned that they would be asked to list their perception of priority areas for FSR collaboration with Australian agricultural scientists. Nor were they provided with a prompt sheet. The nine areas listed in the table of priority demands are, therefore, the result of spontaneous reaction midway through the workshop. Hence, one cannot conclude, for example, that rapid rural appraisal methodologies are unimportant in the priorities of Thailand and Indonesia. The respondents from these countries may simply not have considered collaboration in this area, or may have subsumed it under the rubric of agroecological zone definition.

Nonetheless, there is a remarkable consistency in the table that we should not ignore. Some minor differences notwithstanding, this consistency was also matched by the priority areas for research collaboration identified by the workshop as a whole. However, there was a strong recommendation from the workshop that ACIAR follow up on these assessments of demand for FSR collaboration by

Priority demands for FSR collaboration in five developing countries*

		PNG	Philippines	Malaysia	Thailand	Indonesia
(a)	Agroecological zone definition	2	1	—	1	1
(b)	Strengthening of the FSR efforts of national crop research teams and institutes**	1	2	4	2	2
(c)	Cropping systems modelling and computer applications to systems analysis	2	2	—	2	3
(d)	Rapid rural appraisal methodologies, especially of production-related malnutrition in the poorest districts	2	4	2	—	—
(e)	Policy studies, especially in relation to food policies and agricultural production incentives	3	3	3	3	4
(f)	New farming systems development, especially in:					
	— crop/livestock interaction	4	2	—	4	2
	— soil conservation systems	4	2	—	4	2
(g)	Methodological issues and research priorities in FSR	—	—	1	1	—
(h)	Organisational structures appropriate to FSR	—	—	2	4	4
(i)	FSR training	3	4	4	1	5

* Ranked from highest priority (1) to lowest (5), but all were regarded as of 'high priority.'

** Includes both food crops and export crops such as coffee, cocoa, copra, tea, palm oil and rubber.

visiting relevant FSR institutions, teams, and researchers in Asia and the Pacific. This recommendation is consistent with normal practice by ACIAR research program coordinators.

Priority Areas for FSR Collaboration

A pivotal reason for holding the workshop was to have FSR practitioners from overseas and Australia help ACIAR identify the priority areas for future FSR initiatives. This goal was pursued in several ways, but especially by way of group discussions during the latter two days of the gathering.

The rapporteur reports on the group discussions indicate an encouraging accord on Australia's strengths in FSR, and suggest ways to establish collaborative research. It was generally agreed that in Asia and the Pacific, ACIAR should not seek to create new FSR teams. This recommendation does not apply to Africa, however, given the similarity of physical environment and dryland agriculture problems.

In humid and semi-arid Asia and the Pacific, the agroecological analogues with Australian agricultural systems are not so obvious. In these regions Australian agricultural scientists are more likely to be able to offer specialist skills, such as crop and livestock production systems modelling and agroecological zone definition, that are missing components in existing FSR teams. It was a strong feeling of the workshop, therefore, that ACIAR should seek out opportunites to strengthen the research of active FSR programs in Asia and the Pacific by making available to them complementary specialist skills of Australian researchers. The areas in which these skills are most likely to arise and in which Australia has a comparative advantage were specified in priority order as follows:

- (i) Study of potential land use patterns based on agroecological zone definition;
- (ii) Crop-livestock-pasture interactions, including the use of computers in data analysis and modelling of system components and their interaction;
- (iii) FSR in a policy and methodology development context, especially as these relate to food policy studies, agricultural production incentives, prevention of postharvest losses, rural labour market studies, technology adoption, and the design of policies that support technical progress in agriculture in ways that cause private and social goals to converge. The latter refers especially to problems of soil conservation and other productivity and 'sustainability' issues;
- (iv) Management of rainfed agriculture, especially as this relates to:
  - (a) Soil/water management and conservation;
  - (b) biological nitrogen fixation and integration of legumes into crop and pasture systems;
  - (c) fertiliser management in pasture and crop systems;
- (v) Animal health and production, including utilisation of agricultural residues;
- (vi) Forestry and tree crops as components of smallholder agricultural systems and as a source of systems stability and sustainability; and
- (vii) FSR training and communications research, especially where this involves the development of training manuals, computer games and other research outputs that are not location-specific. Specific mention was made of Hawkesbury Agricultural College's commitment to and success with 'action research' as a farming systems training device. Several commentators also felt that under this heading ACIAR could

support the creation of an FSR newsletter and literature bank to encourage closer networking between researchers in Australia and abroad.

Conclusion

The seven priority areas for FSR development paint Australia's comparative advantages in FSR with a very broad brush. Specific details are subsumed under the various headings. For example, several speakers noted that FSR confronts head-on the vexing but important issues of the role of women in agriculture and the problem of landless labourers. Similarly, issues concerning human nutrition and how the rural poor spend their meagre cash income are part of the 'holistic' view that FSR claims to adopt. Steps need to be taken to ensure that ACIAR farming systems projects do not ignore such specifics. This may require closer links with non-governmental organisations than has been the case in the past. The questions that ACIAR will have to address but which the workshop left unanswered were: how can this be achieved? Can they be linked into FSR teams?

As already noted, participants did not favour ACIAR setting up new FSR teams in Asia and the Pacific. Instead ACIAR is encouraged to support the efforts of existing FSR programs and institutions. At the 'downstream' and least technically demanding end of the science spectrum, Australia is seen as being especially well placed in offering collaboration with base data analysis, policy research, and analysis of experimental data. At the 'upstream' level, specialist skills exist in the evaluation of new farming systems, simple component modelling and development of new component technologies. However, in many cases the most effective way in which these inputs of human capital can be provided is by ensuring close ties with ADAB. The workshop agreed that ACIAR should explore possibilities for FSR projects in regions/locations where ADAB is planning future new technology, extension-dependent integrated area or rural development projects. In this way the results of ACIAR-sponsored research can feed directly into support for Australia's other aid programs in agriculture. It can also ensure that the agriculture components of such development programs have available the technologies and the data needed for successful extension to farmers.

Other matters of significance raised by the workshop concerned: the need to make commitments that are seen as on-going and not merely fire-fighting ('continuity of personnel' was the buzz phrase); willingness to support FSR directed at assigning priorities to competing alternatives for research to be done on experiment stations; recognition that Australia will often have more to offer in on-station than in on-farm phases of FSR programs; and, a cautionary note that in any FSR initiative it is quality and not quantity of input that counts. This implies rigorous attention to a clear formulation of the objectives that can be achieved in a realistic timeframe from the proposed project or program.

Acknowledgments

This was both a successful and an enjoyable workshop. Even the old hands in the FSR game came away enthused and claiming to have learnt something new and worthwhile. I believe this is borne out in the quality of the papers included in this volume.

The sources of this success are many, but not least the commitment with which session chairpersons, paper-givers, panelists, commentators and discussants dispatched their tasks. I am grateful to them all. I am especially thankful, however, to the rapporteurs. Their reports on matters raised in the discussion groups have formed an important source for the preparation of this overview. The rapporteur reports on the plenary sessions are included in this volume.

I would like to express my thanks to the staff of Hawkesbury Agricultural College, and especially to Dr Ray Ison of Hawkesbury and Ms Sylvia Hibberd, ACIAR Research Services Officer, who together shouldered much of the day-to-day administrative and logistical burden before, during and after the workshop. Finally, I would like to thank my fellow members on the Workshop Coordinating Committe, Associate Professor Brian Hardaker (UNE), Dr Ray Ison (HAC) and Dr Jim Ryan (ACIAR). They were instrumental in conceiving the original program, in helping identify paper-givers and participants, and in keeping the convenor from straying too far from the mark.

Approaches to
Farming
Systems
Research

Farming Systems Research in Theory and Practice

D. Norman* and M. Collinson**

THE last 10 years have seen an increasing commitment to Farming Systems Research (FSR) as a new tool of agricultural research. Although it is true that FSR is new in the developing world, some maintain that an earlier version of it was practiced in the 1920s in the US (Johnson 1982). There have been parallel and similar developments in the use of FSR in Africa, in Central and South America and in Southeast Asia.

Nowhere is this increasing commitment more obvious than in the Eastern and Southern Africa region where we work. FSR as a tool in technology choice and development is institutionally established in Zambia (1981), Malawi (1984), and Zimbabwe (1984), where regionally deployed teams of farming systems researchers — each team consisting of a mix of technical and social scientists — have been structured into the national agricultural research services (NARSs). In addition, Botswana, Ethiopia, Kenya, Lesotho, Sudan, Swaziland and Tanzania have significant FSR-oriented programs and are actively debating how these should be integrated with technical component research (TCR) and with the extension services. Beyond this, Burundi, Mozambique, Rwanda, Somalia and Uganda have, or will shortly have, pilot FSR programs focused on technology choice and development.

Although both of us have made the occasional forays into the FSR scene of other continents, African work forms the basis of this paper.

Australian farmers are different from small African farmers. Their commercial orientation is a feature of the developed market structure they operate in and the high levels of resource endowment they enjoy, enhanced by an effective policy and service infrastructure supporting agriculture. Small African farmers are different. They often face poorly developed markets, politically inspired policy distortions, and an inadequate supply and service infrastructure. Their very low resource endowments are not readily enhanced by the fragile and uncertain infrastructure within which they must operate. They need to be self-sufficient. Complexity in African small farming is a function of multiple objectives. Farmers need to produce a continuous, reliable and balanced supply of foods, as well as cash for basic needs and recurrent farm expenditure. These are manifest in multiple enterprise farms where resource allocation exploits enterprise complementarities and demands technical compromise in the interest of the productivity of the whole farm system. Another important difference is the research-farmer link. Research is one of the services of an effective infrastructure supporting farming in Australia. Farmers, particularly the strong managers and innovators who are articulate and often aggressive, pressure researchers to produce the right goods (technology). These pressures arise from farmers reading about research, buttonholing individual researchers and using their own organisations to influence research focus. Small African farmers are often illiterate, and have virtually no opportunity to pressure research or research workers. One of the interests in FSR in Africa is its capacity to reflect farmer research needs more effectively. The absence of regular researcher/farmer contact is a major gap in existing research procedures and organisation in Africa.

Role of FSR in Technology Choice and Development

Effective technology choice for small farmers in Africa is the only means of improving their productivity. This fundamental role of new technology in agricultural development is increasingly realised. Attention has turned, therefore, to the shortcomings of classical agricultural research techniques for smallholder agriculture (Norman et al. 1982). Looked at in system terms, classical

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agricultural research develops and evaluates a subset of relationships within an ideal technical system. It recommends these for application to differentiated, higher level, real-world economic systems where they are evaluated against criteria peculiar to the particular system. The subset may or may not fit. Evidence suggests it seldom does. This weakness in method is compounded by physical isolation. Technical researchers rarely see small farmers and, even more rarely, talk to them as equals. Feedback through the extension service is rarely effective. The lack of any diagnosis from the farmers' perspective results in blindly prescriptive blanket recommendations, unrelated to causal factors, which are invariably location-specific situations.

FSR is, strictly speaking, a research methodology for understanding the real-world economic systems that farmers operate. In the context of technology choice and development, the role of FSR is complementary to technical component research (TCR). There are three parts to this role:

(1) To look at the stock of materials and techniques accumulated from TCR and to choose technical solutions to problems. On-farm experimentation then adapts chosen solutions to the local situation. This is a mobilising and adapting role, finishing the product for an identified market;
(2) To report back unsolved problems to the TCR team. This helps to fix priorities for further research; and
(3) To nurture links with farmers and extension staff in local farm situations, drawing both farmers and extension workers into the technology generation process.

Not all the efforts to introduce FSR into the NARSs of Eastern and Southern Africa have had these roles in view. Confusion as to which role is to be emphasised is one factor that has brought the FSR contribution into question. Recent discussions among eight International Agricultural Research Centres (IARCs) working with FSR in Eastern and Southern Africa revealed four sets of priorities. These were the understanding of representative or prototype systems, the development of prototype crop technologies, the direct adaptation and dissemination of IARC-developed component technologies, and strengthening the capacity to do FSR in the NARSs. Each of these objectives implies a different approach to research, yet all were being sold to NARSs as FSR. This is a certain source of frustration for research directors. To add to the confusion, there are new roles for FSR being generated by development thinkers, which portray FSR as a vehicle for everything from changing the balance of authority between men and women in local communities to bottom-up national policy formulation.

Few would debate the logic of FSR. However, there are many challenges to overcome before it secures credibility. The major problem of FSR is that a conventional methodology is still emerging at a time when donor agencies are pouring millions of dollars into FSR programs and, largely as a result, developing country governments are rushing ahead with plans to establish FSR units. Here lies the dilemma. FSR teams need quick results in order to obtain credibility and ensure continued funding. On the other hand, credibility with scientists, policymakers, extension services and farmers depends more on the suitability of a recommended practice (technology) and not on whether it was developed in one or two seasons. There is a danger that the FSR approach may be supplanted before it has a chance to establish its credibility.

Definition of Farming Systems Research

The primary objective of FSR is to improve the well-being of individual farming families by increasing the productivity of their farming system, given the constraints imposed by resources and the environment. FSR, in the sense in which we use it in this paper (on-farm research with a farming systems perspective), consists of two thrusts towards increased productivity:

(1) The development and dissemination of relevant improved technologies and practices; and
(2) The implementation of appropriate policy and support systems to create opportunites for improved production systems and to provide conditions conducive to the adoption of technologies already available.

These two thrusts signal a major change in the attitude of research workers. It is increasingly recognised that technologies and policies incompatible with the local natural and socioeconomic environment have been the basis of farmers' resistance to proposals for changing their farming practices. Resistance has not been due to irrationality or managerial incompetence. Conceptually, at least, the approach recognises the vital connection between relevant technologies and relevant policy support systems.

On-farm research is not necessarily FSR. To qualify as FSR it has to take into account interactions with the farming system. Shaner et al. (1981) have, to our mind, correctly characterised FSR:

(a) The farm as a whole is viewed in a comprehensive manner;
(b) The choice of priorities for research reflects initial study of the whole farm;
(c) Research on a farm subsystem is legitimate FSR provided the connections with other subsystems are recognised and taken into account;
(d) Evaluation of research results explicitly takes into account linkages between subsystems; and
(e) As long as the concept of the whole farm and its environment is preserved, not all the factors determining the farming system need to be considered as variables — some may be treated as parameters.

Therefore even within its role in technology generation, confusion can be caused by a variety of approaches to FSR. These approaches can be summarised as FSR 'in the large,' and 'in the small' and 'with a predetermined focus.' We need to understand these alternatives and their implications for methodology and institutionalisation.

FSR 'in the large' treats all system parameters as potentially variable in a wide-ranging search for improvement. It is perhaps analogous to the development of a new farming system that uses state-of-the-art technology to model what could be done in a particular situation with existing know-how. It is not particularly complex in concept but extremely complex in implementation. We do not consider it further.

Both FSR 'in the small' and FSR 'with a predetermined focus' recognise that small farmers evolve from their existing situation in steps. The content and scale of these steps must necessarily be compatible with farmer resources, their risk ceilings and their management capabilities. Both seek a focus within the system that identifies potential development steps. Because both recognise the step-by-step development process in small farming and both seek to identify steps in technology, there has been confusion between the two. The difference is that FSR 'in the small' arrives at a focus within the system in the course of diagnosis, while FSR 'with a predetermined focus' moves into the system to research an enterprise, or one facet of an enterprise, looking for improvements that are compatible with the whole farming system. The two approaches have different implications for the level of leverage obtained in the system and for institutionalisation, which we discuss in subsequent sections of the paper.

There is no question that a certain convergence of ideas about FSR is taking place, as a review of some of the major papers indicates. Conceptually there are four distinct stages in the FSR process (Fig. 1; see also Byerlee and Collinson 1980, and Zandstra et al. 1981):

(i) The descriptive or diagnostic stage to determine the constraints farmers face and to ascertain potential flexibility in the farming system.
(ii) The design or planning stage, in which a range of strategies is identified that are thought to be relevant in dealing with the constraints. These strategies are derived from experiment stations, researcher-managed and -implemented trials (RM-RI) off the experiment station, and knowledge obtained from the farmers themselves. This involves *ex ante* evaluation from the viewpoint of:
   (a) Technical feasibility — whether the physical transferability of technical relationships established elsewhere is valid and thereby contributes to the solution;
   (b) Economic viability — whether the proposed solution is economically viable in the local situation of the farming family; and
   (c) Social acceptability — whether the proposed solution is likely to be acceptable to the farming family.
(iii) The testing stage, in which the most promising strategies identified at the design stage are evaluated under local farmer conditions. This stage usually consists of:
   (a) Researcher-managed but farmer-

implemented tests (RM-FI) to establish whether transferred technical relationships are altered by farmers' management of non-treatment variables.

(b) Farmer-managed and -implemented (FM-FI) tests when the team is confident that relationships will hold but need to evaluate the proposed technologies under local socioeconomic circumstances.

Where transferred technical relationships appear likely to be distorted by differences in local natural conditions, RM-RI experiments will be a prerequisite to the subsequent RM-FI and FM-FI stages, and may be undertaken by the FSR team.

(iv) The recommendation and dissemination stage in which the strategies identified and screened during the design and testing stages are implemented.

In practice there are no clear boundaries between these stages. Design activities may continue into the testing stages as promising alternatives emerge during trials at the farm level, where farmers and researchers interact directly. Similarly, testing by farmers may mark the beginning of dissemination activities. It may not always be necessary to go through all four stages. FSR team confidence in transferability during the design/planning stage can mean going straight to FM-FI work or even to the recommendation/dissemination stage. So the process of FSR is recognised as being dynamic and iterative with linkages in both directions between farmers, researchers and funding agencies.

Thus, FSR involves putting the farming family (the consumer of the improved technologies) on centre stage. FSR contributes to this goal by incorporating adaptive on-farm testing and feeding the results back for further work on experiment stations. This promotes success because successful testing gives rise to successful dissemination — all other things being equal — resulting in the improvement of farming families' welfare. Analogous linkages could be established by planning and development agencies to assess proposed policy and support program changes.

There are many challenges facing the practitioner in FSR. We now turn to discussion of some of these, all of which influence the credibility issue. The issues are organised under two major headings: methodological and institutional.

Methodological Issues in FSR

Three principles must be emphasised in designing cost and time-efficient methods:

(a) Minimise the time required to move through the four research stages. The methods applied, in addition to ensuring fast turnaround, need to be practical, replicable and inexpensive (Byerlee et al. 1981). Avoid complex procedures that require scarce, highly qualified individuals to collect and analyse data and to design and test solutions. (Zandstra 1978).

(b) Maximise the return by making results more widely applicable. This means defining target groups of farmers (recommendation domains) in broad terms. The extent to which improved systems can be transferred or extrapolated to other areas directly affects their efficiency.

(c) Be open to using second best solutions or the best of those readily available. Therefore, the emphasis in FSR has been on developing improved technologies that are better than most but not necessarily best for each environment (Winkelmann and Moscardi 1979).

Perhaps the easiest way of presenting the various methodological issues is by reference to the four stages of FSR.

Description/Diagnosis

The objective of this stage is to pick target areas, to divide the frame of farming families into target groups or recommendation domains, and to ascertain the major constraints on farming in the area and also the degree of flexibility that exists for modifying the farming systems.

It is desirable to do a preliminary target grouping first, to help provide a framework for decisions on priorities — such as where the FSR team should go first. Attempting diagnosis across more than one target group — unless the groups are closely interconnected (e.g., draught animal owners and non-owners in the same community) — is very confusing and militates against clear understanding.

Talking to knowledgeable people, examining relevant secondary sources of information, surveys and even technical monitoring are the chief strategies of this stage. In general, however, the methods used should be based on the criterion of the lowest possible cost commensurate with the degree of understanding that is necessary. Extra accuracy takes resources and time.

Informal conversations with farmers without the use of formal questionnaires or random samples can contribute to hypothesis formation, questionnaire development and choice of sampling technique. However, there are two problems: (a) the considerable skill involved if good information is to be obtained; and (b) the problem of convincing decision-makers that the information is valid and representative. Thus we feel that it is certainly useful to supplement the informal survey with at least one formal survey to answer issues of credibility, representativeness and quantification. Formal surveys provide means of gaining credibility through the statistical testing of hypotheses set up in the informal survey. Formal surveys are also valuable for assessing proportions of the population falling into different target groups, following different practices, and identifying themselves with different problems. Finally such surveys can help in improving experimental (trial) planning in: bounding treatment levels; verifying evaluation criteria; identifying special locational characteristics to be observed in siting experiments; and assessing current productivity levels to be standards in judging the economics of trials. However, these formal surveys do not have to precede the design and testing stages. They can also be carried on concurrently.

Our conclusions about surveys agree with Harrington (1981) who concluded the following:

(a) an informal survey represents the minimum data collection effort necessary for planning research
(b) where time and resources allow, it is wise to follow the informal survey with a formal survey. In many cases a small sample, single contact, formal survey will be sufficient to verify the results of the informal survey
(c) when data on farmers are not urgently required, when budget and staff and resources allow, and when flow variables must be measured with some precision in the context of a complex farming system, then researchers in addition can consider using a multiple visit survey.

Two other issues arise concerning the descriptive/diagnostic stage. They are the ways in which recommendation domains should be defined and whole needs addressed.

RECOMMENDATION DOMAINS

One of the functions of the descriptive/diagnostic stage is to help in classifying farming families into homogeneous groups or recommendation domains. Farmers within each specific group should have the same problems and development alternatives and should react in the same way to policy changes. Target grouping should replace conventional frameworks as a basis for research and developmental planning. Nevertheless, major arguments continue on zoning or grouping on the basis of potentials — especially agroecological ones. However, as we have implied, such an approach only focuses on an opportunity set. Choice within it is dictated by social and economic factors. Hence, we argue for selecting target groups on the basis of existing farming systems broadly reflected by enterprise pattern and calendar, product areas, power sources and methods of land preparation. We justify this on the grounds that what is going on now:

(a) Reflects farmers' decisions on opportunities, weighing both technical (natural) and human (socioeconomic) factors.
(b) Is the place from which development has to start.

Once grouping on the basis of the existing systems is done, then causes can be sought. Looking for causal factors first can be very confusing.

It is worth emphasising that recommendations arising out of FSR work may — even if recommendation domains are drawn up carefully — prove to be better for some farmers within a target group than others, or for one particular part of a farmer's farm. Two examples: in one part of Zambia, where weeds became a problem after three to four years of cultivation, herbicide application showed a 50% higher return on land that had been cultivated for four years compared with land that had only been cultivated for one year; in Botswana we found that timeliness of operations was the major problem in increasing crop production. Timeliness is a function not only of managerial capacity but also availability of draught power. In one area we identified six recommendation domains based on the source of draught power. Initially we thought that this was a satisfactory division of farmers. However we have found that farmers often use more than one type of draught power, for example, hiring a tractor and using their own donkeys. Consequently the division between recommendation domains became blurred. However, this is not necessarily critical providing we can come up with strategies to help farmers in each of the groups we are committed to helping. Obviously it will be harder to come up with strategies that help farmers who have to hire donkeys than it will be for farmers who own tractors. The value of the recommendation domain approach is that it forces researchers to disaggregate the farming community, which traditionally has been assumed to be rather homogeneous.

WHOSE NEEDS TO ADDRESS?

What needs or constraints are to be investigated? We believe that criteria used in developing improved strategies should reflect the felt needs of farming families, providing these are compatible with the needs of society (e.g. there is not a decline in soil fertility, nutrition levels, increasingly inequitable income distribution, etc.). However, farmers may not always be able to articulate their major needs. For example, farmers in Niger are so used to striga on their sorghum that they may not always state it is a problem amenable to solution. Thus constraints are not always recognised as problems. In such cases scientists may have to provide leadership. Further informal survey discussions often allow farmers to identify with problems specified by the FSR team, while sometimes it takes comparisons in farmer-managed verification trials to reveal the problem.

Strategies developed need to ensure convergence between the rather short-term private interests of farmers and those of society in the long run. Although few would in principle disagree with this it is in practice a lot more difficult to incorporate societal interests into FSR. The problem of doing this relates to the methodological complexity of the incorporation and the time that would be required in deriving societal impact evaluations. We do not have a good solution to this problem.

However, the design or planning stage does allow long-term technical questions (e.g., whether planned intervention is consistent with soil conservation) to be brought to bear in the choice of solutions. As well, immediate policy issues — such as urgent need for food in urban areas, lack of availability of foreign exchange, etc. — may weight the choice of problem and choice of solution.

Solution Design

The priorities for research should arise from the descriptive/diagnostic stage when there is not much information already available for application to problems or when conditions in the field differ substantially from those on the experiment station. FSR is not a substitute for station-based research, even in areas where research station strength does not exist.

The design stage is increasingly recognised as crucial to the success of FSR in technology generation. It is the turning point of the process. On the whole, farmers' problems are readily identified. In the design stage the FSR team's understanding of the system is brought to bear on the identification and evaluation of apparently appropriate solutions to those problems. The decisions taken can commit several professionals to an experimental program, often over several years.

There are four critical issues in the design work to which we now turn.

LEVERAGE

Is it wise to focus research on a single commodity rather than on the whole farming system or on the crop subsystem? When the single enterprise is a major absorber of farm resources, then it will usually offer the best leverage on such problems as low income, excessive risk, and seasonal variability in the use of farmer owned resources. However, in national programs a different situation often arises. Geographically based FSR teams have responsibility for looking at all crop and livestock enterprises in the system. Obviously most leverage can be obtained with the major crop or livestock enterprise. However, when viewing the relationships between the various enterprises focus on the broader farmer system is advisable, especially when there appears to be little scope for improvement in the farmer's major enterprise.

BREAKING CONSTRAINTS

There are two possible ways of dealing with a constraint: break it, or avoid it by exploiting flexibility in the farming system. A simple technical example is the set of different strategies available to deal with a particular disease on sorghum. The constraint may perhaps be broken by applying a seed dressing (requiring an input distribution system), breeding a disease-resistant sorghum (a long-run strategy requiring an input distribution system) or through exploiting flexibility in the farming system by planting the sorghum at a sub-optimal time (in terms of yield potential) which reduces or eliminates the disease attack. The decision will depend on its severity, the flexibility that exists in the farming system, and the availability of potentially improved strategies that break the constraints or exploit the flexibility. We have had experience with both approaches.

In northern Nigeria it was possible to exploit flexibility in the farming system by planting cotton later than would have been agronomically advisable. However, in Botswana where there is a greater inter-annual and intra-annual variation in the distribution of rainfall there is little flexibility in the farming system, because a key management factor is the ability of farmers to plough, plant, weed, etc., when it is likely to improve water availability for plant growth, and to improve the efficiency of water use. Therefore we are faced with a much more difficult situation of trying to break a constraint. In fact, *if one looks at the success of FSR work to date, much of it can be attributed to exploitation of flexibility rather than breaking constraints.*

We submit that breaking a constraint is a much more difficult problem for both researchers and farmers than the strategy of exploiting flexibility. However, major long-term increases in productivity have to come through breaking constraints. This must be a step-by-step approach evolving away from the present system towards a new one — each step being one that is acceptable to farmers.

VARIABLES

The design stage produces apparently appropriate sets of improved practices for testing on farms. We support the following procedure for designing improved practices:

(a) The experimental treatments should consist of practices in which farmers' management is flexible or where *ex ante* evaluation suggests room for increased productivity. Flexibility in management is enhanced when there are underutilised resources, while increasing productivity is vital to breaking constraints;

(b) The feasible range of treatments is set by the flexibility that exists. Some flexibility could be introduced, for example, by assuming that an institutional source of credit could be made available to supplement the cash flow of the farm business. The development of improved practices should consider the expected infrastructural support; and

(c) Non-experimental variables should be fixed at levels representative of local farm practice. Interaction between farmers' practices and recommendations is a neglected and crucial reason for poor adoption, which leads directly into the question of packages.

SINGLE CHANGES OR PACKAGES OF PRACTICES

Designing improved technologies may involve incremental or single component changes or incorporate packages of practices. The major advantage of packages is the complementary or synergistic effect between the various components. Improved varieties, for example, may respond better than indigenous ones to the addition of inorganic fertiliser. Disadvantages of packages are the complexities of putting them together and the likelihood of them being partly inappropriate for some farmers. Farmers, like researchers, value synergism. Packaging is effective when components are assembled from an understanding of the farming system into which they will be introduced. Where packages contain components that compete heavily for resources, an incremental approach to extension of the package is recommended (Collinson 1972). FSR teams are in the best place to identify the sequence of innovation leading to the adoption of the complete package. Initial steps will ideally be with components with major main effects that are relatively compatible with farmers' existing resource allocations. More complex steps will be possible as farm productivity improves and farmers' confidence in absorbing new technology grows. Unfortunately, however, this technology ladder cannot always be followed, particularly if synergistic effects are very high.

Testing

The objective of this stage is to evaluate the improved practices flowing from the design stage to the farm. The evaluation criteria should be those found important to farmers in the descriptive/diagnostic stage. Usually the performance of the improved technology drops when it moves from the artificial conditions of the experimental station to the farm, and drops even further when farmers manage and implement the final trials.

SELECTION OF FARMERS

The issues of interaction between farmers and research workers, and the representativeness of farmers and farming families are important. Some research workers prefer to select the better, more responsive and more cooperative farmers for the testing stage. However, this strategy raises the potential problem that the improved practices may not be truly relevant for the average farmer in the recommendation domain. There is a trade-off here. Selection of less cooperative farmers will not ensure maximum interaction between farmers and researchers. Of course, the selection of a representative cross section of farmers becomes critically important in FM-FI work.

EXPERIMENTAL DESIGN

At the testing stage compromises have to be made in the experimental design. Farm trials need to be less complex than those undertaken on experiment stations because of costs, worries about too much land being asked from farmers, and the desirability of interaction between farmers and research workers. Researcher-farmer interaction is less likely when experiments become too complex. When one moves from researcher-managed to farmer-managed type work at the testing stage, experimental design becomes even simpler; two plots only — the proposed improved practice compared with the traditional practice. We place a lot more emphasis on replication across farmers' fields rather than within farmers' fields at this stage of testing. The problem of experimental work is exposure to many additional sources of variation, including differences in the management and non-treatment of variables by host farmers, and often inability to explain differences between plots.

EVALUATING IMPROVED TECHNOLOGY

The primary issue is to ensure that effective evaluation takes place *before* technologies are recommended for adoption by the extension services. Since the 1950s many economists have been pre-occupied with *ex post* monitoring of farmer adoption of technologies. Their emphasis has been in explaining why there has been high or low adoption. *Ex post* monitoring is, of course, too late to prevent wasted investment in extension training, and in support and infrastructural services developed to handle expected increases in production. FSR attempts to evaluate the technology as a part of its development. It raises several related issues:

(a) In *ex ante* evaluation, the criteria used should be those that will be used by farmers in the target group. These are often difficult to identify.
(b) Farmer assessment is an important substitute for formal economic analysis.
(c) The balance between evaluation on the criteria used by local farmers and a societal evaluation is a difficult one to strike.

Farmers will use criteria of two types: first whether they are *able* to adopt. This raises questions about whether the required inputs can be obtained locally, whether the resource levels implied are within the reach of farmers, and whether the changes will be socially acceptable to the community. The second set of criteria used by farmers is whether they are *willing* to adopt — broadly speaking whether they will be better able to achieve their goals by using the improved practice. The criteria on which they will decide their willingness to adopt are often obscure. Factors such as the balance between preferred foods, returns to labour during one particular period of the season, the opportunity cost involving the loss of a non-preferred but risk-averting starch staple, are common criteria. Such factors are particularly difficult for technical scientists to relate to, conditioned as they are to an experimental method that deals basically in weight per unit area of land. Often several such criteria may have to be brought to bear on a single proposed change. For example, staggered planting may cause labour or draught power scarcity, risk management, and a preference for a prolonged supply of a certain type of fresh food — all at the same time. There is little chance of weighting these correctly in an economic analysis, particularly where both product and factor markets are rudimentary.

This difficulty in second guessing the balance in farmer evaluation criteria leads us logically to farmer assessment as a practical approach to technology evaluation. The FSR phase of technology development is in the fields, with farmers on the spot. Yet to date the devices developed and used for farmer assessment are rudimentary. We are convinced that this is a vital area for FSR, and urge a contribution from anthropologists and sociologists in designing improved methods for routine farmer assessment of technology. We recognise that this emphasis on farmers' criteria for technology evaluation ignores possible impacts on other farming communities interacting with the target group and on broader societal issues. We cannot see any easy way around the question of full social evaluation. We believe that bringing both long-term technical and current national policy considerations to bear in technology choice at the design stage is the easiest way forward at present.

PRECISION

A continuing problem for scientists engaged in FSR is that of precision. Exposing potential solutions to wide sources of variation, representative of what any recommendation will have to survive, reduces precision. Recognised statistical standards are no longer achieved and coefficients of variation increase. It is becoming commonplace to accept lower confidence levels of 10–20%. However, is this just a compromise? FSR scientists don't seem to be able to pin-point the real answer in a way that satisfies classical researchers and woos them away from 1 to 5% levels. We know farmers work with much lower levels — as indeed we do — in taking decisions. The questions we have are:

(a) Should we do our statistical analysis on the economic evaluation criteria?

(b) How should we express the difference between statistical inference and decision theory in a way which removes scientists' doubts?

(c) Do we continue trying to meet lowered statistical inference standards?

EXTRAPOLATION OF RESULTS

Costs limit the number of sites that can be included in the testing stage. As indicated earlier, efforts are needed to increase the benefits by extrapolating results to other areas. Chances to extrapolate or transfer results to other areas are of course increased if sites for farm trials are picked to represent larger areas. Possibilities for extrapolation are increased by developing technologies that are flexible in timing and other factors. Also at the testing stage, a detailed specification of the proposed improved practices and conditions under which they were tested, is required in order to increase the efficiency of extrapolation to other areas (Zandstra 1978; Norman and Palmer-Jones 1977). Unfortunately we are not always very good at specifying exactly the technical or human environment under which the testing was carried out and the criteria for deciding when it will or will not work. There are deficiencies at this level which need to be overcome if the benefits of such work are to be maximised.

Extrapolation of results can also be assessed in terms of a specific location that has a very variable climate, such as Botswana. In such areas it is important for the FSR team to set up hypotheses about the results of experiments for the different 'types' of seasons they can expect. It serves to remind them, when the results come in, where they are on the inter-seasonal spectrum. Ideas on how many times such a result can be expected are very important for risk-conscious small farmers.

Recommendation and Dissemination

Development of locally specific recommendations via FSR is causing some problems because of highly centralised 'recommendation release' procedures. In a West African country, for example, a two-year lag period has been reported between deciding on and approving recommendations that had to be passed back to 'the centre' for approval. A revision of release procedures, giving more authority to the local level, is important. This should be complemented by a re-gearing of supply agencies and credit banks, to allow initiative and decisions at the local level to alter supply and credit lines. We recognise, however, that such adjustments will mean that demands on local management capabilities will increase.

Issues in Implementing FSR

Research and extension organisations in developing countries are invariably based in, or under the authority of, Ministries of Agriculture. These are classical bureaucracies and the difficulties of changing them are widely appreciated. The institutional and procedural requirements for the adoption of FSR as a tool in agricultural research faces the inertia, red-tape and vested interests of such bureaucracies.

The introduction of FSR has ranged from the addition of a social scientist into existing, multidisciplinary commodity research teams, to the setting up of special teams which include the whole gamut of disciplines. Like packages to farmers, the introduction of innovative institutional components should be geared to the system within which change is to be made. The strategy followed by CIMMYT in eastern and southern Africa is aimed at driving a narrow wedge into agricultural bureaucracies in the region. 'Narrow' in this context covers two ideas:

- (a) To limit the claim made for FSR as a catalyst in generating more appropriate technology, a need felt by many research administrators, and the focus most consistent with CIMMYT's mandate.
- (b) To minimise the number of people who have to be convinced of the efficacy of FSR.

From there the aim is to build up some capacity to apply a systems perspective to agricultural research within the NARSs, and then to open out the wedge in order to forge the links needed for effective utilisation of that capacity. Components of the strategy are:

- (i) Identify national research directors in the region who accept that there is a problem of low adoption rates of present research output. They represent targets of opportunity;
- (ii) Demonstrate, in a local situation of their choosing, the FSR diagnostic techniques to identify an on-farm experimental program relevant to farmers in that situation. Emphasis in this demonstration is on the importance of local economic circumstances in identifying an appropriate experimental program, and the role of the agricultural economist;
- (iii) Promote the need for experimentation under farmers' agroecological and management conditions;
- (iv) Conduct training for local professionals in the use of these techniques and later in the planning, implementation and evaluation of on-farm experiments;
- (v) Discuss the FSR team composition and links with commodity research teams (CRTs) and extension;
- (vi) Draw senior extension staff into the discussions, covering FSR/extension links;
- (vii) Help develop procedures and, when requested, structures to institutionalise these linkages; and
- (viii) Discuss the role of links back to planners and policymakers to ensure that technologies identified as appropriate to a local situation can be effectively serviced there.

This wedge strategy has sometimes led to criticisms from academics convinced of the potential of FSR but ignorant of the hazards of implementation. Other criticisms have focused on slow progress in drawing livestock and extension considerations into FSR. Bias towards crops has often arisen, not only because the mandate of promoting agencies like CIMMYT is in crops, but also because the state of the art in OFR with animals is poor. However, the most damaging cause has been that current responsibilities for research into crops and animals are so widely divided institutionally. An anecdote illustrates this point. In one NARS the crop department had taken the initiative in a trial of FSR techniques. The report on the diagnosis was being discussed jointly by crop and livestock departments. With the rapidly increasing use of cows for ploughing in the target farming system the report recommended research to examine how the reproductive cycle and supplementary feeding could best be managed to complement the ploughing burden. The reaction from the vets was unanimous and vociferous — 'using cows for ploughing is crazy; it should be banned.'

The innovation sequence in institutionalising FSR must be varied, if an honest attempt is made to accommodate the peculiarities of particular bureaucracies and the attitudes of the administrators operating them. The time horizon for building and institutionalising FSR capacity, once the concept is accepted, is not less than 10 years in most countries. Appendix 1 outlines the FSR history in Botswana, Kenya and Zambia as examples of what has been achieved.

FSR: RESEARCH OR EXTENSION

CIMMYT has concentrated its involvement in FSR through its crop mandate in wheat and maize. Our experience is equivocal on whether research or extension is the appropriate location for FSR in technology generation. This remains a debatable point. Several extension services, such as those of Kenya and Zimbabwe, have taken their own initiatives towards an on-farm research effort. Two points perhaps dominate the discussion:

(1) FSR has a local specific area orientation highly compatible with that of the extension services; and

(2) If FSR is located with extension, and research/extension remain essentially separate bureaucracies, there is a great danger that component research will remain isolated from its small farmer clientele. FSR is increasingly seen as an effective device for linking research and extension — something that is lacking in most bureaucracies.

The discussion on location is complicated by different approaches to using FSR in a technology generation role. As indicated earlier the two approaches with which we are concerned can be summarised as FSR 'in the small' and 'with a predetermined focus.' We need to understand their implications for institutionalisation.

FSR WITH A PREDETERMINED FOCUS

FSR with a predetermined focus is relatively easy to reconcile with existing research institutions organised along commodity lines. The commodity is the focus. Commodity teams are frequently multidisciplinary and adding a social scientist to the team to bring the farmers' perspective to bear in experimental planning and evaluation implies no radical reorganisation. The commodity team is expanded and a modified and extended multilocational trials program takes care of a re-emphasis on experimentation under farmers' conditions. The advantages of this approach are easy institutionalisation and an internal CRT/FSR interface, with the commodity team doing both on-station research in the classic mould, and on-farm research. It allows researchers to keep a foot in the camp of their peers, and in the promotional stakes. The career structure for purely farm system researchers remains a grey area in most national programs. Kenya is in the process of developing something close to this pattern and the Sudan presently favours this approach. As an ultimate model it has several disadvantages. The major ones arise from poor exploitation of the system's perspective. However, there are problems, the more important of which are:

(a) The predetermined focus predetermines the range of problems identified in the system. Research effort may be focused on sub-optimal problems and solutions which may not be attractive to farmers whose primary concerns may be elsewhere in the system;

(b) It cannot offer a means of identifying and ranking technical research problems requiring research resource allocation across commodities, a major potential contribution of a full farming systems perspective;

(c) There is great potential for overlap in the workplans of commodity-based FSR teams, and this overlap must be exploited if FSR is to be cost-effective. Small farmers often operate a multi-commodity system, which might draw the attention of five commodity-based FSR teams. However, their relevant technologies, if identified in isolation, would be seen as competing for the use of farmers' limited resources, rather than as an integrated unit with mutual complementarities;

(d) FSR's important linkage role with extension is more difficult to achieve if the focus is excessively limited. Little restructuring is required and therefore FSR is likely to be seen as a creature of research, and its orientation as well as organisation as less compatible with successful extension; and

(e) Difficulties have been experienced in trying to build an FSR capacity within existing commodity teams. This is in part because specialised researchers tend to be locked into a program aiming at peer group recognition. Workplans are not easily re-balanced to absorb a systems perspective, and content is not readily modified without antagonism. As well, an early step in building FSR capacity into a commodity team is the addition of a socioeconomist. It is our experience that unless these people are very experienced in their profession and in FSR, it is difficult to make the case for FSR and for social science with the team. Young professionals need to develop their own perspective and capacity before they are ready to hold their own in the arguments which inevitably greet the new emphasis.

FSR IN THE SMALL

Where FSR is not defined relative to a crop or an existing principal enterprise, it lends itself to institutionalisation as regionally oriented teams. Such teams draw from and feed back to specialist researchers of all commodity and disciplinary affiliations as the diagnosis of local circumstances dictates. Teams are usually made up of a general crop agronomist, an agricultural economist and an animal production scientist in areas where animal enterprises are an important part of the farming system. The advantages of this arrangement are virtually the opposite of the disadvantages of a predetermined focus:

(a) In seeking a focus to give best leverage to the improvement of the system as a whole, priority problems are identified. Appropriate solutions of these should be readily absorbed by farmers;
(b) Feeding back of technical research agendas of unsolved problems helps balance specialist research effort according to farmer need;
(c) The use of only one FSR team in any area contributes to a cost-effective research effort;
(d) An area orientation and organisation is wholly compatible with extension. It offers great potential for drawing local extension staff into the various stages of the generation of technologies, which they will have to sell to their local farmers. It is a natural research/extension linkage device;
(e) It creates a relatively independent niche for FSR. This niche can be sheltered to an extent from both CRTs and extension while a capacity for FSR is established. This is particularly important where young professionals are involved and morale is easily shattered by apparent antagonism from both traditional establishments; and
(f) Finally, and in an apparent contradiction, regionally organised teams allow policy full play in determining the focus in any particular farming system. For example, an overriding policy objective to increase cotton production for import substitution can be implemented by focusing on cotton development in the system through the FSR team.

A more complicated reorganisation of research and extension is needed to fully exploit the advantages of FSR in technology generation. This is undoubtedly a disadvantage and a formal regional structure should probably be seen as a late component in the FSR innovation sequence. Nevertheless in both Zambia and Malawi early institutionalisation of FSR along regional lines has produced a framework of procedures within which FSR teams can operate securely. The other danger in breaking FSR teams out of the traditional research organisation is the danger of isolation from the CRTs. We believe special and careful provision has to be made to avoid this. There are many points in both CRT and FSR processes for interaction between the two sets of teams.

CRTs can contribute in the following ways:

(a) During diagnosis, after focusing on the system, the FSR team may call in a relevant specialist (e.g. a weed scientist) to evaluate technical problems in the field and to identify causes;
(b) During design the relevant specialists are asked to contribute technical information in specifying possible solutions, and to advise on particular aspects of experimental design related to those solutions; and
(c) During on-farm experimentation the relevant specialist may be asked to advise on oddities arising in the experiments, and to help with biological interpretation.

Once the focus is established it is likely that the same specialists will follow through the full sequence with the team.

On the other side the FSR team contributes to specialist programs in the following ways:

(a) Feeding back technical problems, identified as important to farmer development, to the appropriate specialists;
(b) Competing for specialist time, which is a help to research administrators, in

deciding how to redeploy or expand specialist capacity; and

(c) Feeding back local information to specialists to help them structure their experiments. Farmer criteria in evaluating varieties help in the construction and evaluation of selection blocks and yield trials. Rigidities that farmers have to adhere to in their management regimes help to decide which components to combine in packages and how the management of non-treatment variables should be handled in experiments.

Thus there are very significant contributions in both directions. Procedures for interactions should be clear and time set aside in workplans to facilitate them. It must be emphasised that no matter how good such provisions are, effective interaction depends on a mutual appreciation of roles; one side cannot do an effective job without the other. This requires that both sides see an 'effective job' in the same terms; the rapid adoption of research results by small farmers. This is not always the case. Historically CRT reward systems have been geared to other goals.

There is much current discussion on the connection between CRTs and FSR teams in experimentation. In planning on-farm experiments, the FSR team draws possible solutions from the work of relevant CRTs. Transferability has to be evaluated; will the proposed solution hold under the local conditions of the target group of farmers? The FSR team knows the local conditions, and CRT specialists are best able to judge the vulnerability of the technical relationships inherent in the proposed solution to local conditions. Relationships may be distorted by agroecological differences or by interactions with components of farmer management. Adaptation to farmers' management is clearly within the purview of the FSR team while adaptation to different agroecological conditions raises questions of territory. It is already recognised in research services as the role for multilocational trials of the commodity teams. In Zimbabwe, where research services have both Communal Area Research Teams and FSR teams, it seems to be emerging that RM-RI trials — investigating modified technical relationships — will be a Communal Team responsibility, and that FSR team responsibilities begin when the FM-FI stage is reached.

In summary, on the question of institutions, we support regionally deployed FSR teams of a crop agronomist, an agricultural economist and, where appropriate, an animal production scientist. The teams would draw from and feed back to multidisciplinary commodity teams as required by local diagnosis. Strong linkages back to CRTs, and forward to extension, are a vital feature of reorganisation needed to establish such teams. A national FSR coordinator at the headquarter level can be usefully supported by specialists not normally included in commodity teams. Rural sociologists and nutritionists, available to FSR teams on request, are examples of disciplines helping to service FSR in Zambia. Within their regions FSR teams need to work closely with a senior agricultural officer of the ministry. His or her main role is to coordinate the program of the FSR team with extension workplans, and to take initiatives on the policy and planning implications of recommendations emerging from the FSR work. The decision mechanism to make and service new recommendations at the local level is emerging as a gap in several countries of east and southern Africa.

This said — going back to the wedge strategy — entry may be facilitated by extending commodity teams to include FSR. This will be less of a compromise in institutionalisation when two conditions can be fulfilled:

(1) The FSR efforts of such teams can be focused on systems where their commodity dominates resource allocation; and

(2) When a senior professional, strong in FSR, is available to reinforce the commodity team.

Where professional capacity in FSR is weak, caution is needed. Morale is easily reduced by uncertainty in both concept and role. Again, we emphasise that pragmatism and an awareness of the options must dominate the promotion of FSR within national programs.

Attitudes to FSR

Some confrontation is perhaps inevitable in efforts to change institutions. It can surely be minimised by an all-seeing strategy and an advertising and public relations exercise. That confrontations have occurred in the region is partially due to less than perfect diplomacy by would-be salesmen. It has other roots in the attitudes dominating bureaucracies, in higher level education, and in donor activity in the region.

Agricultural establishments are heavily dominated by a technical perspective. Agricultural economists have little representation at the higher levels in many agricultural ministries and planning units are often very subordinate to the decisions of the technical professional at the top. Often trained in the west — or in the east for that matter — farming to them is big fields, straight rows, monocrops, machines and a commercial outlook. Peasants are peasants and rarely perceived as farmers. Even today, university and college curricula are firmly based in large-scale commercial farming. Lip service is paid to the idea of coming to grips with the small farm sectors, but initiatives to base higher agricultural education in a small farm perspective are few and far between. It is seen as a threat rather than a challenge by most agricultural teachers. For example, systems thinking rarely has a place in courses. Indeed some developed country universities have moved further to adjust curricula to the needs of small farming than have many local institutions.

Civil servants tend to be authoritarian and a teacher/pupil juxtaposition dominates research and extension dealing with small farmers. These attitudes manifest themselves in antagonism to ideas which imply a re-ordering of the existing pecking order. Antagonism is aggravated by the difficulty many countries have in controlling donors, who often seem insensitive to national feeling and often seem ruled by fads and fashions. The fact that a single major donor can catalyse a dozen FSR projects in the Eastern and Southern African region over a 5-year period bears witness to fashionability and brow-beating. Money talks. The feeling of being led by the nose brings antagonism against technical assistance in general.

Conclusion

We remain convinced of the value of FSR. However, as we have said for years, we are concerned that it has been oversold. Donor agencies have moved too rapidly in supporting FSR type work before it has had a time to mature. We believe expectations are too high and that results are expected too quickly. Methodologies for resource-efficient ways of implementing FSR are still evolving, and successful institutionalisation of the approach is only likely to be achieved if it is given a much longer time to establish its credibility. Donors have used their funds to precipitate the implementation of FSR and are now turning to its evaluation. There is great danger, if evaluation is done from an academic perspective, without due regard to the slow process of developing national and indeed international capacity, and to the pitfalls of implementation, that the baby will be thrown out with the bathwater.

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Appendix 1

FSR in Botswana, Kenya, and Zambia

Botswana

Botswana had a donor project with 'farming systems' in its title established in early 1976. This project was oriented to the evaluation of improved farming systems and implements — designed on research stations — under farmers' conditions. Its orientation changed as exposure to farmers demonstrated their apathy to the innovations on offer. The country has three other FSR projects: the oldest one is based in extension; the two newer ones, started since 1980, have a more recognisable, bottom-up FSR orientation. Institutionalisation has been weak, perhaps for two reasons: difficulty in establishing credibility and very low number of national professionals to be drawn into FSR.

Poor credibility can be partially attributed to the difficulty of evolving attractive, relevant technology in the harsh unstable climate of much of the country. Station-based experimentation has emphasised intensification, and technologies on the shelf have not usually been useful to the highly extensive strategies followed by Botswana farmers. Yields of sorghum, the starch staple, are about 200-300 kg/ha. Again, Botswana farmers rightly place emphasis on cattle in their farming system, and only one of the FSR projects has seriously addressed the cattle enterprise. Lack of credibility has limited the support for institutionalisation in the upper echelons of the ministry.

Most nationals involved in FSR have diplomas in agriculture. Expatriates working in the country consider a formal training to the MSc level a prerequisite, given the formidable challenge from the environment. Only the latest two FSR projects have had funds for substantial training of nationals. This has often involved upgrading from diploma level, itself a lengthy process. Recently, interest in institutionalising the process has increased and currently a proposal is being prepared for the Ministry of Agriculture by the FSR teams.

Kenya

Kenya has no donor projects in FSR. Following demonstrations of diagnostic procedures in 1976, a national initiative was taken in 1978 when six graduates, with their final year option being in agricultural economics, were recruited and added to commodity teams on six research stations. Six more were recruited in 1979 as agricultural economists. A senior agricultural economist supported by technical assistance was appointed coordinator and he, with CIMMYT, was charged with the development of their skills and the guidance of their work programs. Poor consultation with research station directors hindered program development. A new director of research appointed in 1981 was unconvinced of the need for FSR and the program atrophied over the three years to his retirement at the end of 1983. Under a new research director in 1984, FSR teams were established at 10 research stations. These, together with extension staff from adjacent districts — in total some 50 professionals — have embarked on training programs with CIMMYT assistance.

Zambia

The idea of FSR as a means to foster adoption of technology was introduced to the Ministry of Agriculture and Water Development in 1977. Two demonstrations of diagnostic and target grouping procedures were made in 1978 and 1979. Zambian nationals were sought to form FSR teams. Recruitment was difficult with a low turnout from the agricultural faculty and a high demand from the private sector. In 1981 a new research director institutionalised FSR in the form of regionally based Adaptive Research Planning Teams, and spelled out the relationship with the CRTs. A national coordinator was appointed and the aim over time was to develop to nine Adaptive Research Planning Teams, one for each of Zambia's provinces, each with a crop agronomist and an agricultural economist. The strategy was to build three Adaptive Research Planning Teams with six young Zambian professionals and then divide to provide the nucleus for six teams. Donor interest was strong to the point of being forceful at times, and Zambia now has seven Adaptive Research Planning Teams in seven provinces, each supported by technical assistance and funds from a different donor. Rapid expansion has inhibited the development of effective national professionals and low quality in fieldwork has been compounded by inexperienced technical assistance. Nevertheless, significant strides have been made in experimental capability and in the development of linkages with both CRTs and extension. The most recent development is the appointment of committees at provincial level to approve recommendations emerging from Adaptive Research Planning Team work and to coordinate the servicing of locally approved recommendations.

A Research Paradigm for Systems Agriculture

Richard J. Bawden, Raymond L. Ison, Robert D. Macadam, Roger G. Packham and Ian Valentine*

COMMENCING in the late 1970s a multidisciplinary group of staff at Hawkesbury Agricultural College embarked on what we now understand as an Action Research Project. Our experiences of agriculture in Australia, UK, Asia, Africa and South America convinced us that agriculture is a complicated human activity involving uncertainty and change. From our interactions with farmers and employers across the agricultural sector we increasingly believed that our graduates were not being sufficiently equipped to cope with this complexity and change — to be professional agriculturalists for the twenty-first century (Macadam and Bawden 1985). We were also conscious of Dahlberg's (1979) assertion that the 'conceptual maps that most people have of agriculture fail to recognise it as the basic interface between people and their environments.'

We decided to investigate ways of learning about how to improve problem situations in agriculture. This required the development of insights into the learning-problem-solving- research process, which we elucidate subsequently. Through this process we have come to view problems as 'things that never disappear utterly and that cannot be solved once and for all' (Lakoff and Johnson 1980) in contrast to the present widely held view of problems as puzzles for which, typically, there is a correct solution. To convey this meaning we use here the phrase 'improve problem situations' rather than 'solve problems.'

In this paper we will first outline the conditions in Australian agriculture that led us to decide to adopt a systems approach at Hawkesbury, which we are calling *systems agriculture.*

We will follow this with an outline of the methodologies of the approach and relate these to a psychology of learning. For debate during the workshop, we will present our perception of the relative position of systems agriculture in the spectrum of systems approaches to research in agriculture and postulate a model of influences on their evolution. Finally, we will outline our views on the application of systems agriculture in researching complex problem situations in agriculture.

Dynamics of Australian Agriculture

Our view of Australian agriculture has been aided by authors such as Plunkett (1977), Powell (1977), Longworth (1979), Campbell (1980) and Lawrence and Mackay (1980) who not only revealed the now familiar declining terms-of-trade

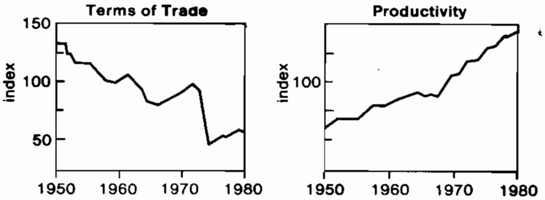

Fig. 1. a) Terms of trade of the Australian farmer 1950–80; b) Productivity growth in Australian farming systems 1950–80.

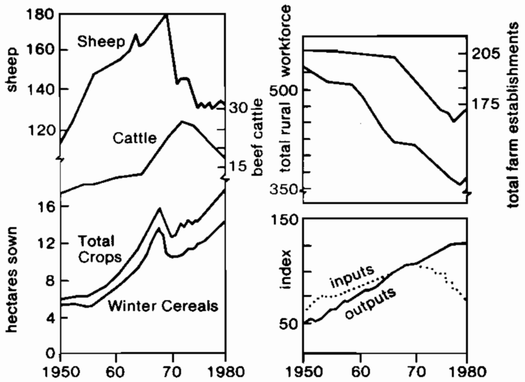

Fig. 2. Structural changes in Australian agriculture 1950–80.

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and associated productivity growth data (Fig. 1a and b) but also provided important insights into reasons for why it had all happened. Briefly, the story, as illustrated in Fig. 2, was as follows:

- Since the early 1950s Australian farmers had been facing declining terms of trade with rises in input costs outstripping the growth in rates of return for farm outputs.
- During the 1950s and 1960s these pressures were met by the adoption of technological innovations based essentially on improved pasture, and the shedding of farm labour.
- Impressive gains were made in the growth of total output during this period, particularly from the livestock sector. This growth strategy was encouraged by governments anxious to earn export revenue for the purposes of balance of payments.
- The 1970s saw a dramatic contrast in this situation occasioned by increased instability in international commodity markets, and acceleration in the rate of decline in terms of trade, and a spiralling inflation in the price of certain inputs.
- The response of Australian farmers during this period was an acceleration, not in output, but in the efficiency with which such output was produced — in productivity. The increased growth in total factor productivity over this time could be related to a further shedding of labour, the exodus of many farmers themselves and a marked cutback in inputs on the remaining restructured farms.
- The restructuring included an increase in scale as well as in the range of farming activities. Through the 1970s cattle were initially substituted for sheep in the pastoral areas and then cropping was substituted for grazing livestock in those areas where this was possible.

Consequently the pressures were increasingly for farmers to become more productive or to leave farming altogether. Government rural policies reflected these dynamics as they shifted from the encouragement of output production towards 'increased productivity, rural reconstruction and adjustment, and economic progress' (Miller 1979).

As the quest for increased productivity was pursued, so farmers and researchers began to detect threats to the stability and sustainability of the systems of production. The increased cultivation associated with the expansion of cropping areas was accelerating the rate of erosion of many soils. Salination was becoming a problem associated with rising water tables through more intense uses of irrigation and extensive clearing. There were disturbing signs that the use of legume nitrogen was contributing to the marked acidification of some soils with resultant loss of pasture productivity and crop production.

If these and other issues indicated that all was not well in the production process of agriculture then there were also signs of discord in the arena of plant and animal protection. Aphids were decimating lucerne crops and fungal pathogens (anthracnose) Townsville stylo pasture, while resistance to many biocides amongst pest and parasite populations was reaching disturbing proportions. The impact of many of the technological innovations of the 1950s and 1960s was beginning to cause anxiety to producers.

The pressures to restructure today are as virulent as they have ever been, yet to merely illustrate such dynamics in statistical terms fails to emphasise the increasing personal tensions that farmers and members of their families were having to face. Studies by Hawkins and Salmon (e.g. Salmon et al. 1978) with their colleagues at Melbourne University and by the group at the (then) Kellogg Rural Adjustment Unit in Armidale did much to highlight the often tragic human face of change. Russell Craig and Basil Sheahan at Roseworthy Agricultural College (e.g. Craig 1983) also drew attention to the human plight of many 'unsuccessful' farmers in South Australia. Meanwhile Makeham and his co-authors popularised how many people were feeling about the situation in farming with the publication 'Coping with Change' (Makeham et al. 1979). On another equally disturbing social aspect, Anderson (1981) was to report on the inadequacies of the conventional diffusion model of extension and its implications for furthering inequities, and thus anxieties among producers.

Anxiety-provoking issues were not confined to concern about the abiotic and biotic components of the ecosystems that farmers were attempting to manage. The increasing instability of world commodity prices was causing severe fluctuations in prices for price-accepting rural producers. Labour disputes and institutional inefficiencies were also adding to disturbances in the export scenes. Meanwhile on the domestic front, internal economic conditions were occasioning changes in the national diet associated with the increased involvement of women in the workforce and the emergence of a demand for take-away food. Unemployment and high internal inflation was also affecting the purchasing power of consumers. Other changes were being fuelled by concern about the role of diet in health, particularly with regard to the possible adverse effects of meat and dairy products.

Finally, and in addition to all of the obvious forces, a number of insidious cultural forces were also at work. Many of these emanated from the cities and they threatened to heighten the isolationism of those in the rural sector that the declining economic and thus political role of agriculture was occasioning. The early rumblings of the urban-based animal rights movement was becoming a roar and environmental protectionists were forcing farmers onto the defensive. Complex cultural issues such as land rights and rural land utilisation were yet further dimensions to the extremely complex nature of the environment in which farmers were operating in the late 1970s.

It must be admitted that much of the interpretation of these cultural and social impacts was speculative and derived mainly from the media. But that in itself seemed to us at Hawkesbury both an indictment of the thrust of the two hundred million agricultural research dollars, and a stimulus for the emergence of a new approach to improving agricultural problem situations. We determined to view farmers and the members of their families as the subject of help through research rather than merely one of the components of the farming system to be objectively improved!

Systems Agriculture — Hawkesbury Approach

Neither agricultural science, with its largely reductionist, discipline-based emphasis, nor management science with its focus on optimising productivity and farm income, appeared able to encompass the interactiveness of the (farmer × natural environment × social environment) complex that the Hawkesbury group had begun to identify. We felt that if progress was to be achieved in the concurrent development of productive yet stable and sustainable systems of agriculture in this country, then it was unlikely that the conventional model of research and extension was adequate. This spurred our interest in pursuing the conceptual basis of research approaches and how they related to fundamental tenets of learning, problem solving, managing change, and the extension process.

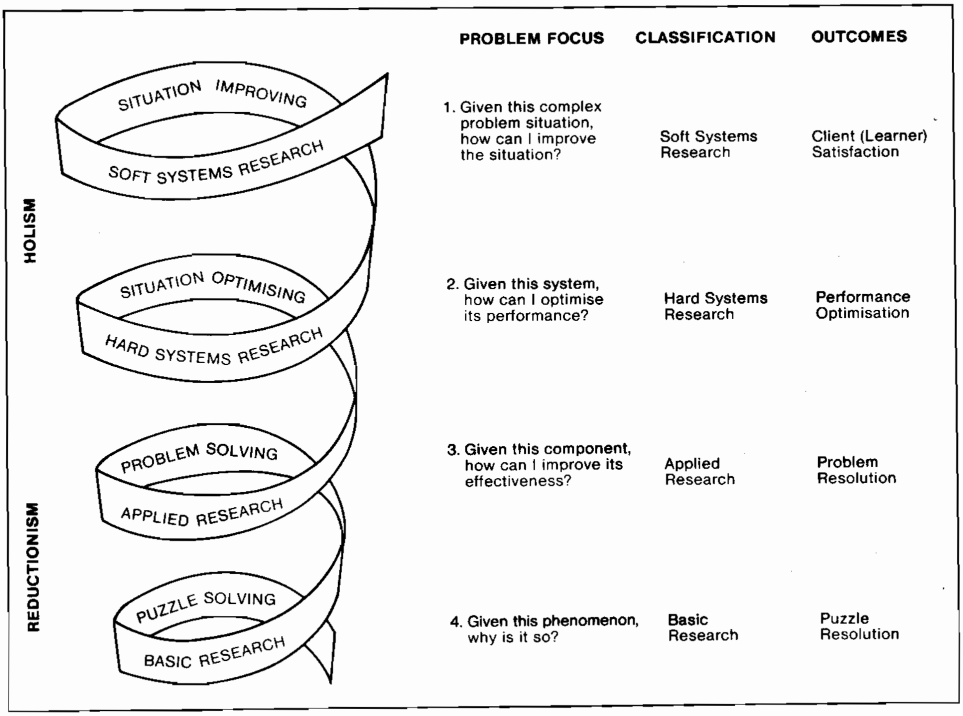
We came to a conclusion, shared by others (Huxley 1976a 1976b; 1982; Altieri et al. 1983; Potts et al. 1983) that a new breed of professional agriculturalist was needed who could view agricultural issues with a sense of their complex wholeness, and who could take effective action that would lead to feasible and desirable change (Bawden and Valentine 1984). Systems thinking and practices seem to provide an appropriate perspective, so we investigated those systems-based research approaches in use in agriculture obvious to us at that time:

- *Agroecology and the management of applied ecosystems* These approaches it seemed to us, were concentrating too heavily on energy relationships within farming systems. The use of this parameter for the measurement of efficiency and stability of farming systems seemed to us to be too conceptual to be of practical use for improving real-world problems. Furthermore, we believed that they failed to conceptualise the process of management.
- *Systems analysis in farm management* This approach to designing optimising models of farming systems seemed to encompass two questionable assumptions: (i) That farmers made decisions only to optimise the performance of their farming systems and, (ii) that farmers would readily adopt any strategies that the output of such models indicated as desirable. Thus the systems analysis approach also seemed remote as a practical instrument for improving problem situations on farms.
- *Simulation modelling and systems research* There were in vogue a number of biological and economic simulation models that had been constructed with a knowledge of the form, function and dynamics of basic biological functions and their economic relations. These models certainly had a role to play, especially in explaining complex interactions, but they still did not satisfactorily meet our needs for a practical tool for farm level improvement.

While each of these approaches had a number of strengths, none involved the farmer in the research process. Furthermore, although claims were made for the essential holism of the approaches, many of the methodologies belied this sentiment. Only the agroecological approach seemed to concern itself with the possible impact of technological innovation, yet its utility was lost for us in its abstract focus on energy relationships. We continued our quest for approaches that would complement both reductionism and the systems approaches as above but which allowed us to embrace both the physical ecosystem that farmers manipulate and the socioeconomic systems with which they interface.

We subsequently became aware of the Applied Systems Research Group at Lancaster University in the United Kingdom. Their 'soft systems' methodology (Checkland 1981) had an attractive potential for us in dealing with agriculture as a complex and purposeful activity. The soft systems approach relates to situations where there is uncertainty or even conflict about what constitutes the problem in the first place and thus what actions are appropriate to improve it. This contrasts with the hard systems approach, which deals with situations where there is a clear statement of purpose.

From this we have developed the concept of a hierarchy of methodologies for researching problems of increasing complexity (Fig. 3); the basis of this development is reviewed by Bawden et al. (1984). The methodologies range from reductionist to holistic, and choice of approach by a systems agriculturalist is contingent upon the problem situation or the stage in the research process. A range of research methodologies exists at each level. At the soft systems level we have found the Checkland methodology (Fig. 4) to be useful as an entry point into complex problems (Checkland 1981; Macadam and Bawden 1985; Macadam et al. 1985). An attraction this has for us is its emphasis on informed debate about desirable and feasible change among actors, that is the key participants, in the problem solving process. This



PROBLEM FOCUS	CLASSIFICATION	OUTCOMES
1. Given this complex problem situation, how can I improve the situation?	Soft Systems Research	Client (Learner) Satisfaction
2. Given this system, how can I optimise its performance?	Hard Systems Research	Performance Optimisation
3. Given this component, how can I improve its effectiveness?	Applied Research	Problem Resolution
4. Given this phenomenon, why is it so?	Basic Research	Puzzle Resolution

Fig. 3. The Hawkesbury hierarchy of approaches to problem solving and situation improvement.

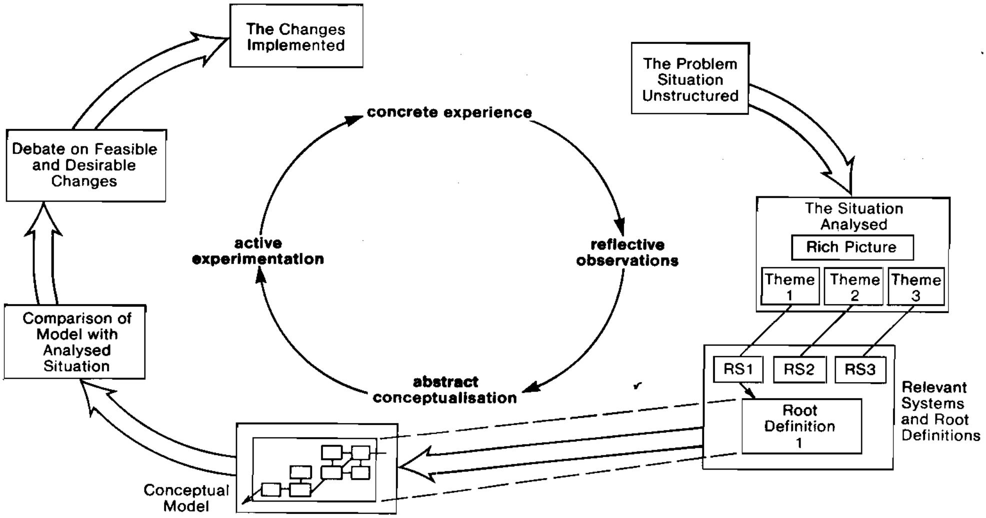


Fig. 4. The relationship between learning (inner circle: after Lewin 1946) and the Lancaster methodology for problem-solving (outer circle: after Checkland 1981).

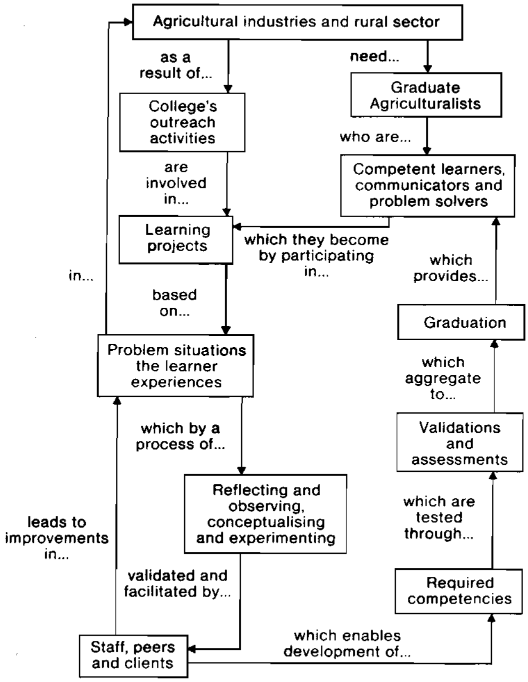


Fig. 5. Program design and the interaction between the needs of agriculture and the rural sector, education of graduates to meet the need, and the experiential learning process.

is compatible with the emphasis on learning within the Hawkesbury Approach.

We view learning as an active transformation process, in which people attempt to make meaning out of their changing environment. Learning needs to be life-centred, and is most successful when it is viewed as a process of mutual enquiry between learners and others (Tough 1971), following clearly established principles of adult learning (Knowles 1978; Brundage and Mackeracher 1980). Lewin (1946) viewed research, problem solving and learning as the same process, and he developed a four-step cyclical model to illustrate this. We have found this model useful in our approach, and this development is shown in Fig. 4, overlaid by the steps of the Checkland methodology to emphasise our interpretation of the connection between the learning process and research.

Our understanding of Action Research is compatible with that of Lewin (1946) where the focus is action to solve a problem or improve a situation, and the research is the conscious effort, as part of the process, to formulate concepts and generalisations that can be applied in other situations. It also has an educational function when the owners of the problem collaborate in the process. The effectiveness of action research in rural development has been measured (Tandon and Brown 1981) and is the basis for a

Chulalongkorn University Social Research Institute and East-West Center Resources Systems Institute rural energy development program (Pongsapich and Bajracharya 1983).

Action Research at Hawkesbury has concentrated on the development of a set of educational programs (Bawden and Valentine 1984) and a compatible organisational structure (Macadam et al. 1985; Macadam and Bawden 1985). The *action* has been directed to these ends and the *research* outcome is the conceptual framework that underpins the Hawkesbury Approach. The educational strategy we have developed to link the complex reality of agriculture and learning how to manage it is shown in Fig. 5. This is the strategy on which our learning programs are based.

A further example of research outcomes at Hawkesbury is the conceptual models which reflect Dahlberg's (1979) view of agriculture as an interaction between natural and social systems (Fig. 6a) and Checkland's (1979) concept of a human activity system that we have transformed into a generalised model of farming as a human activity system (Fig. 6b). The latter model assumes that farming is concerned with the manipulation and management of ecosystems to meet the often ill-defined goals of the people managing the process. Thus management results in a transformation of inputs into outputs, the success of the management process being judged not by the efficiency of this transformation, but by the degree to which there has been a successful attainment of the overall complex of the goals of the people (their purpose). Achievement of systems purpose may be constrained or enhanced by a range of forces that can rarely be manipulated but, if understood and recognised as dynamic entities, may result in more effective attainment and reassessment of system purpose.

The starting point in the Hawkesbury Approach is when the researcher joins with an individual or group of people who are concerned about their situation. The situation is more likely to be characterised by a collection of many different

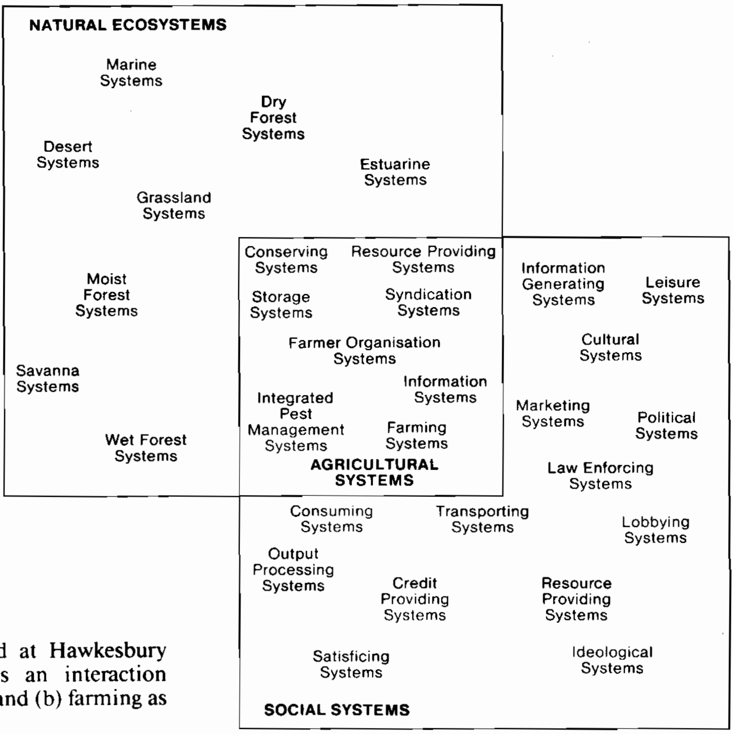


Fig. 6. Conceptual models developed at Hawkesbury which represent (a) agriculture as an interaction between natural and social systems and (b) farming as a human activity system.

types of problems, rather than as a single issue, and the source of the investigation is a sense of unease among the clients. This is the usual starting point in the action research process and because there is confusion about the cause of the trouble and uncertainty about how to respond, a soft systems approach is an appropriate way to begin.

Using this approach over 150 students have already been involved in the analysis of problem situations on farms in this State and beyond. Students in the undergraduate degree program spend a semester on a farm or other appropriate off-campus situation midway through the program. They have a brief to: (a) do a systems analysis of the situation; (b) negotiate a 'contract' with the manager about learning (research) projects arising from the analysis that have potential for improving the situation, and (c) pursue the project(s) when they return to College while (i) maintaining contact with the manager and validating the practical value of the work; and (ii) validating the learning outcomes with academic staff. Their experiences and their interaction with us have led us to refine the Hawkesbury approach.

An outline of how the approach might be used to tackle a common problem for research directors, that of deciding on priorities for research, is illustrated in Fig. 7. The first step would be a holistic and thorough analysis of the problem situation. This would then lead to judgments on themes that have the most potential for improving the situation. Conway's (1983) Agroecosysten Analysis seems to us to be a good method for structuring this analysis for agricultural research purposes. It begins without preconceptions of the nature of the problem and is structured in a way that leads to an exchange of information and meaning between disciplines. It has as its outcome 'a set of agreed questions for further research or alternatively a set of tentative guidelines for development.'

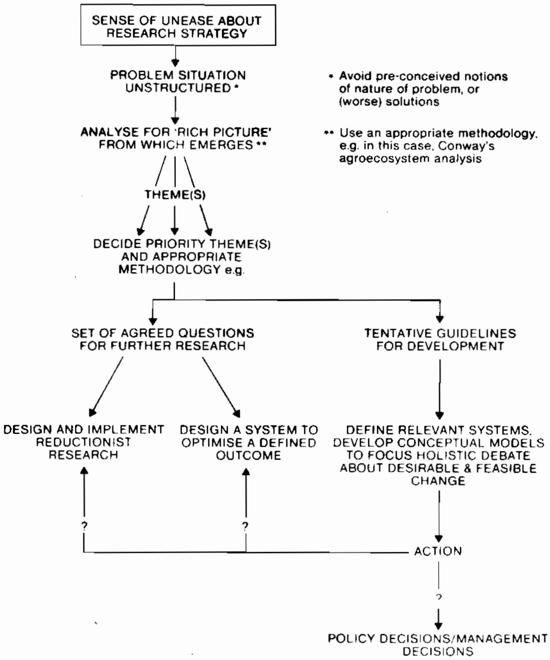


Fig. 7. An example of how the concept of a hierarchy of methodologies would be implemented in tackling the problem of deciding priorities for research.

The concept of a hierarchy of approaches for research (Fig. 3) is of particular significance at this point. If the questions for further research lend themselves to a reductionist approach there are well developed methodologies for further work. Where a reductionist approach is not appropriate the techniques of defining and developing conceptual models of systems that are relevant to the tentative guidelines for development is an appropriate starting point. The techniques for doing this have been developed by Checkland and his colleagues (Smyth and Checkland 1976; Checkland 1979). These models are then used to give reluctant people a new perspective and to focus informed debate about feasible and desirable change. It is likely that this will raise issues of institutional or organisational politics and these have to be taken into account if effective decisions are to be made.

A fundamentally important aspect of this whole process is the shaping of the perceptions of participants such that they develop a holistic perspective within which they can make their particular contribution.

In summary, the Hawkesbury Approach is an Action Research one where the aim is to improve the problem situation by facilitating learning and decision-making by the participants. A range of research methodologies, some reductionistic and some holistic, are utilised.

A Taxonomy of Systems Approaches

Spedding (1979) has suggested that 'as agricultural research and development are generally aimed at the improvement of systems . . . success depends upon being clear: (i) what constitutes an improvement; and (ii) about exactly which system

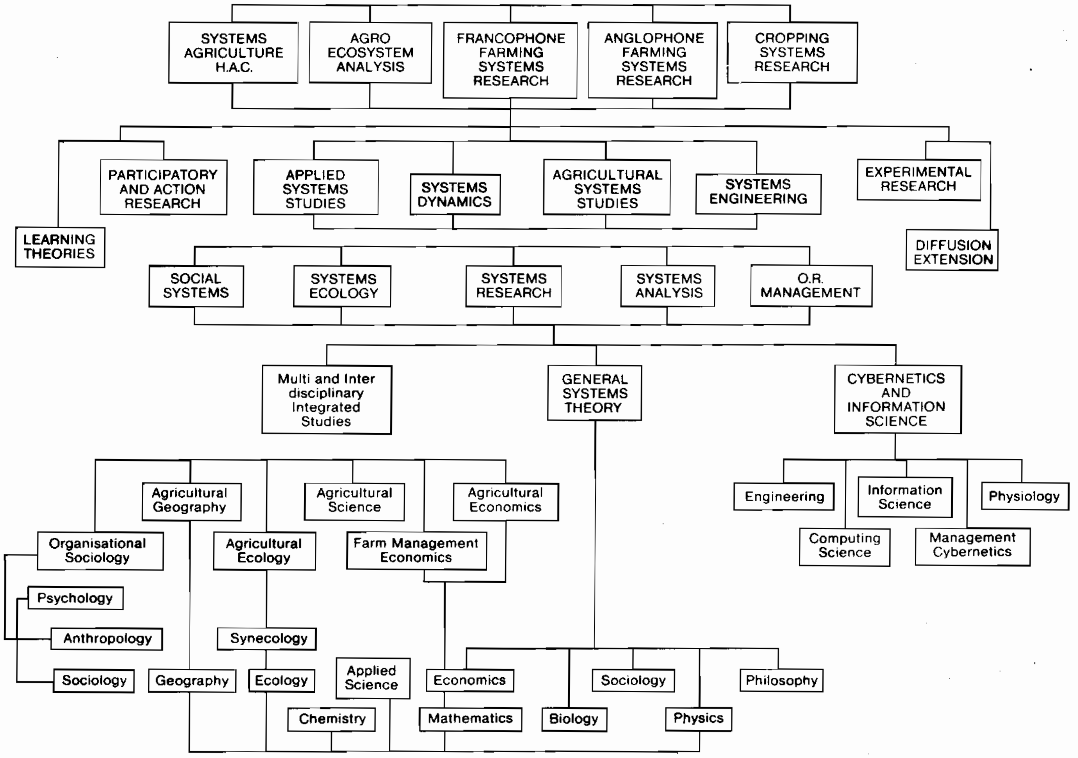


Fig. 8. A model of influences on the development of systems approaches to problem-solving in agriculture.

is being improved.' With the implicit variability around these two issues and the heterogeneous nature of the systems movement, it is not at all surprising that a variety of different systems-based methodologies for agricultural research have been developed. Our own selection of a systems paradigm has evolved and continues to evolve to meet our purpose. In the process of its development we have had cause to consider and often draw from many systems approaches. We therefore feel it is important to illustrate the general relationships we see between the Hawkesbury Approach and a number of other systems-based agricultural research methodologies.

As illustrated in Fig. 8 we believe that it is convenient to recognise five main such approaches which, although united by their underlying concern for systems and their properties, differ in the ways by which those properties are examined. We submit that the five represent the sort of spectrum that Checkland (1981) has referred to, from those 'relatively hard systems characterised by easy-to-define objectives, clearly defined decision-taking procedures and quantitative measures of performance' (e.g., cropping systems research) to 'soft systems in which objectives are hard to define, decision taking is uncertain, measures of performance are at best qualitative and human behaviour is irrational' (systems agriculture).

This distinction between hard and soft systems by Checkland (1981) closely approximates the distinction by Ackoff (1973) between purposive (clear goals) and purposeful (willed) systems. In a review comparing Anglophone and Francophone (see below) approaches to FSR and extension, Fresco (1984) makes the following observations:

- *Cropping Systems Research* concentrates on the cropping subsystem and seeks technologies that will increase production by either the introduction of improved management practices into existing systems or the introduction of additional crops. Its focus is on all of the components (physical, biological, technological, labour and managerial) required for the production of the set of crops on a farm and the relationship between them and the environment (Zandstra et al. 1981).

- *Anglophone FSR* is primarily concerned with the adaptation of existing agricultural research to provide technology relevant to low resource, low external input farmers. The emphasis is on the whole farm as a system and focuses on (i) interdependencies between the components under the control of members of the farm household and (ii) how these components interact with physical, biological and socio-economic factors not under the household's control (Shaner et al. 1982).
- *Francophone FSR* constitutes an integral part of a long-term, country-wide rural development effort. The emphasis here lies on developing the potential of a (sub-) region in which technology provides a starting point. On the basis of an assessment of this potential, i.e., the maximum production that can be achieved given the ecological conditions and optimal input and management levels, this approach defines the steps that will lead farmers to a complete transformation of their farming systems (Fresco 1984).

Fresco points out that the essential difference between these three approaches appears to be scale and time-frame. We believe that a fundamental distinction between them, in both their perspectives and methodologies, reflects the fundamental systems concept of emergent properties in hierarchical relationships. In other words, each of the three approaches addresses different levels within a systems hierarchy, extending from the cropping subsystem through the whole farm to the larger regional aggregation of farms in conjunction with institutional infrastructures. These three approaches are more typical of Checkland's hard systems in that the assumption is made that the research will lead to the purpose of improved productivity at whichever of the three levels one focuses. The agroecosystem and systems agriculture approaches do not assume that the purpose of the research is to increase productivity, and as a result enable researchers to develop creative insights about the nature of the problems. Thus, in his description of the agroecosystem analysis methodology Conway (1983) reports:

- *Agroecosystem Analysis* is developed from the basic concepts of systems analysis 'encouraging wide and easy participation and the flow of new ideas and insights.' Although Conway argues that it is not intended as an alternative to FSR but a 'technique that can be used within the framework of that approach' we believe that it rates as a methodology that complements the other approaches while embracing their essential thrusts. The agroecosystem approach encourages the definition of the problem situation by the researchers as a first step before the system is identified and its properties, especially productivity, stability, sustainability and equitability, are examined. This brings a special flexibility to the approach and emphasises the importance of the concepts of hierarchy and emergent properties (Conway 1983).
- *Systems Agriculture* has been defined 'as the application of systems approaches to the improvement of problem situations in agriculture' (Bawden and Valentine 1984). Like the agroecosystem and francophone farming systems approaches, it does not focus its attention in the first instance on any farming systems per se. Rather it is concerned with the identification of problem situations by the participants themselves. It is clearly an action research approach with the researcher acting as a facilitator of the learning processes of the client participants. As has been outlined earlier, it embraces a spiral hierarchy of methodologies the use of which will be contingent on the nature of the problem situation being investigated. Frequently, it utilises the Lancaster soft systems methodology as its first gambit and this reflects its focus on agriculture as a human activity system.

Clearly these five approaches have much in common and they are certainly complementary to each other. All of them provide a focus for multidisciplinary studies, yet each also demands a comprehension of a commitment to systems thinking and systems practices. We feel that it is important to emphasise this point as we believe that the systems movement is much more than an integrating mechanism to bring researchers of different disciplines to work together on different aspects of the same problem. Rather it reflects a fundamental shift in the way most of us have been educated to think and learn. Systems thinking is rooted in the philosophy of holism, and according to Checkland (1981) is founded upon two pairs of ideas 'those of *emergence and hierarchy* and of *communication and control.*' We have avoided the temptation of ascribing one set of major influences on any of the research approaches we recognise but prefer to view each as a distillation of many. It is worthwhile, however, emphasising our view of the three major sources in systems thinking, (i) cybernetics and information science, (ii) general systems theory, and (iii) integrated studies from multi- and interdisciplinary endeavours; which we believe form the basis of the systems practices outlined higher in the scheme.

Application of Systems Agriculture

It is now pertinent to consider the application of systems agriculture and its relevance to research. We do so tentatively and with the realisation that ours is an emerging paradigm that has yet only been validated in action research projects within our own institution and to some extent by the research of our students. Two examples of these relate to the reorganisation of our School and to a student learning project carried out with a dairy farmer and his family.

The first began in 1983, and arose in response to a chronic sense of dissatisfaction among staff and students with the way the School was meeting the learning needs generated by a range of new curricula. The project, described by Macadam et al. (1985) comprised a series of sub-projects that led to a consensus among staff about the need for, and details of, a radical restructuring of the School. A mismatch between organisational structure and functional needs of the new programs had been clearly identified. The projects were guided by soft systems methodology (Fig. 4). It led to both client satisfaction and learning outcomes as to how to apply the methodologies and techniques. The School moved from an organisation based on discipline departments to matrix management based on functions of resource provision and academic servicing. Underlying the whole organisation was a theme of participative management.

The second project arose as a consequence of a one semester off-College, on-farm phase of the agriculture degree program (Bawden and Valentine 1984). The female student worked on a dairy farm in coastal New South Wales during which data and experiences were collected for a farming systems analysis (Hollis 1985). On return to College and following the experiential learning process (Fig. 4) she reflected on the experience looking for ways to improve her host's situation as well as enhancing her own learning. Despite collection and analysis of a range of technical data the student remained unconvinced that these factors were constraining the attainment of this farming system's purpose (Fig. 6b). An issue of poor communication between the three households which made up this family farm was identified, which, in the student's opinion, threatened the sustainability of the family unit due to the varying expectations of the family members. To achieve an improvement in the situation the student had to first conceptualise the whole process of communication by reading appropriate material and working with staff experts in this area. She then devised an action plan based on these concepts and those of soft systems methodologies, which involved facilitating a meeting of all the farm family members. While the process entailed a high degree of risk, it was well thought out and carried through. The outcomes were twofold — a marked improvement in the farm situation, validated by the farmer, due to the student helping the farmer and his family learn more about their own situation, and secondly considerable learning for the student. This is a successful but by no means unique example of action research projects undertaken by our students. It is our belief that this approach will lead to long-term benefits to agriculture based on helping people learn to make sense *themselves* of their own situation.

In Australia, one has only to read or view the daily news or travel to rural communities to understand the complexity of problems facing farmers, and their overwhelming sense of unease about their situation. There appear to us no easy answers, given the basic inelasticity of demand for agricultural commodities, the continued decline in farmers' terms of trade, and the isolation of much of the developed world's agriculture from market forces. Perhaps of more importance for the current generation of farmers is the threatened decline in the value of their major asset, their land.

There has also been a failure by Australians to adapt their own successful agricultural technology to fit the economic and social requirements of client countries (e.g. Chatterton and Chatterton 1984), and to provide education that is more relevant to developmental needs, with concomitant benefits to Australian students and the Australian economy (Commonwealth Government 1984). Given the situation that we have outlined for Australia's farming systems, which appears to apply to the agricultural sector of most industrialised nations, we feel apprehensive about the continuance in developing countries of a research approach that has largely focused on increasing productivity and which excludes the farmer from the research process.

Within the countries with which ACIAR is involved and among researchers with experience of these systems, are many calling for the alteration of the present paradigm to enable sustainable rural development (Woods 1983; Castillo 1983; Coombes and Ahmed 1974; Bunting 1983). They see the emphasis on agricultural productivity as too narrow a focus. If the aim is sustained development, then technological approaches are unlikely to succeed without accompanying development of the human resource. A development strategy that has human development as a central rather than a peripheral concern is needed. This suggests to us the need for a compatible agricultural research and extension paradigm and we believe *systems agriculture* has much to offer.

The recent review by Biggs (1985) highlights the range of constraints facing the farming systems movement. The problems of institutional constraints to systems research and the need for effective training have also been highlighted during this workshop and they are largely soft problems. These problems surrounding the development of the movement may be a fruitful area for application of the systems agriculture paradigm.

Conclusion

Systems agriculture because of its essential thrust of learning/research/action — 'the triangle that should be kept together' in the words of Lewin (1946) — offers a research strategy to address complex agricultural issues. Given the major changes that are now confronting Australian farmers, they deserve to be involved as participants in the action research process so that they might understand where their systems are going and what the outcomes are likely to be. Australia can provide research expertise at all four levels (Fig. 3) in the hierarchy of *systems agriculture* relevant to the needs of those countries with which ACIAR is involved. Much more should be done to develop soft systems research methodologies that will enable the definition of appropriate ways to proceed to improve complex agricultural situations.

We hope for further development of our paradigm aided by: (i) an increasing network of support both nationally and internationally; (ii) the development of post-graduate programs where the research focus will be client-based action research projects; (iii) the establishment at Hawkesbury of an Applied Systems Research Institute to undertake systems agriculture-based research; and (iv) the application for funds for action research projects from traditional agricultural research funding sources.

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Agricultural Ecology and Farming Systems Research

Gordon R. Conway*

THE linkage between agriculture and ecology is as old as agriculture itself. Ecological knowledge played a crucial role in the transition from hunting and gathering to settled farming and in the evolution of swidden agriculture. Roman agriculture was firmly based on ecological principles as, later, was the New Husbandry of 18th century Britain. In the tropics, today, the linkage is clearly apparent in a multitude of successful traditional farming systems ranging from the rice terraces of the Ifugao to the home gardens of Central Java. Yet the history of agriculture demonstrates that there can be important periods of development when the linkage is effectively broken and ecological principles are ignored and overridden. This happened, for example, in India in the 19th century when a technological revolution all but failed due to a disregard for critical ecological and social factors, and early in this century American farmers created a dust bowl out of the midwestern states through a mistaken belief in the unlimited resilience of soil and water resources.

In the past, such breakdowns of communication and understanding have been relatively restricted geographically. Thus right up until the Second World War, while the dust bowl was being created in the midwest, European agriculture was developing on the principles of conservation and husbandry, and in the tropics colonial plantation agriculture, while highly exploitative in social terms, was relatively sound ecologically. But since World War II we have experienced a revolution in agriculture on a global scale. High farm incomes in the West and food self-sufficiency in the Third World have been sought through a combination of new technology (agrochemicals, agricultural machinery and new varieties) and massive government aid, in the form of direct subsidies in the West and infrastructure development in the Third World. The results in productivity terms have been spectacular. Yields in the West have grown almost exponentially (the average wheat yield last year for the UK was 7.5 tons/ha) and in the Third World, overall, food production has kept ahead of population growth (per capita agricultural production has risen by over 8% over the past two decades) and several countries, particularly in Asia, are close to cereal grain self sufficiency. But these successes have been accompanied, throughout the world, by a growing array of ecological and social problems (Conway 1984).

The success of the Green Revolution in the Third World was engineered by concentrating on breeding programs utilising high payoff genetic characteristics, and then distributing the new varieties, together with inputs of fertilisers and pesticides, to farmers in the best favoured agroclimatic regions and with the best expectations of realising the potential yields. However, this narrow emphasis, so crucial to success in productivity terms, has largely ignored both environmental and socioeconomic heterogeneity. As a consequence, there has been an inevitable mismatching of agricultural development and the needs and potentials of individual localities. The effect has been to create a coarse-grained agriculture, manifest in a large scale uniformity of crop varieties and techniques of cultivation.

The accompanying problems have received increasing recognition and attention. Some, such as the recurrent pest and disease outbreaks, soil erosion, declining soil quality, pollution and increasing inequity, can be more or less directly attributable to the Green Revolution itself; while others, such as desertification, salination and widespread malnutrition and famine, have persisted because the revolution so far has offered few solutions.

The conventional approach has been to tackle these problems individually as they arise. But there is now a growing realisation that they are essentially systemic problems, linked to each other by basic agroecological and socioeconomic pro-

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cesses and caused, in many instances, by fundamental incompatibilities between these processes and the introduced technology (Conway and McCauley 1983; KEPAS 1984).

A good example of the ramifying consequences of introduced technology has recently been provided by Senanayake (1984) from Sri Lanka (Fig. 1). The replacement of buffalo power by tractors involves at first sight a trade off between timely planting and labour saving, on the one hand, and the provision of milk and manure, on the other. However, associated with buffaloes are buffalo wallows, which in turn provide a surprising number of benefits. Loss of these benefits could then result in responses, such as increased pesticide use to kill mosquito larvae, which might generate further adverse consequences, and so on. In the final analysis, the substitution of tractors for buffalo may still be justifiable, but probably only if it is linked to complementary programs in multiple cropping, integrated pest management and agroforestry.

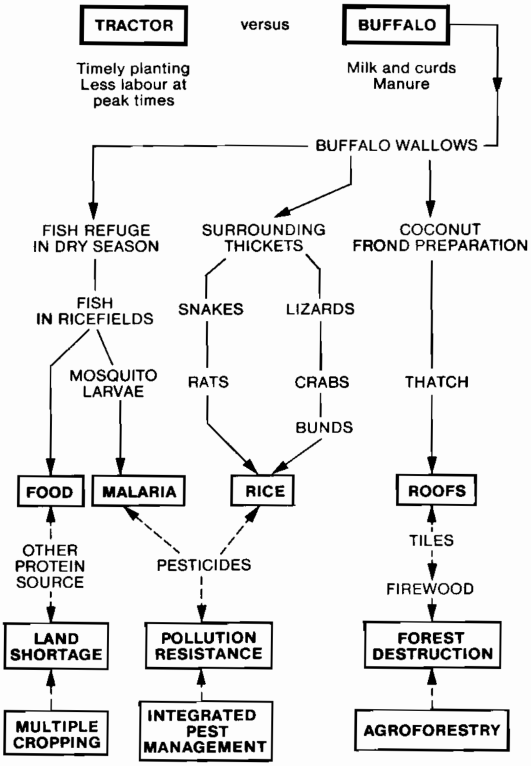

Fig. 1. Issues involved in the substitution of tractors for buffalo power in Sri Lanka.

Inevitably, the agricultural revolution is also beginning to run out of steam. The incremental returns to the varieties and inputs on which the revolution depends have begun to diminish. Yield plateaus appear to be being reached, and high oil prices have begun to put the costs of the critical inputs, fertilisers, pesticides and agricultural machinery, on which the increased production is heavily dependent, beyond the reach of farmers with poor access to credit. Partly for these reasons, the focus of development is also increasingly shifting to the so-called marginal lands (Conway et al. 1983). Here the new technologies are particularly inappropriate and, as experience has already shown, their application, either directly or indirectly, may often worsen an already fragile situation.

The next phase of agricultural development would thus seem to require a radically different approach, one that is holistic and also more sensitive to the complexities of agroecological and socioeconomic processes. The payoffs would come from the breeding of specifically adapted varieties and the design of inputs and techniques specially tailored to the needs of specific agroecosystems, at the level of the region, the farm and indeed the field. The target would be a more fine-grained agriculture, based on a mosaic of varieties, inputs and techniques each fitting a particular ecological, social and economic niche.

To date there have been two significant responses to this challenge as it applies to the Third World. The first has been FSR, characterised by its focus on the small farm as the basic system for research and development, and by the strong involvement of the farmers themselves at all stages in the R and D process. The second response has been integrated rural development (IRD), which is even more holistic in scope, focussing on projects that go beyond improving agriculture to encompass fish, forest and handcraft production, for off-farm employment, and the provision of health, education and other communal services. In practice IRD projects are commonly seen as means of improving coordination and better working relations between different government agencies.

In this paper I present a third approach, Agroecosystem Analysis and Development (AAD). This differs from FSR and IRD in two important respects. First, it can deal with all levels in the hierarchy of agroecosystems, from field through farm, village and watershed, to region and nation. Second, it provides a technique of analysis and packages of technology that focus not only on productivity, but also, explicitly, on other indicators of performance — stability, sustainability and equitability — and on the trade offs between them. However, it is not intended as an alternative to FSR or IRD, but is offered as an approach that can be used within the framework of FSR or IRD and indeed in any multidisciplinary agricultural R and D program, at whatever level of intervention.

Agroecosystem Analysis and Development is based on the disciplines of agricultural ecology and human ecology, and in this paper I begin with a presentation of some of the key concepts. This is followed by a summary of the method of analysis, giving examples of its application drawn from several workshops held in recent years in Indonesia and Thailand. I then discuss the challenge of agroecosystem design and development and conclude with some comments on implementation.

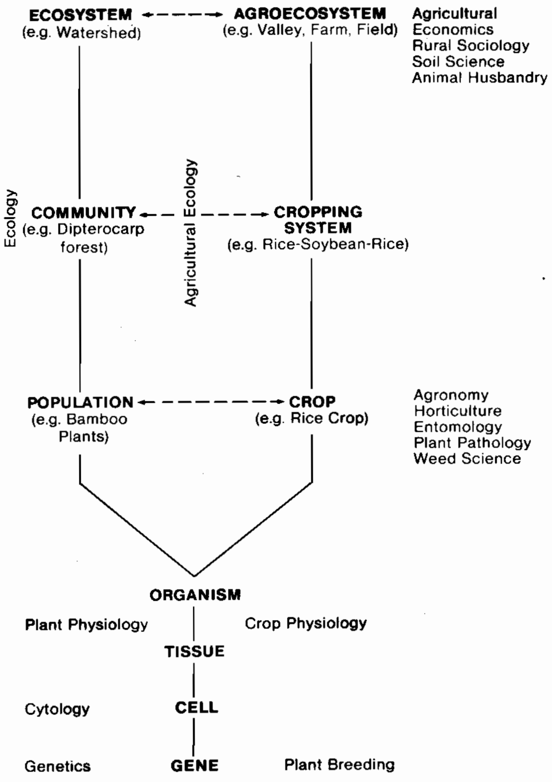

Fig. 2. The hierarchies of biology and agriculture and their related disciplines (KEPAS 1984).

Agricultural Ecology

We can conceive of the natural living world as a nested hierarchy of systems from the gene through to the ecosystem (Fig. 2). In the process of agricultural development, these systems are modified for the purpose of food or fibre production, so creating hybrid agroecosystems. They too can be arranged in a hierarchy. Agricultural ecology provides the bridge between the two hierarchies, linking the pure ecology of natural living systems with the multiplicity of disciplines that lie within the broad remit of agriculture. Human ecology provides the bridge between both these hierarchies and the heirarchy of social systems — family, kin group, tribe, etc.

Table 1 lists some of the topics that fall within agricultural ecology and the agricultural disciplines with which they are traditionally linked.

Table 1. Agricultural disciplines and examples of ecological topics with which they are concerned (KEPAS 1984).

Agricultural discipline	Ecological topics
Agronomy and horticulture	Crop competition
Weed science	Crop–weed competition Weed ecology Biological control of weeds
Agricultural entomology	Crop–pest interactions Insect ecology Biological control Integrated control
Plant pathology	Crop–disease interactions Disease epidemiology Biological control
Plant breeding	Gene–environment interactions
Soil science	Soil ecology
Animal husbandry	Livestock–vegetation interactions

However, agricultural ecology is now becoming more than a simple umbrella for disparate ecological topics. Drawing on the concepts of systems analysis and modern theoretical ecology, and in collaboration with human ecology, it is beginning to provide an understanding of the behaviour and dynamics of agroecosystems that can be applied to the practical problems of agricultural analysis and development.

The transformation of an ecosystem into an agroecosystem involves a number of significant changes. The system itself becomes more clearly defined, at least in terms of its biological and physicochemical boundaries. These become sharper and less permeable, the linkages with other systems being limited and channelled. The system is also simplified by the elimination of much of the natural fauna and flora and by the loss of many natural physicochemical processes. However, at the same time, the system is made more complex through the introduction of human management and activity.

An example of an agroecosystem that illustrates these points is the ricefield (Fig. 3). The water-retaining dyke or bund forms a strong, easily recognisable boundary, while the irrigation inlets and outlets represent some of the limited outside linkages. The great diversity of wildlife in the original natural ecosystem is reduced to a restricted assemblage of crops, pests and weeds. The basic ecological processes, such as competition between the rice and the weeds, herbivory of the rice by the pests and predation of the pests by their natural enemies remain, but are now overlain by the agricultural processes of cultivation, subsidy, control and harvesting. Essentially the same picture can be drawn for higher levels in the hierarchy of agroecosystems, for the farm, village or watershed, but the increasing complexity of the interactions makes a simple representation difficult, if not impossible.

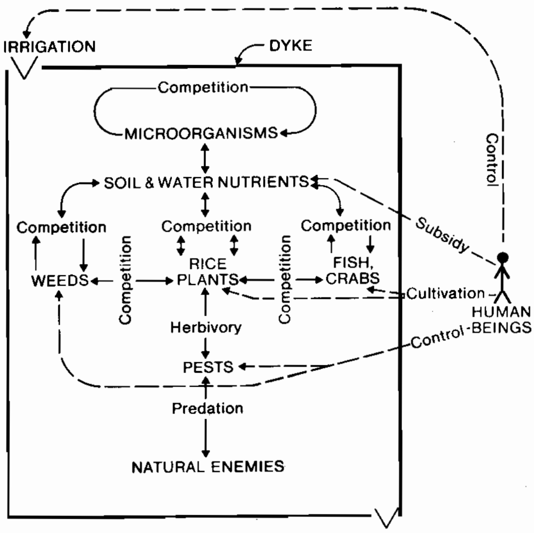

Fig. 3. The ricefield as an agroecosystem.

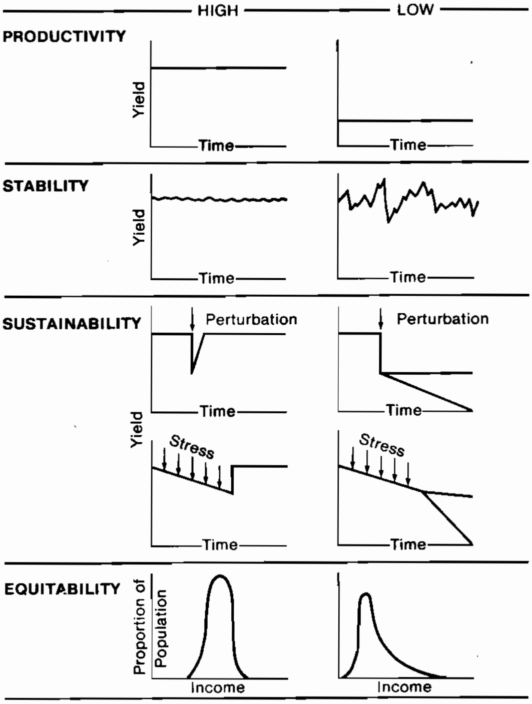

Fig. 4. The system properties of agroecosystems (Conway 1985).

Agroecosystem Properties

However, this complexity, at least in terms of its dynamic consequences, can be captured by four system properties which, together, describe the essential behaviour of agroecosystems. These are productivity, stability, sustainability and equitability. They are relatively easy to define (Fig. 4) although not equally easy to measure:

Productivity is the net increment in valued product per unit of input, and is commonly measured as annual yield, net income, or gross margin.

Stability is the degree to which productivity remains constant in spite of normal, small-scale fluctuations in environmental variables, such as climate, or in economic conditions; it is most conveniently measured by the reciprocal of the coefficient of variation in productivity.

Sustainability can be defined as the ability of a system to maintain its productivity when subject to stress or perturbation. A stress is here defined as a regular, sometimes continuous, relatively small and predictable disturbance, for example the effect of growing soil salinity or indebtedness. A perturbation, by contrast, is an irregular, infrequent, relatively large and unpredictable disturbance, such as is caused by a rare drought or flood or a new pest or a major political upheaval. Unfortunately, measurement is difficult and can often only be done retrospectively. Lack of sustainability may be indicated by declining productivity but, equally as experience suggests, collapse may come suddenly and without warning.

Equitability is a measure of how evenly the products of the agroecosystems are distributed among its human beneficiaries. The more equitable the system the more evenly are the agricultural products, the food or the income or the resources, shared among the population of the farm, village, region or nation. It can be represented by a statistical distribution or by a measure such as the Gini coefficient.

Evolution of Agroecosystems

These four properties are essentially descriptive, summarising the status of the agroecosystem. But they can also be used in a normative fashion, as indicators of performance, and in this way can be employed both to trace the historical evolution of an agroecosystem and to evaluate its potential, given different forms of land use or the introduction of new technologies.

Experience shows that in agricultural development there is almost inevitably some degree of tradeoff between the different system properties. New forms of land use or new technologies may have the immediate effect of increasing productivity, but this is often at the expense of lowered values of one or more of the other properties. There are, almost invariably, significant tradeoffs involved between productivity and stability on the one hand and sustainability and equitability on the other, and indeed between all the properties. Agricultural development thus typically involves a progression of changes in the relative values of these properties, successive phases of development producing different priorities.

Table 2. Agricultural development as a function of agroecosystem properties (Conway 1984).

Pattern	Productivity	Stability	Sustainability	Equitability
A Swidden cultivation	Low	Low	High	High
B Traditional cropping	Medium	Medium	High	Medium
C Improved	High	Low	Low	Low
D Improved	High	High	Low	Medium
E Ideal (best land)	High	Medium	High	High
F Ideal (marginal land)	Medium	High	High	High

Traditional agricultural systems such as swidden cultivation generally have low productivity and stability, but high equitability and sustainability (pattern A in Table 2). Traditional sedentary cropping systems tend to be more productive and stable, yet retain a high degree of sustainability and some of the equitability (B). However the introduction of new technology, while greatly increasing the productivity, is likely also to lead to lower values of the other properties (C). This was particularly true, for example, of the introduction of the new high yielding rice varieties, such as IR8 and its relatives, in the 1960s; yields fluctuated widely, but have tended to decline, in part due to growing pest and disease attack. More recent varieties combine high productivity with high stability, but still have poor sustainability (D). The ideal goal could be pattern E or, on marginal lands, where there is a conflict between productivity and sustainability, pattern F may be more appropriate.

Two further examples show how such a scheme of analysis can be applied to particular locations. The first concerns the upland watersheds of East Java and was produced at an AAD workshop held in 1984 (KEPAS 1985a). Typically traditional cultivation in the uplands under a low population pressure, has a relatively low productivity. Nevertheless, upland agroecosystems have usually evolved a high degree of sustainability, arising from the use of traditional techniques that maintain fertility and reduce pest and disease attack, while traditional land tenure and social practices ensure that the productivity is fairly evenly distributed. However, with rapidly rising population pressure the stability and sustainability drops, largely due to increased erosion, and this soon has a detrimental effect on productivity. Government reforestation programs, by halting erosion, will restore the sustainability, but the productivity of timber forests is low compared with agricultural cropping and few of the benefits go to the local villagers, so the equitability is also low. The alternative of cash cropping, for example potato production, can produce a very high productivity but the stability is often low because of pest and disease attack, while erosion and pesticide resistance result in lowered sustainability. The common pattern of land tenure that accompanies cash cropping also results in a lowered equitability. Interplanting of tree gardens with cash cropping usually restores some of the stability and sustainability, due to the buffering effect produced by the greater diversity of cropping. The equitability is usually higher, but it is usually at the expense of a somewhat lowered overall productivity compared with sole cash cropping. In theory an integrated pattern of tree and home gardens, by reducing erosion and pest and disease attack and by exploiting the intensity and diversity of multiple species cropping, could produce high values in all of the system properties (Table 3).

The second example comes from an AAD workshop held in Kalimantan, Indonesia which focused on the development of the swamplands (KEPAS 1985b). These have been designated as rice growing areas by the Indonesian government, but they suffer from severe problems, largely stemming from the acid sulfate potential of the soils. The workshop revealed that the farmers in the area were progressively transforming their ricefields into a pattern of coconut plantings separated by fish ponds. Our analysis suggested that, although the rice is sometimes more productive, the coconuts appear superior in terms of stability, sustainability and equitability (Table 4) and this is the probable explanation of why the farmers are switching crops. The government, of course, may well be correct in terms of its national priorities, but the analysis highlighted the need for research and development to correct the problems of rice production to restore its favourability.

Table 3. Hypothetical evolution of an upland agroecosystem (KEPAS 1985a).

Pattern	Productivity	Stability	Sustainability	Equitability
Traditional cultivation (low population)	Low	Medium	High	High
Traditional cultivation (high population)	Very low	Very low	Low	Medium
Reforestation	Low	High	High	Low
Cash cropping	High	Low	Low	Low
Tree gardens and cash cropping	Medium	Medium	Medium	Medium
Integrated tree and home gardens	High	Medium	High	High

Agroecosystem Analysis

Details of the procedure for Agroecosystem Analysis have been described in detail elsewhere (Conway 1985). Here I will restrict myself to summarising some of the important features of the approach, using illustrations from some of the seven AAD workshops that have so far been held in Thailand (Gypmantasiri et al. 1980; KKU-Ford Cropping Systems Project 1982a, b; Limpinuntana and Patanothai 1982) and Indonesia (KEPAS 1985a, b, c).

The basic assumption of agroecosystem analysis is that agricultural land use can be viewed as a set of more or less distinct agroecosystems that are typically arranged in a hierarchic fashion. Each agroecosystem also has a characteristic behaviour, which is summarised by the system properties discussed above. A further important assumption is that although agroecosystems are complex it is

Table 4. Indicators of performance in the tidal swamplands of Kalimantan, Indonesia (KEPAS 1985b).

Attribute	Rice	Coconuts
Productivity		
Yield	Poor–High	Moderate
Income (Rp)	100000–500000	400000
Stability		
Yield (by area)	Variable	Constant
Yield (by year)	Variable	Constant
Yield (by season)	Single harvest	Constant
Price	Low at harvest	Varies seasonally
Sustainability		
Salinity/acidity	Susceptible	Resistant
Flood/drought	Susceptible	Resistant
Rats	Serious	Moderate attacks
Insects	Many, serious	None
Equitability		
Agrochemicals	Several	None
Labour	Hired seasonally	Steady family labour
Land	Needs good land	Suitable for any land

not necessary to know everything about them in order to produce a realistic and useful analysis. Understanding the important properties of an agroecosystem requires knowledge of only a few key processes. And producing significant improvements in the performance of an agroecosystem requires changes in only a few key management decisions. The initial object of agroecosystem analysis, therefore, is to define and answer a limited number of key questions that will provide an understanding of these key processes and decisions. The outcome of each workshop is then a set of priorities for research and development.

Identifying the key processes and decisions in such agroecosystems is essentially a multidisciplinary process and the procedure described in Fig. 5 is an attempt to order that process in a way that allows for flexibility and the contribution of genuine flashes of insight. Experience has shown that the procedure is best followed in a seminar or workshop environment in which meetings of the whole team are interspersed with intensive work sessions involving small groups of individuals. (A guide to the organisation of an AAD workshop can be obtained from the author.)

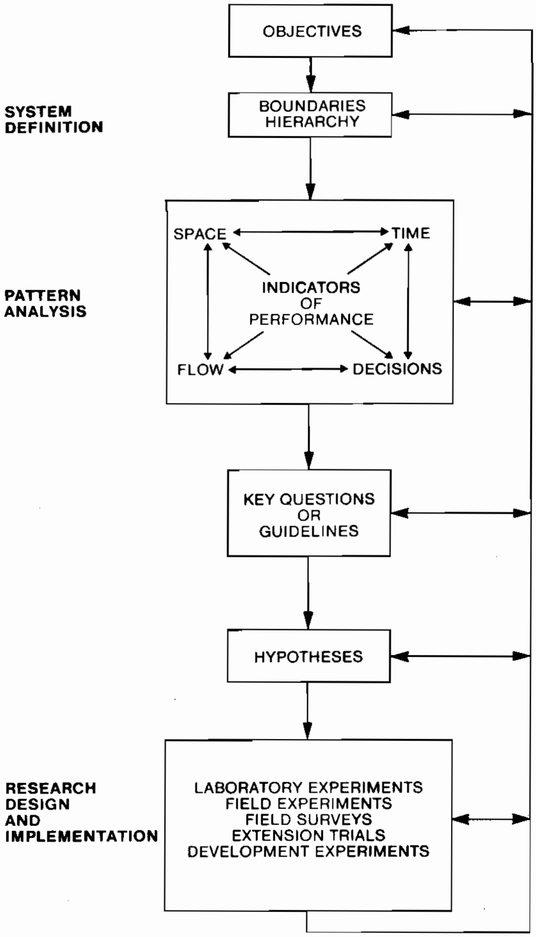

Fig. 5. The procedure for agroecosystem analysis (Conway 1985).

The key to success in the workshop lies in clear communication between the different disciplines present. The participants are urged to present their disciplinary and specialist knowledge in such a fashion that all other members of the workshop can easily grasp its significance. This process is greatly helped by the use of diagrams and extensive use has been made in the workshops of maps, transects, graphs, histograms, flow diagrams, decision trees, venn diagrams and any other pictorial device that appears to aid communication.

An important phase of the procedure is pattern analysis. Four patterns are chosen as likely to reveal the key functional relationships that determine system properties. Three of these — space, time and flow — are known to be important in understanding the properties of ecological systems (May 1981). All three patterns also have the virtue of being neutral with respect to scientific disciplines. Space, time and flow are equally important patterns for both natural and social science analysis and hence provide a basis for the generation of cross-disciplinary insights. The fourth pattern — decisions — reflects the processes of human management of agroecosystems and its analysis contributes to an understanding of all four system properties. Although this pattern is primarily the province of socioeconomic analysis, experience shows that it generates lively discussion among both social and natural scientists.

Space

Spatial patterns are most readily revealed by simple maps and transects. Overlays are particularly useful in uncovering potentially important functional relationships. Thus in the Chiang Mai Valley of Northern Thailand they indicated that cropping intensity was determined by the form of irrigation system rather than by soil type (Fig. 6). Subsequent analysis of the pattern of irrigation decisions (Fig. 12) suggested that triple cropping is more feasible in traditional and tube or shallow dug well systems than in government systems.

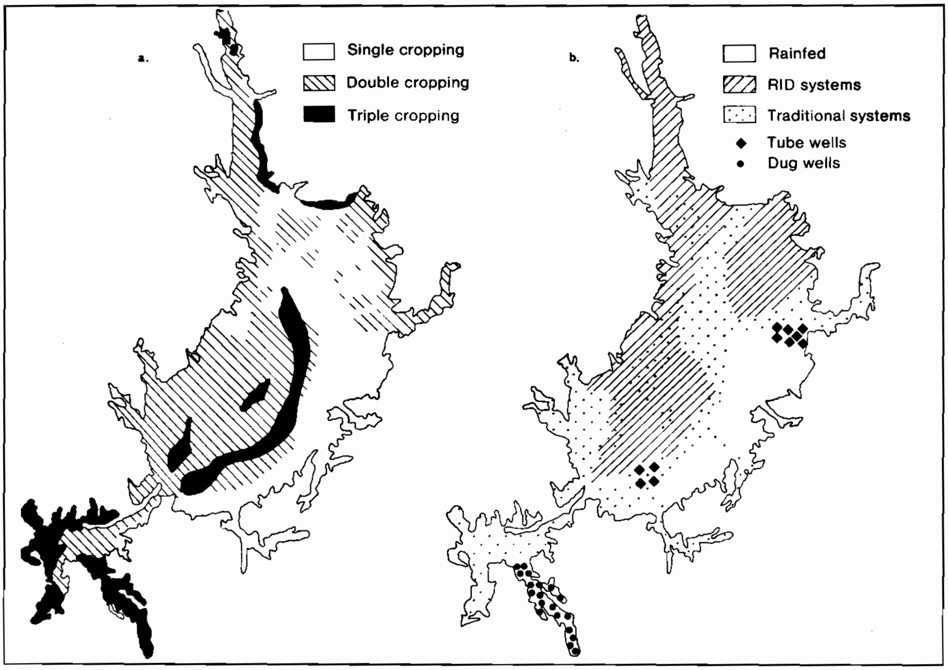

Fig. 6. Spatial patterns in the Chiang Mai Valley, Thailand: (a) cropping intensity, (b) government (RID) and non-government irrigation systems (Gypmantasiri et al. 1980).

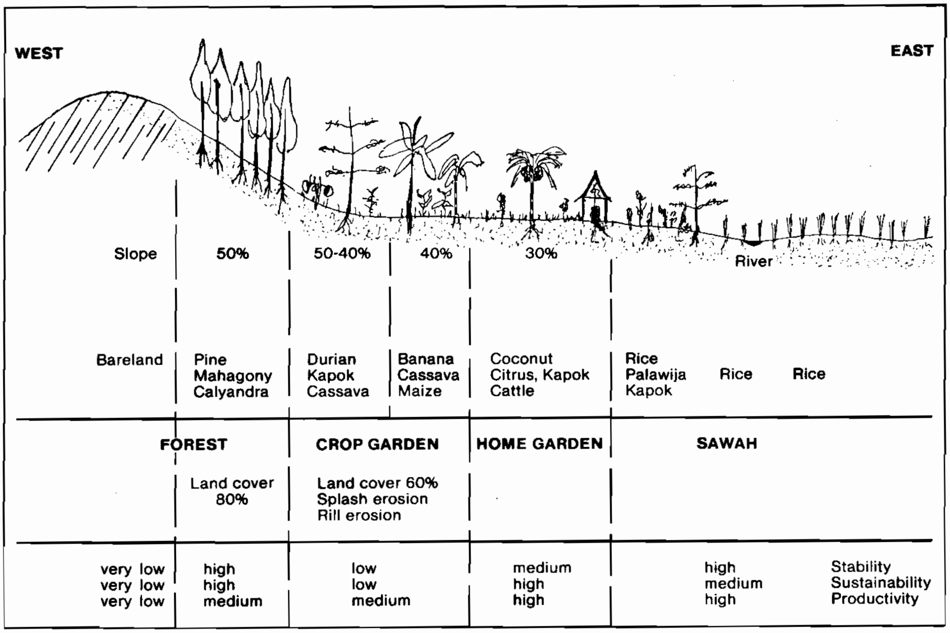

Fig. 7. Transect of an upland agroecosystem in East Java (KEPAS 1985a).

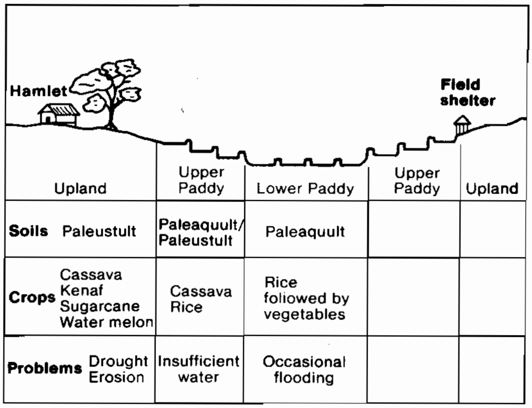

Fig. 8. Transect of a mini-watershed in Northeast Thailand (KKU-Ford Cropping Systems Project 1983a).

Farmers exercise greater control over traditional systems and hence the water supply is more reliable.

Transects are particularly useful in revealing the spatial relationships of different forms of land use and in pinpointing the location and origin of important problems (Fig. 7). In the analysis of Northeast Thailand agroecosystems, the recognition of the mini-watershed agroecosystem and its subdivisions pinpointed the role of the upper paddy fields as the generator of instability in rice production (Fig. 8). At a more micro level, detailed transects can reveal the pattern of interactions between different crops.

Time

One of the most useful conceptual tools here is the seasonal calendar (Fig. 9). This can reveal the interaction between climatic patterns and the cropping cycle and can identify the critical points in the year when labour or credit is in most demand and describe the expected flow of income.

Graphs are also valuable in examining the longer term patterns in time. For example, they can be used to compare the fluctuations in price for various annual or perennial crops or to examine the relative yield stabilities of monocultures versus intercropping.

Flow

Included under this heading are the patterns of flows and transformations of energy, materials, money, information, etc. For example, in the uplands this includes the flows of water and the

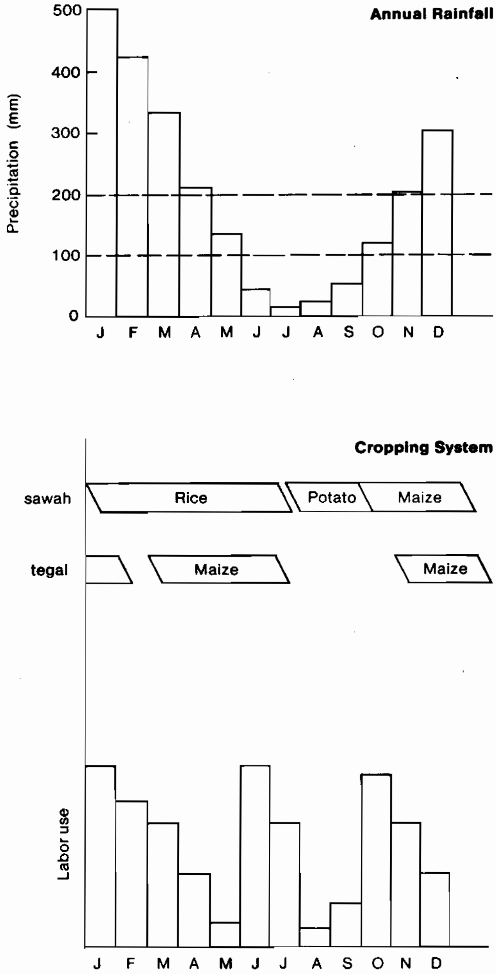

Fig. 9. Crop calendar for an upland agroecosystem in East Java (KEPAS 1985a).

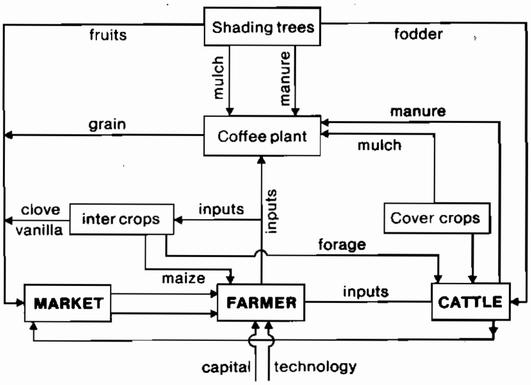

Fig. 10. Flow diagram of an upland coffee garden in East Java (KEPAS 1985a).

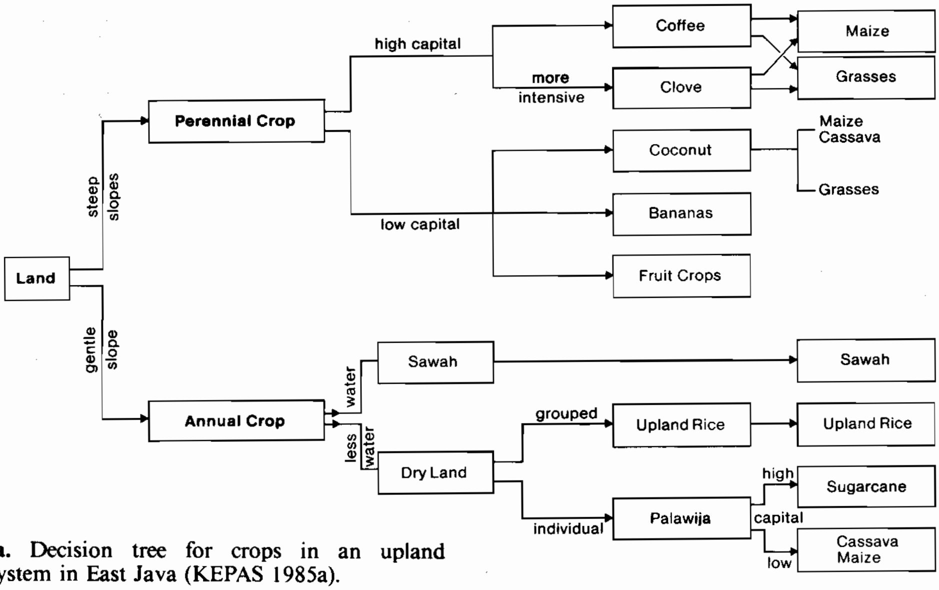

Fig. 11a. Decision tree for crops in an upland agroecosystem in East Java (KEPAS 1985a).

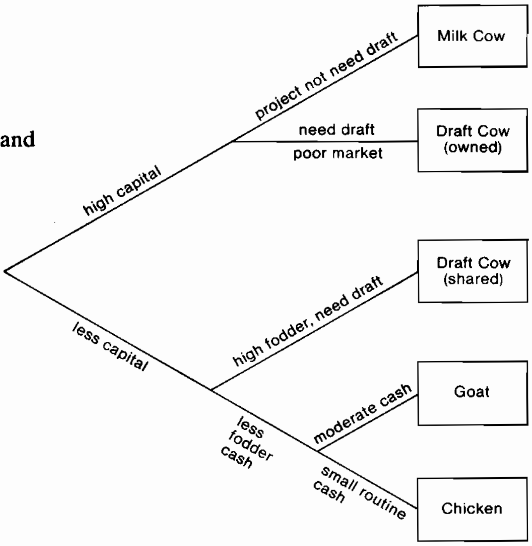

Fig. 11b. Decision tree for livestock in an upland agroecosystem in East Java (KEPAS 1985a).

related processes and consequences of soil erosion. There are also flows involved in the generation of farm income and the transference of cultural influences and ideas. These are best described and analysed by simple flow diagrams (Fig. 10) and bar diagrams.

Decisions

Two patterns are important. The first is of the choices made in a given agroecosystem under differing conditions and is best described by means of a decision tree. These can suggest what are the important factors that determine, for example, whether a farmer plants annual crops or perennials or a mixture of these, and whether he invests in terracing or reforestation (Fig. 11a and 11b).

The second pattern is of the spheres of influence of decision makers. Here analysis is primarily required in order to identify the critical decision makers in the system hierarchy, and simple diagrams are useful in distinguishing the points of contact and overlap in decision making. Analysis

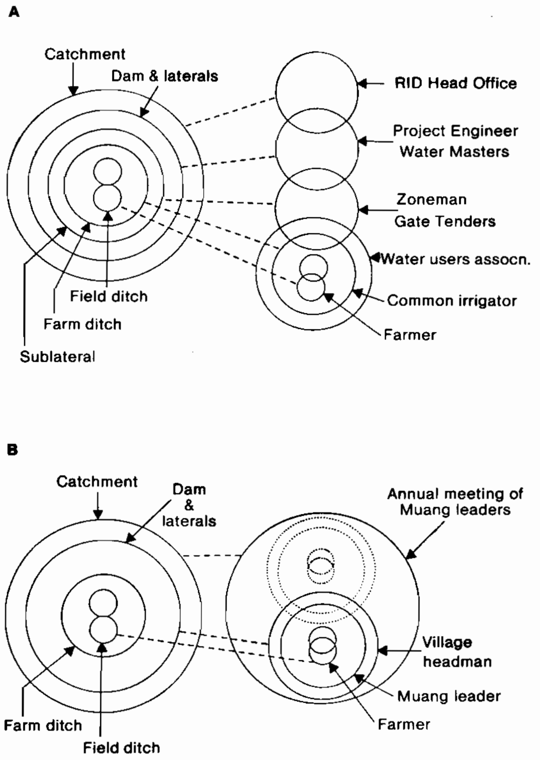

Fig. 12. Diagram showing points of contact and overlap in irrigation decision making in Northern Thailand: (a) government (RID) systems; (b) traditional systems (in each diagram the physical systems are on the left and the decision making systems on the right; Conway 1985).

Table 5. Examples of key questions from agroecosystem analysis and development workshops.

1. Can new rice varieties be bred to produce more stable yields on the upper poorly watered paddy fields? (Northeast Thailand).
2. What is the optimal application of fertilisers to traditional rice varieties under highly variable rainfed conditions? (Northeast Thailand).
3. How is the form and productivity of cropping systems in the Chiang Mai Valley affected by the government policy on the price of rice? (North Thailand).
4. To what extent are the gains in productivity and stability from land consolidation in the Chiang Mai Valley likely to be offset by a decline in sustainability and equitability? (North Thailand).
5. What is the best time to close irrigation systems for maintenance so as to improve cropping systems options? (North Thailand).
6. Do present tenancy patterns prevent better soil erosion control in potato cultivation? (East Java).
7. Are lack of capital and of feed the main constraints to improved livestock production? (East Java).
8. Would the productivity and sustainability of village forest lands be improved by giving villagers rights to grow fruit trees and forage grass there? (East Java).
9. In what ways can government transmigration schemes benefit from the organisation, techniques and methods of spontaneous migrants? (Kalimantan).
10. Can farmer income and income stability be improved by cooperative marketing of coconuts and local coconut processing? (Kalimantan).

Table 6. Potential effects of intensification in Northeast Thailand.

Area of Intensification	Productivity	Stability	Sustainability	Equitability
High-yielding varieties	++	-	-	-
Improved local varieties	+	+	+	0
Fertilisers	+	-	+	0
Water supply	+	+	-	-
Pesticides	+	+	-	0
Livestock	+	-	-	-
Rural works	+	-	+	-
Crafts	+	+	+	+

of irrigation water control in the Chiang Mai Valley, for example, revealed the extent of farmer participation in decision making under different systems (Fig. 12).

The pattern analysis phase leads into a discussion of system properties and a common agreement on what constitutes the most important contributing relationships and variables. This is then usually followed by a form of technology assessment in which possible changes and innovations are discussed in the light of their effect on system properties (Table 6).

Key questions arise throughout the procedure, during system definition, pattern analysis and the discussion of system properties. Good key questions are usually of a multidisciplinary nature but are nevertheless highly focussed. They need to be framed as virtual hypotheses and hence be in a form that is readily capable of being answered. Formulation of general research and policy issues or problems is not a sufficient outcome of the workshop. Thus for the upland workshop identification of *'The integration of perennial and annual cropping'* (a research issue), *'The improvement of farmer's income in the uplands'* (a policy issue), *'The prevention of erosion'* (a research problem) or a general question such as *'How can* *erosion be prevented?'* were not regarded as acceptable outcomes. Key questions, by contrast, are of the form: *'Are tree gardens superior to bench terracing in reducing erosion, and in increasing and stabilising farmers' net income?'*

Table 7 lists some of the key questions from the workshops held to date.

Where the object of analysis is to identify possible ways of developing an agroecosystem the key questions may be framed in the form of tentative guidelines: *'It is likely that crop production in village x will be significantly improved by the provision of better quality second crop seed'.* Although written in this form, the implicit question and hypothesis are apparent. If better quality seed is provided it should be seen strictly as an experiment and the results used to modify the overall analysis.

The remaining phase of the procedure is one of conventional research and development. The hypotheses are tested as appropriate: by laboratory or field experiments, field surveys or extension trials, or by development trials in which guidelines are enacted and assessed. The multidisciplinary activity of the workshop may or may not extend into the research phase; many of the key questions will be phrased in terms of single disciplines and are best answered by the appropriate specialists. To this extent the outcome of the workshop may appear superficially similar to research programs arising from a collection of individual initiatives. But they will differ crucially in that the individual research projects are the direct consequence of a multidisciplinary systems analysis and the results feed back to, and modify, that analysis. The research has thus a better contextual basis and is likely to be more appropriate and relevant, while the results have a greater chance of being acted upon.

The procedure is intended to be iterative. New knowledge and perspectives at each stage are likely to require revision of earlier stages; in particular, answers to key questions will modify earlier assumptions. Experience suggests that the procedure can be applied at any time in a project's life, but it is particularly useful at the beginning of a project when data are scarce. Ideally it should be repeated and updated at regular intervals.

Despite its foundations on the concepts of systems analysis, the procedure makes no explicit mention of the role of mathematical models. We have deliberately avoided the conventional approach of using a large-scale simulation model as the focus of analysis. This is partly because many individuals may be excluded from the analysis through a lack of skill or inclination to interact with the model, and partly because in such large-scale modelling exercises the key issues and questions tend to be obscured by a preoccupation with the details of construction. Nevertheless it is clear that the potential for use of a wide variety of models (matrix models, regression, linear programming models, simulation models, etc.) exists throughout the procedure.

Agroecosystem Design

The key questions generated during Agroecosystem Analysis pose a number of important challenges for agroecosystem design, for technology assessment and development and for implementation, and I will discuss these in the rest of the paper.

Given the 'ideal' goals described in Table 6, an important question is how can they be reached speedily and efficiently? For example, is it possible to go direct from traditional agricultural systems to the 'ideal' systems without passing through the Green Revolution phase of high productivity and low sustainability? Recent development work suggests that it may be possible, given sufficient skill and sensitivity. Thus, in Indonesia the Central Research Institute for Field Crops has designed a productive and apparently sustainable cropping system for the red-yellow podzolic soils, hitherto regarded as highly marginal and unproductive (McIntosh et al. 1981). The system, which replaces traditional mixed cultivation followed by a fallow of *alang-alang (Imperata cylindrica),* consists of a more organised inter- and relay-cropping of corn, upland rice, cassava, peanuts and cowpeas, grown in a continuous cycle without a fallow. Sparing, but targeted, application of fertiliser, together with the return of all crop residues as mulch, maintains a high fertility, producing experimental yields in food calorie terms ranging from 12–25 tons/ha of paddy rice equivalent. But clearly, just how sustainable and equitable a system it will be in practice must depend on how and where it is implemented and on its appropriateness to the specific ecological and socioeconomic conditions of each locality.

There is also evidence from regions such as the Chiang Mai Valley in Northern Thailand that farmers may achieve such a goal with a minimum of government help (Gypmantasiri et al. 1980). The valley has a 1000-year-old tradition of communal irrigation on which new government schemes have been grafted. There are also excellent transport and marketing systems. The farmers have responded to these opportunities by developing over 20 different kinds of rotational cropping patterns, usually of rice followed by one or two cash crops. Yields are high yet the rice is a traditional type, with over 60 different local varieties in current use, and the crop receives no pesticides (there are no important pests and diseases) and very little, if any, fertiliser.

Agroecosystem Technology Assessment

Frequently the questions that are generated by agroecosystem analysis and design focus on the viability and impact of different, and often alternative, technologies. But, far too often, such technology assessment has been carried out on the basis of potential productivity alone, with only passing reference to other consequences. A more holistic and revealing assessment could be achieved by explicit use of all four indices of performance — stability, sustainability and equitability as well as productivity. I believe this should be done as a matter of course, ideally within the context of agroecosystem analysis workshops as I have indicated above.

As an example, such an assessment is urgently needed for current proposals in the genetic engineering of crop plants. Clearly, if genetic engineering can develop plants that fix their own nitrogen, or are resistant to pathogens, then this may be highly desirable. But these achievements must not be judged in isolation. If the end result is to produce new plants which produce higher yields while requiring even more inputs and protection, then on balance it may be a retrograde step.

Agroecosystem Technology Development

Implicit in the agroecosystem approach to analysis, design and assessment that I have described above, is a need to change the emphasis of agricultural research and development away from support of distinct, specific techniques toward the development of more broadly based packages of technology. To some extent this is already happening under FSR, but the current interest in such techniques as genetic engineering is resulting in strong pressure to reverse the process. Techniques of genetic engineering or zero tillage or controlled droplet application, to name only a few, have considerable potential application in agriculture and deserve support. But if agricultural innovation is to satisfy not only the demand for increased productivity but also for enhanced stability, sustainability and equitability of production, exploitation of these techniques needs to be firmly embedded in the development of packages of closely integrated techniques and policies explicitly designed with all the appropriate criteria in mind.

Such packages complement those developed under the rubrics of FSR and IRD, partly because of their greater relative emphasis on properties other than productivity. But they also differ in that their primary focus is not at the level of the farm (as in FSR) or the village or watershed or region (as in IRD or watershed development projects) but rather at all the intermediate levels in the agroecosystem hierarchy (Fig. 13). In FSR terms they are component system packages, but explicitly designed to simultaneously satisfy the agroecosystem goals of high productivity, stability, sustainability and equitability.

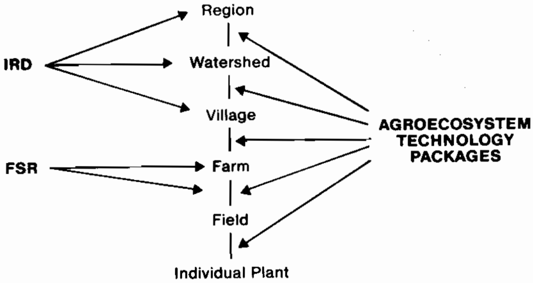

Fig. 13. The hierarchy of agroecosystems and the relative inputs from Integrated Rural Development (IRD), Farming Systems Research (FSR) and Agroecosystem Technology Packages.

While agroecosystem analysis starts with the farm, village or region as its target of investigation, the key questions that the analysis generates are focused not on the target agroecosystem as a whole, but on the key processes and decisions that it contains. Furthermore, the experience of the agroecosystem workshops that have been held so far suggests that certain key processes, for example the interrelationships between crops and livestock, or the integration of pest control and multiple cropping, and certain key decisions, such as are involved in the communal control of water or the provision of credit for cropping systems, recur again and again, not only in different places but at different levels in the agroecosystem hierarchy.

It is these ubiquitous key processes and decisions that focus the technology packages. Some of the packages are already well known and receiving research and development support; others are less well defined. The following is only a partial set:

Integrated Pest Management

Both in concept and practice this approach to pest control is over 30 years old, yet it still receives relatively little support. Viewed primarily as a means of reducing pesticide use while increasing the efficiency of control, it has clear benefits for sustainability (fewer pest resurgences, less likelihood of pesticide resistance) and for equitability (lower costs and fewer health hazards). It has a potentially strong, but still underexploited, linkage with multiple cropping practices.

Multiple Cropping

Again, this is a relatively well developed technology package, at least in experimental terms. But as a topic of research it was seen initially as simply a way of increasing productivity. Hence the emphasis on leaf area indices and land equivalent ratios. Its role in terms of maintaining stability and sustainability of production and in promoting equitability, particularly in terms of labour employment, has so far received relatively little attention.

Agroforestry

This is a more recent topic of research interest, which is not as yet very well focused. Its greatest potential contribution to the development of sustainable agriculture appears to lie in its role in the control of upland erosion, as an alternative to conventional engineering and forestry approaches. Successful erosion control depends crucially on the provision of incentives to upland dwellers, but conventional approaches are usually inequitable, taking away resources from the upland dweller and providing very little by way of return. Agroforestry can provide both immediate and longer term incomes and if designed well can minimise erosion. There is, however, a need for more basic research on the physiological interactions between perennial tree and annual understorey crops, particularly with reference to the effects on soil quality and structure.

Crop-Livestock Polyculture

The emphasis on food grain production that has characterised the Green Revolution has inevitably meant a relative neglect of other food crops and in particular of livestock production on the small farm. Apart from the obvious benefits of increased income and a protein-rich food supply, livestock production has the capacity to both employ resources and generate subsistence and cash products on a sustainable year-round basis. Coupled with this its 'banking' component provides an important means of overcoming adverse periods. However, on the small farm success depends crucially on the close integration of livestock and crops in terms of land, labour, capital and the products and by-products themselves. This needs far more multidisciplinary research and development.

Soil Ecology

In many respects this is the oldest focus of sustainable agriculture, identified in the West with work under the rubric of 'organic farming.' Much of that work has been concerned with arguments over the relative benefits and drawbacks of inorganic and organic fertilising. In the Third World the benefits of inorganic fertilisers have been amply demonstrated over the past 30 years. Problems of nitrate pollution and soil deterioration have yet to occur to any significant extent. The contribution of soil ecology, in this context, thus lies more in the search for biological and on-site sources of fertility to provide a sustainable alternative to increasingly costly outside inputs, and which, at the same time, will preserve soil structure and quality.

Selection for Agroecosystems

Plant breeding programs during the Green Revolution stressed, quite rightly, the importance of developing crops that were widely adapted, early maturing and high yielding under a very considerable range of conditions. In this the breeders were highly successful. However, in many cases this results in plant types that will do extremely well in very favourable environments but only moderately well under more marginal conditions. In general, plants that do extremely well in marginal environments will do poorly in better conditions, and hence have not been favoured by plant breeders. In the post Green Revolution phase, however, such plant types should be receiving attention in programs to breed crops (and livestock) specifically adapted to target agroecosystems, as part of the aim of developing a fine-grained agriculture. To some extent this is already happening in breeding programs for special conditions, such as acidity, toxicity and micro-element deficiency, but target agroecosystems for breeding need to be more broadly defined, in particular to include socioeconomic as well as physical variables.

Communal Self-Help

There has been interest for many years in promoting various self-help arrangements at the village level, but too often they have been seen as exercises in social engineering rather than as pragmatic solutions to problems of sustainability and equitability of production. There have consequently been many failures, particularly where the schemes attempted to be all encompassing. At the same time, traditional communal systems of self-help, and especially those concerned with the provision of support at times of famine and hardship, have been eroded by the growth of freer market economies and the institution of national relief schemes. Research and development is needed to help define more precisely the relative importance and potential roles of communal, governmental and market institutions in such areas as the provision of credit, the regulation of prices, the supply of labour and the provision for disaster.

Communal Water Management

In some ways this is a subset of the preceding package, since the success of communal arrangements for water control depends on the extent to which they are seen as of mutual benefit to all participants. On engineering and other criteria, traditional systems may well appear inefficient, but their clear advantages in terms of sustainability and equitability may often be overriding. Again, this is a topic on which there is already a considerable body of knowledge. The priorities seem to lie in finding ways of integrating traditional communal systems with larger scale government funded irrigation, so as to combine the best features of each and, with the decline in support for such large-scale projects, in developing new small-scale engineering designs that are explicitly meant to be operated on strictly communal lines.

Social Forestry

This parallels, in terms of objectives, the preceding package, but with the difference that large-scale communal control over forest management and exploitation is rarer. The traditions lie mostly with hunter-gatherer and swidden cultivation communities, and it is not yet clear how much of this is transferable to the management of forests in the context of settled, intensive agriculture. Probably new forms of communal control need to be developed.

Village Resources

Closely interlinked with several of the preceding packages is the role of communal resources, in particular common land, village ponds, woodlots, grazing pastures and forage land, in the sustainability and equitability of production at the village level. The benefits of such resources are often underestimated in conventional analyses of farm budgets, and their role in supporting the subsistence livelihoods of the landless is also often forgotten. Work is needed to quantify these benefits more precisely, to unravel their connections and to determine what and how improvements can be made.

Non-agricultural Production

As a final package in this preliminary list I have included the role of non-agricultural production on the farm. This includes, in particular, the manufacture of handicrafts, such as silk, other textiles, pottery, basketwork, etc., where at least some of the resources apart from the labour are provided from within the local agroecosystem. The benefits lie in the 'banking' component, providing resilience at times of hardship, and in the greater equitability of income within the farm household that often occurs. Again, however, not only these but the immediate benefits in terms of production are often ignored in conventional farm analysis, and it is still rare for improvements in cropping or livestock husbandry to be designed with the implications of changes in labour, products and by-products for handcraft manufacture in mind.

Implementation

I want to conclude with a few comments on the implementation of sustainable agriculture. The approach adopted in the furtherance of the Green Revolution, which was a key component of its success, was to design new varieties and their accompanying packages on experiment stations, test them in a number of differing locations and then transfer them as widely as possible to receptive farmers, either through the conventional extension service or via a specially created implementation program. This conforms essentially to the classical linear model of R and D and was made possible by the deliberately engineered wide adaptability of the new technology. To some extent this approach has persisted in FSR, particularly where such programs have been under the wing of one of the International Agricultural Research Centres. Often such FSR has attempted to emulate the Green Revolution approach by producing cropping system or even whole farm system packages with, hopefully, broad adaptability and extending them in the same fashion.

However, it is becoming increasingly clear that the post Green Revolution phase of agricultural development requires a very different and, in many ways, more challenging approach. This is partly because a fine-grained agriculture, with technologies specifically adapted to individual agroecosystems, will be impossibly demanding in terms of labour, resources and time, if the traditional linear model approach to implementation is adopted. However, there is also a more fundamental difficulty. As FSR work is beginning to show, it is virtually impossible, from outside, to optimally design a whole cropping system, let alone a whole farming system, for an individual farm. Only the farmer can carry out the final optimisation, because only he or she has access to much of the information, including essential details of the local environment, the local culture and his or her real goals. The research and development worker has a great deal to offer and can bring about highly significant changes, but in the final analysis there is a limit beyond which advice is either irrelevant or counterproductive. It is primarily for this reason that I believe the future of sustainable agriculture research and development lies in the kind of agroecosystem technology I have discussed above.

Increasingly, agricultural research and development and extension in the Third World is going to approach the patterns now predominating in the West i.e., a situation in which each farmer is presented with a 'supermarket' of packaged technologies from which to choose, and out of which he or she produces an optimal farm design. The important task that faces those responsible for research and development policy is thus to ensure that the individual packages in the 'supermarket' have arisen by way of the processes of analysis, design, assessment and development that I have described above and hence, when integrated by farmers into their farming systems, will help to fulfill the goals of an agriculture that is not only more productive, but is more sustainable and equitable.

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Modelling Biological Systems

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WE have been asked to place particular emphasis on how models have been used to aid decisions on research and technology for agriculture, and for farming systems. We do not intend discussing the procedures involved in model construction. There is a substantial literature on the subject.

We discuss the motives and guidelines for modelling, the levels of modelling and the roles that modelling might play in Farming Systems Research (FSR). We then consider, briefly, modelling and the developing world. Some examples of models of farming systems, and their use, are then outlined.

Guidelines for Modelling

Bennett and Macpherson (1981), among others, have presented guidelines for modelling that should discourage all but the lion-hearted or stubborn from such unpromising involvement. Some of their arguments are undoubtedly valid but one might wonder whether, if their conditions are met, the effort of modelling is necessary.

We see much modelling in agriculture proceeding in the face of scarcity of data, limited understanding of relationships and uncertain socioeconomic parameters. In such circumstances, these authors would warn us to keep clear. However, many of their restrictions are based on a requirement for a suitable market (users) actually existing. We tend towards a view that one doesn't know what the market might be until one has a product. Henry Ford did not wait for an assured market when he set about building millions of cars. In our experience, many models, if not a majority, have been motivated by a desire for self-enlightenment, to understand what is happening in a system, and to predict what would happen if... We are our own market.

It is arguable, however, that public funds should not be spent on the esoteric satisfaction of the curiosity of a tiny 'elite.' While not accepting this argument in principle, we must admit that when such modelling is paid for by funds earmarked for the advancement of some industry, or to overcome some problems, the funding bodies have a right to their pound of flesh.

What motivates modellers on industry funds? A number of motives can be identified: (a) a desire to seem trendy; (b) an attraction to computing; (c) to aid understanding; (d) to identify gaps or inconsistencies in information; (e) to extrapolate to horizons beyond information available; (f) to aid management decisions; and (g) to estimate returns from activities such as breeding, extension work, management training.

If the model is closely related to some sufficiently important system or potential system, all the above, apart from (a) and (b), could deserve support, or at least some place in a priority list.

Modelling, although more than 20 years old, is still a rather recent and novel component of agricultural production research. Most serious modellers have attempted to quantify the biological or the economic components of some systems rather than attempt adequate modelling of whole systems. The need for research to proceed beyond particular components has even been opposed on funding and academic committees and by editorial boards of some journals. When one considers that quantitative genetics, although over 40 years old, has had little impact on the breeding of most livestock, one should trim one's expectations to reality.

Levels of Modelling

An analysis of biological systems can proceed at several levels. Consider a herd of cows grazing pastures, producing milk and calves, and being given supplementary feed and medicines accord-

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ing to management rules. The following levels of modelling might be appropriate:—

Models of Cellular and Subcellular Processes

One might model processes in the liver, the pollen grain, or the mammary gland. Models of cellular and biochemical systems have been constructed and could be useful, perhaps to examine the consistency and adequacy of some biochemical theory. In a wider sphere, one could model a cellular process involving the development of nitrogen-fixing systems, having in mind the effect on fish grown in a farm pond, or on rice grown on millions of hectares of paddy.

Models of Organs or Subsystems

A model of a ruminant digestive system could cast light on processes of digestion of 'low-quality' browse, and estimate the effect(s) of adding a range of nutrients to the system. The mammary gland of a dairy cow might be profitably modelled in relation to the physiology of milk secretion.

Models of Individuals

A plasmodium, a plant, or an elephant can be studied as a system with its inputs and outputs. A model of an elephant could be useful for the design of better elephant harnesses, or to optimise the division of a working day into periods of labour, rest and wallowing.

Models of a Farm Enterprise

A crop or a herd might be modelled to improve the yield or efficiency of production, to examine the need for resources and the availability of surplus resources, or to consider the value of genetic improvement. A whole herd of cows might be modelled. It may or may not be necessary to consider individual cows for some subsystems; it could be for others. Thus the level of milk production of the herd might be calculated from a few variables, such as feed supplies. However, different cows could be at different stages of lactation, and pregnancy. Cohorts of cows, or even individuals, may have to be modelled if interactions between reproductive status and feed supplies are important. A profound knowledge of cow physiology and nutrition as well as pasture agronomy and meteorology must be available to the modeller to aid decisions on what level of detail must be included. Unfortunately, most specialists seem to require great detail for their speciality, but are reasonably tolerant of simplification where other disciplines are involved.

Models of Whole Farms

Such models introduce a new level of complexity. Interactions between enterprises in the use of resources, including time, skills and finance, make such modelling a formidable task. A number of 'quick and dirty' linear programs have been developed, but few seem to merit serious study. Consequently, the field for good linear programs as aids to whole farm decisions is wide open.

Models of Regions, Industries or Other Large Groupings

Dairy production of a number of herds in a district, region, country or continent might be our concern if we are attempting to develop policies in relation to prices, subsidies, market forces, or support for research. Levels below herds could scarcely be significant, but variations between herds and operators must be considered since responses to prices and subsidies are unlikely to be uniform even within a district. They would depend on factors such as herd size, breeds and variations between seasons of the year and between years.

National Models

The modelling of Australian, Chinese or Thai agriculture is a formidable task. An Australian model has been constructed but it has not been described in sufficient detail for serious comment. It has been used as an aid to policymaking, but whether it is adequate for such purposes is uncertain.

Unfortunately, such models can be manipulated to attempt justification of policies which were developed for reasons not apparent in the model. The recent justification of CSIRO research programs, without considering the costs of decisions, is a blatant misuse of modelling. Fortunately, the suggestions are unlikely to be taken seriously. However, this example warns us that modelling can be a two-edged sword and we must be cautious of superficial claims, such as 'The output of the computer model of the system indicates . . . ' It may be a lousy model, a biased model, a model that leaves out awkward parts, or one which misleads in some other way.

Role of Modelling

Modelling may be highly purposive in relation to farmer or national objectives, or it may be little more than doodling by a curious investigator. Such doodling can certainly give satisfaction to the modeller and some colleagues, and it is made easier by removing incentives to do anything with models beyond, perhaps, publication.

Is such activity to be condemned as useless any more than is much so-called basic research? Is the modeller required (by whom?) to make his output useful? Not always, in our opinion. Therefore, we must disagree with some of the statements of the pragmatists in this field. But we certainly accept many of their viewpoints. For example, we must emphasise that claims for the usefulness of a particular model should not be made until it has been shown to have been useful. As in other types of research, a requirement for reasonably strict validation could mean that publicity could be delayed for decades, which would often be a real benefit.

The roles of modelling are numerous, but the following merit consideration.

Definition of the Objectives

The construction of models imposes the discipline required by definition of the objective(s) of the policy of the policymakers. For example, is a proposal under examination (being modelled) to benefit a consumer through better quality and lower prices, the farmer through higher prices and less stringent controls, the nutrition of some underprivileged groups in the community or the state treasury by conservation of hard currency. Whatever the objective, the end users (policymakers, retailers, extension workers, farmers) must be kept in mind and consulted as far as posible at each stage. It is thus a role of modelling to bring into sharp relief the network of consequences of decision-making, and of the consequences of emphasis on any part of that network.

Providing a Logical Framework

The construction of a model should provide a logical framework on which to make use of the information available. This is a particularly important connection between research and management, both in respect to identification of gaps in information and to the total consequences of applying research in an industry. The second of these applications requires that the framework includes relevant subsystems. For example, introduction of a new management practice (e.g. nitrogen fertiliser) could cause a glutted market. Unless good market information is available and included in the framework, the uncritical acceptance and application of the results of a model could be disastrous.

Statement of Predictions

A model should indicate the logically predicted effects of component processes and structures of the system in question. If current information predicts yields of 4 t/ha and only 3 t/ha are usually obtained, a deficiency of information exists. The model could thus help identify processes, procedures or structures that impose limits on productivity.

Computer Experiments

Models can be used to estimate the consequences of perturbation of the system. They complement physical experiments in doing so, but frequently they explore possibilities ('what if?') that could never be examined by physical experimentation, e.g. the consequences of the greenhouse effect of CO_2 in the atmosphere, or of some strategies of parasite control of sheep and cattle.

Extrapolation

Most information from experiments, surveys and case studies is limited by sites, seasons, soils and scientists. Extrapolation and generalisation are necessary steps in the use of information and both processes require models. At present these may be no more than 'gut feelings,' intuition or wishful thinking. The introduction of a formal model imposes discipline by compelling recognition of assumptions and statements of relationships. Perhaps this is one reason why models seem to be anathema to some 'authorities.'

This list is necessarily superficial, but indicates some roles that models might play. We have not explicitly mentioned education among these, as all roles are educative, whether to the individual, to an 'in group,' or to sections of the whole community. However, we emphasise that models such as SHEEPO, which is a management-oriented model of a sheep grazing system (Whelan et al. 1985) could be very powerful tools for educating students, their teachers and research and extension workers in the management of grazing and cropping systems.

The consequences of a particular breeding program, introduction of pasture cultivars, the variations between years in pasture growth, in animal performance, in requirements for supplementary feeds, and in the ebb and flow of finance, would be very enlightening. Few farmers would be aware of such fluctuations, as their records are seldom sufficiently complete. The matching of model prediction against farm performance could reveal problems and possibilities hitherto only suspected.

Modelling and the Developing World

The industrially developed world is providing enormous resources to the less developed world in a wide range of aid programs. Agricultural projects ranging from fish culture to forest development and conservation are being proposed, many of these representing simple attempts to transfer technology. Mechanisation of cropping, lot feeding of livestock, the incorporation of new crops and the expansion of existing cropping systems have all been advocated.

Socioeconomic Constraints

The development of greatly modified systems of agriculture must have widespread socioeconomic implications and limitations. If new crops need protection from birds, who will do the work? The adoption of a higher school leaving age could mean that labour will not be available! Mechanisation removes dignity from many lives. And so on. Most people who have worked in such countries become aware of such problems. The political consequences of the distribution of benefits of aid are sometimes difficult to predict, and the inclusion of appropriate subsystems in formal models is hard to visualise. Nevertheless, intensive study of the socioeconomics, the traditions, the aspirations and the motivations of relevant communities would seem to be a critical prerequisite for any aid programs. Religions, languages and traditional loyalties could be major barriers.

Technical Opportunities

Population pressures have imposed new dangers to many parts of the world. Overuse of the Sahel has caused widespread deterioration of vegetation and fewer opportunities for nomadic livestock husbandry. A formal model is scarcely necessary to show the dangers of such deterioration to people who are by tradition at the lowest level of the pecking order. The dangers mean that alternative pursuits must be found for many people. Opportunities exist, but all involve substantial investments and a new way of life for many of the people involved.

Models of intensified systems of use of waters of rivers such as the Niger could disclose opportunities and constraints. Acceptance and application of the results of models of cropping on the Niger could buy time to alleviate the pressure on the Sahel and permit longer-term plans for population control.

In Latin America and parts of Africa, models are being used to guide the development of livestock enterprises (e.g. Sanders and Cartwright 1979). Unfortunately, some of these do not include the critical elements of plant-animal interactions, and proceed as if pasture were a resource that is not influenced by its utilisation (Whelan et al. 1984). We hope we are unnecessarily pessimistic about the role of such models as aids to agricultural management.

In parts of Asia (e.g. Thailand), multiple cropping systems are an unusual but promising means of making fuller use of a short rainy season. Some have been tried on a small scale on experiment stations and some farmers' fields. In other places (e.g. China) multiple cropping is general. Such systems offer the land-hungry farmers opportunities of expanding production and probably of increasing incomes by fuller use of available resources.

Experimental investigation of such opportunities is almost impossible because of the almost infinite number of combinations possible, the variation in seasons, sites and management and the range in skills of the farmers.

Models are available to estimate yields of a wide range of crops over a wide range of environments. They depend on meteorological data, on some information on local soils, and on the physiology, ontogeny and agronomy of crops in question.

Countries such as Thailand have good meteorological networks by most standards, and good information on soils. Much information on potential crops has already been assembled in data-banks in Australia, the Philippines and elsewhere. It therefore remains for all these resources to be brought together with the objective of advising farmers after appropriate field validation on choices of crops, crop sequences, agronomic practices and the allocation of soil and water to different crops. Models are an essential technique for doing this.

Other investigations should focus on markets, benefits to different sections of the community (farmers, agents, consumers) and likely long-term trends in soil fertility, plant disease and prices.

The main limitation to the widespread adoption of the modelling approach seems to be the availability of suitably trained personnel.

It is very acceptable to give aid to people trained in the conventional rural disciplines. Soil chemists, plant breeders, animal nutritionists and the like show the aid flag and are not going to make too many revolutionary suggestions too quickly. Models represent challenges right from the beginning. They rock boats!

This is not to denigrate the assembly of information (cf. collection of data). This is necessary to validate models (i.e. keep the modellers honest) and a substantial effort is necessary to check on the ground the accuracy, feasibility and acceptability of any model-generated systems. Perhaps the survival level of such systems will be low, but at least the field work can be clearly related to some goal. It can be purposive rather than an aimless exploration and accumulation of data of questionable relevance.

Transferability of Models

Models of systems and subsystems are produced in sufficient quantity to support several journals. How transferable to developing economies are those constructed for industrially developed countries?

Models at the cellular, organ subsystem or organism level are largely transferable. Certainly a rumen in a cow near Delhi will not function in quite the same way as one in a cow near Dublin. But there are many common features. Similarly, models of greenhouse crops would apply equally to Peru or the Philippines. However, models of pasture production systems must be defined in terms of soils, meteorology, species of plants and animals, various inputs and outputs and the socio-economic scene.

The resources available for agricultural production in the developing countries vary enormously and are mostly very different from the resources available in more sophisticated economies. Further, the prices obtained for many commodities in the latter offer opportunities for sophistication of production systems that must be irrelevant to countries where skills, finance and markets are severely restricted.

Models developed for systems of production in the USA, Australia, Europe and Japan are therefore of strictly limited value relative to systems of production in Southeast Asia, much of Africa and Latin America. Moreover, models of systems in Europe and the USA are often of marginal interest in Australia, New Zealand, Argentina and South Africa. Countries that rely on exports of agricultural produce must remain competitive, and so cannot afford much of the technology that is available. Yet it is often such technology that attracts research dollars.

Success in transferring much of our technology to developing countries requires recognition of major differences such as:

(a) The objectives will usually differ critically. For example, cattle, donkeys, goats and sheep are largely kept in developing countries for draught power, as walking banks and for social purposes such as celebrating important family events. These could include a birth or coming-of-age, buying a wife or simply for prestige. There are parallels in our own society. Further, taking risks can involve temporary financial embarrassment, but not death from starvation.

(b) Communications are very ineffective between individuals or organisations separated by barriers of administration, geography, culture or affluence.

(c) The organisational structure of the country, with all its limitations of infrastructure and services, is frequently inadequate for sophisticated recommendations to be adopted.

These restrictions need not apply to most of the biological properties of agricultural plants and animals. Therefore, the more fundamental components of models developed for Australia or the U.K. may well provide useful routines in models for Botswana or Burma, if models are needed for the production systems of such countries.

Models that are to be used for policymaking or agricultural management in developing countries may incorporate portions of models from sophisticated economies, but their application depends on routines closely related to the objectives, communications and infrastructure of the developing countries. Unless aid experts are able to perceive this fundamental principle, and to implement programs appropriate to the developing countries, much aid will be wasted.

Examples of Models

Estimation of Optimal Stocking Rates

In southeastern Australia, the post-war years saw a substantial area of land being converted from native to improved pastures, particularly through the application of phosphatic fertilisers and the introduction of more productive grasses and clovers. Higher stocking rates could be shown to increase overall production and to capitalise on this investment in pasture improvement.

Tribe and Lloyd (1962) pointed out that the stocking rate at which the gross margin per hectare was maximised was lower than that at which production was maximised. It was therefore economically irrational to stock at a level that would maximise production. Lloyd (1966) went further and suggested on 'intuitive grounds' that a farmer who was moderately averse to risk might choose to stock at about 60% of the most profitable stocking rate. This analysis appeared to contain several assumptions that our own data did not support. We therefore set out to determine whether a fairly substantial decrease in stocking rate below that for profit maximisation really did confer much increased stability on a wool-producing enterprise.

Inventory analyses were used by White and Morley (1977) to examine the long-term relationships between the stocking rate of Merino wethers, financial stability and profitability. For each stocking rate studied, the cash flow, net farm income and mean and minimum bank balances of a farmer were simulated over a number of years. The stocking rate at which the highest minimum bank balance was recorded was about 15% lower than that at which the standard of living and the mean bank balance were at a maximum.

Low stocking rates usually imply low income per hectare from sheep, so that a risk-avoidance policy that seems intuitively obvious might indeed be one that increases risks. This is because the farmer is unable to increase cash reserves sufficiently in the good seasons to get through the poor seasons when cash is needed. We concluded on predominately economic grounds that the choice of stocking rate should therefore involve a compromise between profit maximisation and financial security, the selected stocking rate being at least at a level at which financial risks, and hence the threat of bankruptcy, are minimised. We deduced that for Merino wethers, the difference between the most profitable stocking rate and the most secure one is probably not very great. Similar studies have been conducted with Merino ewes grazing either annual pastures in northern Victoria (White et al. 1983) or perennial pastures in western Victoria (White et al. 1982).

It is true that initially these models were used only by us. Nevertheless, we have both referred to them widely when educating farmers, advisers and students on biological and economic responses to stocking rate. Some farmers seem to have accepted our conclusions. Furthermore, we are pleased to report that a few extension officers, at least, are doing likewise. Nevertheless, years of conflicting advice on choice of stocking rate (as outlined by White 1981) and widespread unease and lack of awareness of models and their predictions have meant a painfully slow acceptance of the message.

Grazing Management

Systems of rotational or controlled grazing are frequently advocated, though field studies in Australia have almost never shown these to be more profitable than set stocking. An exception to this is the need to rotationally graze lucerne. Using a perennial pasture model, Morley (1968) was able to show that systems of grazing management may vary considerably without serious loss of pasture production, provided pasture stability and animal welfare are not jeopardised.

Economics of Increasing Reproduction Rate

The breeding ewe flock model of White et al. (1983) was modified to evaluate the economic benefits of increasing the reproduction rate of Merino ewes. A study by White (1984) indicated a modest increase of about 7.5% in gross margin per hectare in response to lifting lambing from 80 to 90% within a traditional wool production system. There are several opportunities for manipulating the feed supply so that lambing percentage and flock productivity could be more profitably improved. Feeding supplements to breeding ewes before mating as a means of increasing lambing percentage was found to be most unprofitable (White and Bowman, personal communication). The cost of hormone therapy or short-term supplementation to achieve a 10% increase in the number of lambs weaned has to be less than about 80 cents per ewe in a wool-producing flock. This is hardly likely!

Microcomputer Programs for Sheep Extension Officers

Frequent discussions with sheep extension officers have revealed a need for computer programs that can predict changes in available herbage, animal production and profits in response to different management strategies. These include, for example, changes in flock structure, culling percentages, lambing percentages, marketing strategy (e.g. at what age should wethers or cast-for-age ewes be sold), stocking rate and lambing time.

SHEEPO has been developed as the result of a very successful collaborative project involving Sheep Industry Officers and producers. SHEEPO uses mathematical functions incorporated in the original model of White et al. (1983) and predicts changes in pasture availability, herbage quality, animal liveweights and requirements of supplementary feed. It appears to be a very realistic and objective means of assessing carrying capacities, feed requirements and alternative management strategies at the farm level. It has recently been released to selected District Offices of the Victorian Department of Agriculture and Rural Affairs, and is currently being tested in other Australian states. It also had a key role in two workshops for sheep extension officers in 1984. The first one was to examine management options for lamb producers on irrigated properties. The second workshop evaluated a family farm that was financially at risk.

SHEEPO is an easy-to-use computer package that is assisting extension specialists to advise local graziers on sheep enterprise management. It considers pasture growth, availability and quality, flock size and structure, nutritional requirements of all classes of stock, management procedures and economic criteria when analysing a management option. It is written in PASCAL, initially for use on a Rainbow 100+ microcomputer (Whelan et al. 1985).

Drought Ration Programs

A microcomputer program was written to formulate rations for different classes and liveweights of sheep and cattle that are maintaining, gaining or losing weight. The program uses the metabolisable energy system (Oddy 1978) to enable predictions of feed requirements and costs over several months, the resultant cash flow and break-even values for different classes of sheep and cattle providing a basis for decisions on whether to sell, slaughter or feed. These programs (Drought Pack I, Whelan 1982; Drought Pack II, Turnbull 1982), with the appropriate documentation, were evaluated by extension officers and used in District offices throughout Victoria and New South Wales during the 1982/83 drought. The Drought Packs have been sold from the Department of Agriculture Book Shop to producers and agricultural colleges.

Drought Mitigation Strategies

Fodder conservation policies for the Queanbeyan environment of New South Wales were investigated by Morley and Graham (1971). They concluded that for a wide range of possible drought sequences a farmer might be encouraged to store up to 100 tons of hay for each 1000 sheep. However, a feasible alternative, if his land or personal preferences made fodder conservation undesirable, would be to put aside funds for buying wheat to meet his drought needs.

Control of Sheep Nematodes

The control of parasitic nematodes in sheep has been based for some years on drenching with anthelmintics at fixed times of the year, such as at weaning, in mid-January and immediately before lambing. Further drenches are applied when animals happen to be in the yards for some other reason, or when they appear to be stressed (e.g. lambs scouring), though such assessments are notoriously unreliable. Not only is there a waste of drench and associated costs, but excessive drenching hastens the build-up of resistance by the nematode populations to the anthelmintics being used.

NEMAT is a simulation model of the life cycle of the sheep nematodes, *Trichostrongylus* spp. and *Ostertagia* spp., and of the epidemiology of nematodiasis in sheep (Callinan et al. 1982). It is used to devise management strategies for nematode control, such as drenching with anthelmintics at strategic times or moving the sheep to less infected paddocks. It has formed the basis of the Nematode Control Advisory Service operating in Western Victoria since January, 1982 (Callinan 1984), the predictions of the model being compared at regular intervals with observations on monitor farms of pasture availability, sheep liveweights and egg and larvae counts. The model simulates the growth of perennial ryegrass/ subterranean clover pasture and weaner sheep using mathematical functions described by White et al. (1983). The development and survival of the free-living stages of the nematodes depend primarily on air temperature and moisture, the rate of infection also varying with pasture height. In a 20-year simulation (1957 to 1976) for the Hamilton District of western Victoria, NEMAT confirmed the value of a drench in February and another at the autumn break for weaner sheep drenched in the previous December. It also showed the value of a drench and shift on to 'clean' pastures in July. If a shift to 'clean' pasture was not possible, a drench at the autumn break and 0–5 drenches in winter and spring were required (Callinan and Morley 1982; Callinan et al. 1982). Since the number and timing of these drenches depend on the weather, they may be predicted only by a model of the sheep/nematode system. Before the inception of the Nematode Control Advisory Service in western Victoria, published recommendations for nematode control included drenching weaner sheep every six weeks from April to August. In the three years, 1982–84, observations and computer predictions have indicated that this would have been a waste of 10 drenches. The model has therefore recommended savings of more than $1 million for the Hamilton district alone (Callinan 1984). Variants of NEMAT are now to be tested in other States, including the Riverina District of New South Wales and in Queensland.

Eradication of Bovine Brucellosis

A model to compare alternative strategies for the control and eradication of bovine brucellosis was constructed by Roe (1977). The predictions of this model contributed to the design and provision of cost estimates for the Australian brucellosis eradication program. It was shown that a program of cattle identification, test and slaughter was required, and that vaccination should continue until the reactor rate had fallen below 0.2%

Another model was used to assess how many teams would be needed in a particular district for testing beef and dairy herds (Beck 1977). The model predicted testing workloads, cattle slaughtered and disease status over the course of the campaign, taking into account the constraints on abattoir capacity, finance and time. For the particular district studied, provisionally free status was predicted to be achieved in 10 years with one team and just over 2 years with five teams.

The planning and implementation of the Australian brucellosis eradication program have benefited from the use of epidemiological and economic techniques not previously applied to national disease control programs in Australia. The procedures have been used to assist veterinary staff responsible for implementing the program, and to demonstrate to governments that eradication is economically desirable and feasible.

Cattle Tick Control in SE Queensland

Eradication of the cattle tick *(Boophilus microplus)* from Queensland, though highly desirable, has never been considered feasible. Queensland has therefore sought cost-effective and practical methods for 'living with the tick.' Computer simulation was chosen to compare the economic efficiency of different tick control strategies.

A computer model that simulated populations of the cattle tick was developed by Sutherst et al. (1979) to assess alternative control strategies. For European cattle breeds, which are susceptible to the tick, acaricide dipping was shown to be best performed at regular 3-week intervals, beginning either in spring or summer. In the short-term, a sequence of five or six dippings was found to be the most profitable strategy. In the long-term, the best strategy involved the use of resistant Zebu × European cattle combined with a single spelling period or limited dipping.

The above model was incorporated into a larger model that simulated a typical commercial beef production system in southeast Queensland (Elder et al. 1983). This model predicted that crossbred Zebu cattle in a series of poor seasons would return a much higher profit than European cattle in any season. It also indicated that producers of crossbred Zebu cattle without tick control facilities would be better off culling the tick-susceptible animals in their herds. It suggested that, if feasible, the most profitable strategy for managing crossbred Zebu cattle is to move them between paddocks (spelling half the property at a time) at 6-week intervals during spring and summer.

The Tick Extension Group is continuing to promote tick-resistant cattle using field trial results and the model predictions (Elder et al. 1983). They are also discouraging the overuse and misuse of chemicals and promoting cost-efficient tick control methods. This has contributed to a 4.0% drop in the sales of acaricides between 1976 and 1982.

Prediction of Grain Yield in Wheat Crops

A simulation model has been constructed to describe the development, growth and yield of wheat crops in northwestern Victoria (O'Leary et al. 1985a). It considers the effects and interactions of weather, site, agronomic practice and cultivar characteristics. The performance of the model has been tested against field data, including an experiment at Longerenong Agricultural College involving different sowing dates (O'Leary et al. 1985b). The model has also been used to identify optimal flowering dates for wheat cultivars in the Victorian Wimmera (O'Leary and Connor 1985). It is therefore able to predict the effect on yield of different management decisions in different seasons. It has been modified to operate on the Rainbow 100+ microcomputer systems installed in the District Offices of the Department of Agriculture; a manual is in press (O'Leary 1985).

This model was developed to provide a means of estimating the economic returns from seeding clouds with silver iodide (White and O'Leary 1980). In addition to the above applications, it will also be incorporated into a whole-farm model to develop principles of crop-livestock integration. Field studies to compare different crop-livestock rotations and management strategies over many years in different environments are clearly beyond the resources available.

General Conclusions

Models of systems or subsystems may be developed for a variety of reasons but not all are likely to produce results that are useful in the socioeconomic sense. The main useful objectives include developing understanding, guidance of research, extrapolation of limited information and aiding management decisions.

Modelling may proceed at many levels — from the cell to the industry or nation. The choice of level depends on the reason for modelling — the use to which it may be put. Modelling as a form of doodling may be justified, but its limitations should be recognised.

Models may play several roles, including forcing definition of objectives, providing a logical framework for information, examining the current state of information on some subject, performing computer experiments and extrapolating from available information. There are opportunities and dangers in each of these roles.

Modelling of production systems in the developing world offers opportunities but is subject to severe socioeconomic constraints. Immediate transfer of technology in the form of models is not feasible because of these constraints, as well as because of biological and physical differences between sophisticated and developing economies. That is, modelling of systems in developing countries should be a local activity rather than a direct importation.

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Structuring a Successful Modelling Activity

D. Bennett* and D.K. Macpherson**

OUR title has four concepts in it. Each of them will bear attention and reanalysis, as in: What do you mean — 'successful'? and so on. We will do some of this reanalysis — our motivation is that by some important measures of success, farming systems modelling is not doing well. Advice about what to do is available from a number of sources — mostly outside the agricultural research community in the broader area of policy analysis. Thus most of what we have to say is not original. However, it seems to need repeating: modellers need to become more self-aware, and more self-critical. And agricultural modellers need to realise that they are part of a wider community of policy analysts.

Analysis

Modelling

This goes first to get it out of the way. We mean the construction of computer models, not physical ones, and most people at this workshop have probably had some relevant experience, even if only that of doing a regression analysis. Others have done things that are much more ambitious and may accordingly have more invested in this way of proceeding, which can be a handicap. We expect that the audience can be classified into those who have no idea of what it is like to write a model, those who belong to the old orthodoxy that sees models as accurate scientific descriptions of the world, a few who see them as conventions for guiding economic efficiency (Majone 1983), and a very few who find them interesting mainly for what they say about their makers. By this last we mean that models are indicators of what is seen at any time as interesting or fashionable or soluble or saleable or useful by modellers and their peer groups — which usually don't include farmers, let alone developing country farmers. One or two here may be concerned with models as elements in problem-solving dialogues, but no-one is very good yet at getting dialogues going between mathematically inclined people and others.

Our point is that a particular model of bovine metabolism or of a farm enterprise is always someone's invention, and almost never the only way of performing that modelling task. Since there are no uniquely correct, infallible models in the Farming Systems Research (FSR) area, a model that fits a publishable curve through some biological data is not enough (hard though this is to achieve) or else may be too much to hope for. The choice of model must be narrowed or guided by consideration for social structures and objectives. A lot of people in the field know that more is needed, though a surprising number belong to the old orthodoxy, but not enough is being done about it.

Success

Success is not only a 'bless-word,' it is vague enough to make the need for more thought apparent. Finding out whether a model is a success means at least: a) defining what is meant by success; and b) seeing if the model succeeds in those terms.

Usually success in the FSR area is defined (explicitly or not) as something to do with usefulness. Systems analysts generally do not perceive this as being very different from two other important criteria: truth and goodness. Pure scientists occasionally spoil this happy state of mind by being over-insistent on truth. Wider definitions of goodness than usefulness are usually left in books by philosophers or sometimes policy analysts (e.g. Leys 1949). Beauty, the other major criterion handed down to us, now generally plays a cameo role as simplicity (fashion has changed since the 1960s, and the rococo model is despised).

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Bowing to practicality we will consider mainly usefulness from now on as the measure of success. The first task here is to point out that there is such a thing as the subdiscipline of *evaluation,* which is located within the general area of 'policy studies.' Changing the relevant words from a monograph on the subject (Crane 1982) to apply its definition to our topic, evaluation is the 'appraisal of [models] in the light of data [on their application] collected by standard research procedures.' This is a rare activity, but before asking why, we will be more specific about the meaning of 'appraisal.'

Innis (1972) clarified thinking about appraising models, when he divided the value of engaging in modelling into three parts: (1) conceptual utility: the model as a frame of reference for thought; (2) developmental utility: training of the modeller in thinking about the system or problem; and (3) output utility: useful information for non-modellers (which might include recommendations or new ways of thinking).

In our experience all modellers claim conceptual utility — they would have to be in a very unusual state of mind not to, once having invested time, effort and reputation in a model. Beyond this, of course, the possession of a model allows an invisible college of modellers to develop, and so serves a social function which might be classed under 'conceptual utility.' We have not heard of any attempts to measure this component of value, but we presume it exists, given that there is so little evidence of the other components and there are so many models. Developmental utility is a very popular and easy claim to make about a model that 'works' but produces unrealistic results, or results not used by policy makers or decision takers. Cordova et al. (1983) is an appraisal that proceeds at this level, though without much rigour — which still leaves it as an unusual example among modellers of openness and the self-critical spirit.

Output utility is the key issue, and hopelessly little is done about checking that it exists and that it was worth the effort. Reasons for this may include: (a) modellers don't care; (b) modellers don't know how; and (c) modelling projects aren't set up with evaluation in mind. Reason (a) is less common than it used to be when money was easier to get; (b) is still true, and gets mixed up with (c). After all, it can be hard to draw the line where trying out a new idea changes into being responsible for a policy initiative. However, Crane (1982) expects that what he calls the 'scope' of program evaluation should include the 'formulation' stage as well as 'implementation' and 'outcome.' That is, before anything is done, one should be considering the likely 'coverage, adequacy, equitableness, appropriate citizen involvement and effectiveness' of the program, and how to measure them.

These problems are enough to keep a lot of people (many or most of them not biologically trained) in work, trying to find out what the end users of FSR want in their lives, and why FSR isn't giving it to them. An interesting example in the FSR area of how involved this can be is Roumasset's (1976) study of 'Rice and Risk' among Filipino farmers, which seems to show that what everyone 'knew' about peasant proprietors' attitudes to risk just wasn't so. Where modelling is concerned, evaluation is even a little harder than for the average social program such as a negative income tax, because one may be offering not just a product or a service but a way of thinking. This may imply a need to collect data not only on such questions as whether (a) the user used the 'useful' information, (b) the user is 'happier' as a result, (c) benefits outweighed costs, (d) inequality and oppression were not increased, (e) other development aims were met; but also whether, (f) the user has some idea what was going on, (g) the user's reasons for using the information are what the modeller thought they were, (h) the user is prepared for the advice to change with changes in research findings; and, given ambivalent answers to some of these questions, whether, (i) the question or the answer is wrong.

These are probably only a few of the questions that should be answered in the affirmative if a model is to be described as a success. Looking for successes recently, we searched the AGRICOLA data base, and found many thousands of references keyed by 'model' or 'system.' A few hundred also keyed 'evaluation' or 'assessment.' All except a very few of these could be classed as 'use of a model to evaluate...' rather than 'evaluation of a model of ...' And the number (of the few hundred) that also keyed 'development aims and objectives' was zero. This large but casual search can be supplemented by such smaller scale studies as Syme and Bennett (1979), Bennett and Syme (1979), Morley and Anderson (1983) and Blokker (1982) which disclose the poor record of computerised farm advice. Taken together they suggest that successes are rare, even by a weaker set of standards than (a)–(i) above.

There is a defense against this dismal conclusion. The sanguine modeller will now assume that even though hordes of users are not revering the computer, there is a diffusion of the relevant 'facts' and 'innovations' through a marketplace of ideas. There is probably some truth in this, but there is also a lack of evidence that the investment in modelling is being paid back. This attitude also appears to be inconsistent with a belief in models as expressions of scientific rigour; general experience suggests that this quality does not diffuse well. And the true FSR person would probably like to see users take the system to their hearts, rather than be merely recipients of advice from a numerate expert with significant digits in every pie.

Activity

Gravity may be discovered in isolation, but researching a farm needs a team. The team will be required to achieve the theoretically impossible task of deciding by rational means what it thinks is the best course of action. In addition it will be pulled in one direction by purists in the republic of science and in another by those in the user community who won't see reason. The point here is that, despite the flow charts and other boxes-and-arrows, finite-state diagrams in textbooks of systems analysis, 'activity' is not an algorithm working itself out, and is not (in any strict sense) rational. The modeller may (for example) construct a system that generates a 'rational' profit-maximising allocation of crops to fields, but he will have decided by non-rational means that this was the class of problem to be attacked. Some of the means will have been pre-conscious and directed by the modeller's training. Others will have had the nature of rules of thumb and practical compromises. Behind the logical workings of the computer there is a dubious regress of choices. This leads on neatly to talk about structuring.

Structuring

We have just concluded that systems analysis is a way of life, an ethical stance, a cognitive style, a (bad) habit, a banner with a strange device; 'Preposterior'! — and not a recipe, an algorithm, the production of value-free information or even the Answer. How can one structure something like this? There may even be a Second law like that of Thermodynamics operating, according to which systems create (the semblance of) order in a defined area at the cost of greater disorder (alienation, de-skilling, disrespect for intangibles) everywhere else and in total.

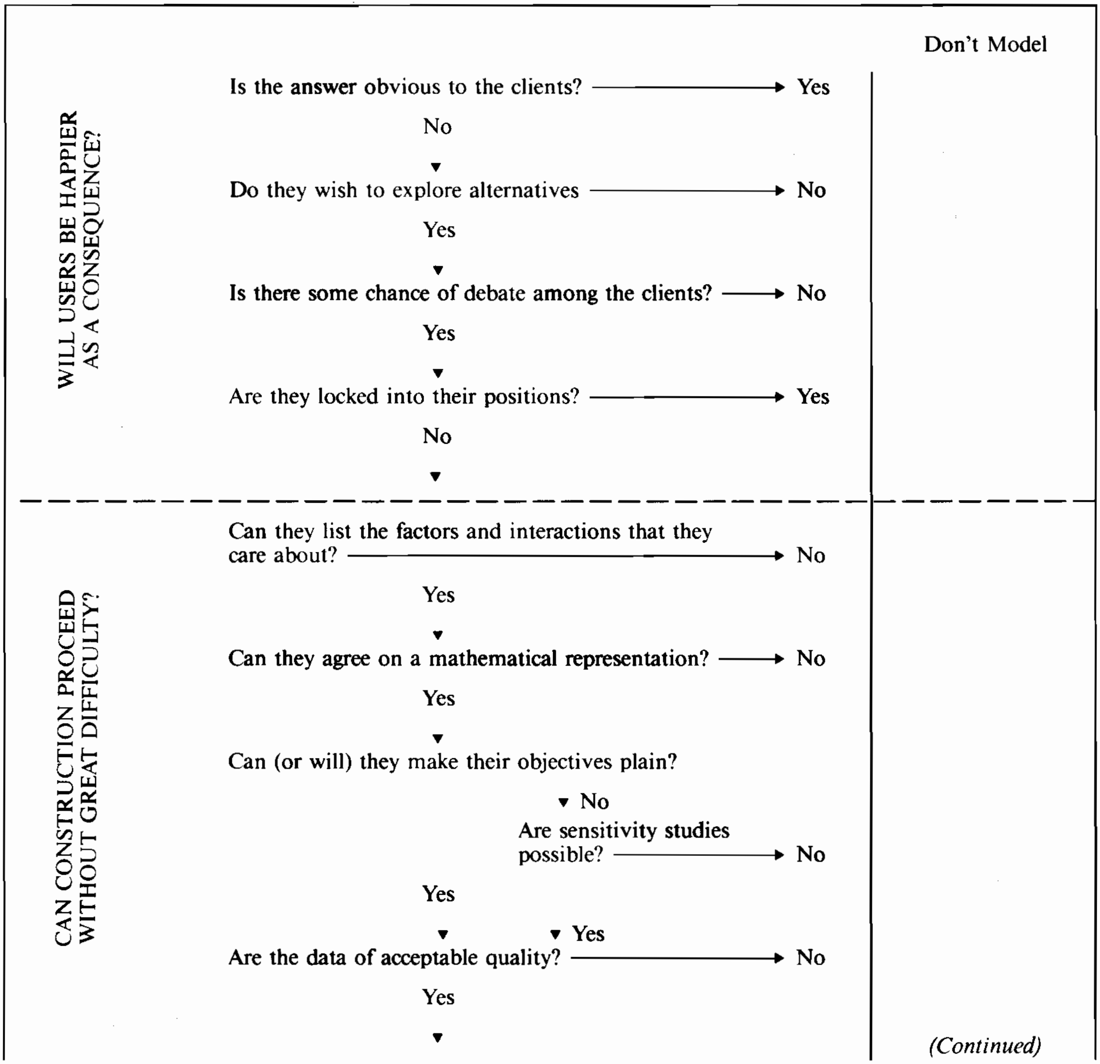
A number of approaches have been tried. Enthusiasm was applied in enormous quantities in the sixties and early seventies. Charisma has been observed in a number of places (think of your own idols) and seems not to have worked particularly well. We now seem to be at a stage where the recommended measures are: (a) adherence to standards, (b) avoidance of recognised pitfalls, or more succinctly, guidelines. Some standards are already in place among certain kinds of modellers. For example, econometricians test the prediction errors of their models for non-normality, serial correlation and the like. Simulation modellers advise fitting the model to half the data and testing it on the other half (or other more sophisticated schemes). This kind of activity is, however, mainly directed at satisfying standards of pure science, not of engineering or agricultural extension: these standards test that a claim of conceptual utility is not deluded. Much FSR does not apply this kind of test. Being more concerned with usefulness than truth it assumes, for example, that linear programming is a good way of looking at a particular management problem, and then goes ahead and applies it. Perhaps it is good, more exactly, perhaps after the user is used to it, it *will* be — for that user. But as we indicated above, evaluation is rare — especially if it is the user's conceptual utility (which is a component of overall output utility) that is an issue.

Then there is the avoidance of pitfalls. This phrase now has more weight behind it than it used to because of the existence of Majone and Quade (1980) in which eight chapters discuss pitfalls of separate phases of applied modelling projects (including pitfalls in evaluation). These discussions are far more extensive than can be covered here, and in any case do not include all the folk wisdom that is available; however, the book is well worth reading. But without prejudice to the real educative value of recording pitfalls, we would like to point out that advice on avoiding pitfalls tends to be like Jiminy Cricket's advice to Pinocchio: '... and always let your conscience be your guide.' That is, pious, and not quite specific enough. Kathleen Archibald hints at this in the last chapter of Majone and Quade (1980); the pitfall of listing pitfalls in systems analysis is that you may think you have a system for avoiding pitfalls.

In an earlier paper (Bennett and Macpherson 1981) we reviewed five sets of guidelines for modelling and ended by being rather disrespectful of them. They showed a faily earnest concern for criticism and the growth of knowledge, and little concern with the politics of agenda setting, and the fluid nature of issues and perceptions. It seemed that their authors would have been no match for Machiavellians interested in manipulating policy and, for that matter, no match for a user who was merely disorganised. We came to the conclusion that such guidelines should include statements of the modellers' own motives and those of the users, so that misunderstandings don't get turned into models. This is another piety, because either party may not dare or may be unable to put their motives into words. It is illustrated by Table 1 — our own guidelines.

The current piety which seems to be most in need of repetition at an occasion like this is: stay close to the customer — a phrase which is also popular in current talk about management in general (Peters and Waterman 1982). The argument for staying close to the customer is that it

Table 1.



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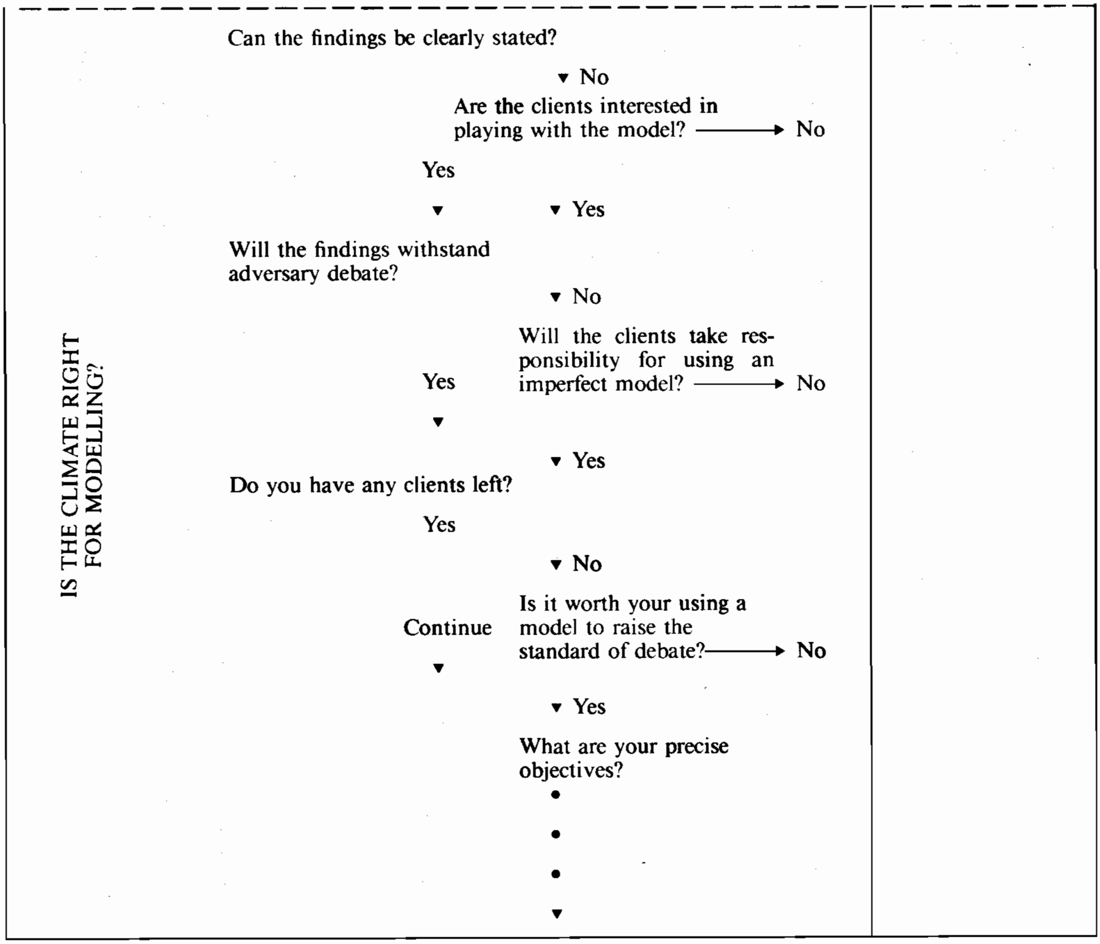

allows what the user thinks is the issue to be defined and redefined and redefined, and with luck may make it clear whether there is a modelling task at all. It is very easy for the modeller to drift into a familiar bag of tricks, rather than appreciating the client's values. Which is not to say that those values cannot be challenged. To rule a challenge out would be another version of the 'value-free-information' pitfall. But the modeller is now expected to make the system 'user-friendly,' limit the demands on the user to gather data, be ready to explain strange results quickly and so on. Once again we are reproducing pieties, but there is some possibility of putting meat into these pieties. For the purpose of discussing this we would like to point to two main elements in the modeller/customer relationship. The first of these may be called the movement of both parties towards defining what would count as success. The second is the sharing of responsibility for failure.

Defining Success

A way of achieving this objective is to explore the information flows with which the user deals. Questions useful in this exploration include: What entities does the user see as significant and why? What are the rules that both parties believe govern these entities? If data are collected about these rules and entities what would normally be done with them? How would this help? What do the possible consequences sound like to the user?

These questions are radically different from the traditional systems analyst's: What is the problem? What are the alternatives? Which alternative is best? (Simon 1960), because they explore what happens before Simon's procedure starts. The problem definition is negotiated, not 'found' by inspection. The organisation for taking decisions may be part of the problem. What is 'best' may no longer be an issue. In much of the current literature this shift in focus is being presented as an advance, the move from 'hard' systems analysis to 'soft' systems analysis, whereas it is partly a failure of nerve. It can be argued that once we get away from the idea of the optimising model improving on the biological system, we fall back almost totally on the human observer's unformalised capacity to spot why previous practices and interventions have failed. What then is the *ex ante* status of the new (even model-guided) practices and interventions? Are they more than changing fashions? Why should they be trusted?

No one (well, not everyone) is going to take this level of pessimism seriously in practice. Besides, the asking of the new kinds of question is becoming more organised. While our First World experience does not make us see the construction of multivariate utility functions as particularly useful, some of the softer approaches offer hope. The works of Eden (Eden and Jones 1983), Checkland (1981) and de Marco (1979) offer fairly down to earth techniques (for a First World situation) of linking the mathematical model to the 'problem situation.' But we must finish this section by quoting de Marco: '[any problem description] you can't show to the user is *totally worthless* as an analysis tool.' Has anyone passed this test for a computer model and a Third World small farmer?

Responsibility for Failure

Our second area, the sharing of blame, is the really tough one for the tender of conscience. Traditional wisdom (from the bulletin board of a computer room) has it that the last phases of any project include the search for the guilty and the punishment of the innocent. Since innocence for all is impossible, we would like to see things arranged so that no one is innocent. How can this be? How many users can give 'informed consent' to a model when only a tiny fraction of any population understands difference equations?

The best we can offer here is little more than a buzzword. In the field of artificial intelligence, workers are having some success in producing 'expert systems' that explain their own output (Hayes-Roth 1983), and this seems like a good precedent to follow. The idea here is to describe the social and biological systems as a set of logically linked rules of thumb and ask a program to check whether a proposed practice conflicts with the rules. If it does, then a list of the relevant conflicts can be generated. Also, with some more difficulty, practices that apparently have nothing against them can be designed. In either case a record of the logical process answers the question 'why did it turn out that way?' that plagues every modelling exercise.

This is potentially a much more flexible way of describing systems than the older process of examining linear programming output to see which constraints were active. In support of the value of this we observe that in Western Australia, farm planning by linear programming has become more popular since human beings started to explain the results to users. What an explanation of a more complicated dynamic system would look like if it were to be communicated in a remote village is unclear, but a worthy research topic. Explaining the basis for advice about risk might be even harder. Perhaps in the next swing of the pendulum between Western arrogance and Western humility, analysts may feel impelled to explain von Neuman gambles to users, believing when forced to act that their own culture and subculture really have something to offer.

Conclusions

Our tacit agenda in composing this paper was our wish to reduce modellers who clung to the old ways to jelly — the well-known prerequisite for a conversion experience. The old ways were not much in evidence among the other authors. They were concerned to make much the same points that we make about models, but about the richer context of the overall FSR enterprise. This has led them to put modelling well down their list of priorities. This may be overdoing it. While the easy 'hard' systems exercises may be rare, it is fair to expect that the harder 'soft' systems, like other 'soft' disciplines will have a lower success rate or outcomes that are harder to interpret. In this context we note the remark of Remenyi and Coxhead (these Proceedings) that widely applicable interventions 'only marginally dependent' on FSR, such as biological control, may offer the biggest dividends. And these may be just the systems most easily modelled.

Which brings us back to the lack of evaluation, especially of models. We don't expect work to stop. But we would like to point out that even God is thought to be preparing an evaluation program for Creation, one that will have to deal with problems caused by lack of citizen involvement in the early stages. Also, faith without working extension programs is dead. More prosaically, we suggest that documented success (and reasoned definitions of that success) of models in areas of interest to ACIAR is so rare that an investigation program would be worthwhile, and we suggest the following terms of reference: 1) That ACIAR supervise a review of evaluations made on (a) agricultural modelling activities, especially in Australia; (b) overseas agricultural aid programs, with special emphasis on Australian financed ones (requirements — three intelligent graduate students for one year each, with some careful planning and overseas travel); 2) That ACIAR commission a number of new evaluations of projects identified in (1) above, where key variables affecting success and failure may be revealed; 3) That until the guidelines for successful overseas aid-agricultural modelling activities can be prescribed, ACIAR write into all contracts financial resources and mechanisms for full evaluation of these projects; and 4) That ACIAR contract an appropriate agency to write a technical memorandum on procedures to be followed when attempting to develop agricultural models in overseas aid projects, perhaps as part of a general memorandum of procedures for overseas aid projects.

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Socioeconomic Modelling of Farming Systems

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IN the early days of Farming Systems Research (FSR), practitioners recognised the farm as an entity with interrelated production and consumption dimensions, got on with the job and did it, often with very modest physical and financial resources. More recently, but especially since the advent of the big spenders supported by the CGIAR, USAID and others (see Fresco 1984), more seems to be said than done in a proliferating literature that is long on pontifical evangelism and anecdote (e.g. Dillon and Anderson 1984) but short on substantive method and genuinely successful work of significant impact. Among the gentle persuaders, few have been as prolific as the socioeconomists. It is thus with considerable trepidation that we embark on this essay.

The practice of FSR has surely matured to the point where it is no longer necessary to argue the importance of socioeconomic considerations in FSR work or, indeed, in other even more important work. One convenient indicator of the extent of socioeconomic territorial relevance is the (somewhat arbitrarily sketched) hatched area in Fig. 1.

One of the few (almost) universally agreed concepts of FSR is the centrality of dealing with the human element in any farming system. To the extent that farmers' and their households' interests

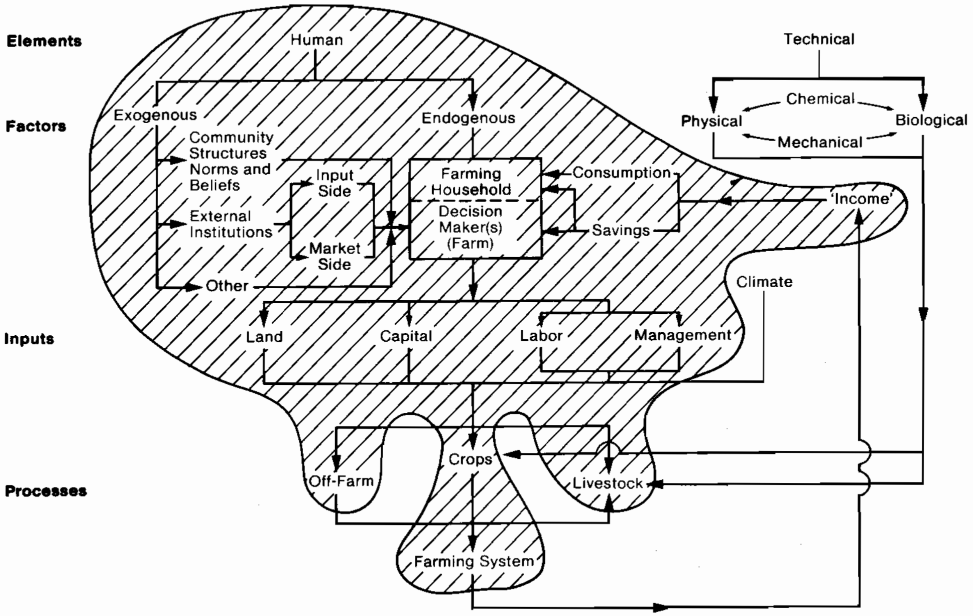

Fig. 1. Schematic representation of some determinants of a farming system (after Norman 1980). Hatched domain of socioeconomics added.

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are nurtured and kept to the fore, socioeconomics must play a rather central role in any serious FSR. Better that the socioeconomic concerns are maintained enthusiastically, even if by other than socioeconomists (sociologists, anthropologists, economists and other social scientists including political scientists, historians, geographers, etc.), than neglected for the absence of appropriate disciplinary specialists.

As in all science, modelling plays a central role in social science research generally and in the socioeconomic aspects of FSR in particular. This role is charted briefly later as a prelude to some of the contributions and limitations of modelling adumbrated, respectively, in the following sections. Finally, to conclude this overview of socioeconomic modelling in FSR, we sketch our view — an optimistic one — of the way forward.

Role of Modelling

Inclusion of socioeconomic considerations in FSR may be necessary but is certainly not sufficient for worthiness and virtue in such work. Again, as in all sciences, there are many inherently artistic elements that condition progress (Ladd 1979). We suggest a scheme of the real world (including a farming system under study and the rest of reality) which is separate from the farming systems researchers' world (including its assumptions, concepts, models, insights and conclusions) by a 'threshold of relevance' (Anderson and Pandey in press, Ch. 1). The necessary condition for crossing this threshold is an artistic achievement of acceptability and accuracy in the modelling of the system under study. The artistry is emphasised here to caution on the lack of speedy, objective or even possibly knowable criteria for ensuring safe passage to reality with useful impact.

The process of modelling per se is beyond our concern here, but features multistage and somewhat cyclical steps of problem definition, system analysis, system synthesis, model implementation, model verification, model validation, model experimentation and interpretation (see e.g. Anderson 1974). Not all steps are taken by all modellers on all assignments. The general process, however, is remarkably similar across the spectra of socioeconomic modelling — micro to macro, rural to industrial, etc. (see e.g. Thomson and Rayner 1984).

How Does it Best Fit In?

The place of socioeconomic modelling in FSR is most readily seen by reference to a chart of the typical FSR process. Figure 2 is such a chart, which might best be referred to as a juxtaposed, gyrating schema. Within this schema, the heartland of socioeconomic modelling consists of items 1, 2 and 3, constituting, respectively, aspects of problem definition, system analysis and system synthesis and beyond, and spanning both the downstream (on-farm) and upstream (research station) activities of FSR.

We must hasten to add that, in so placing socioeconomic researchers at the centre of things, we do not wish to overstress their importance in the overall process. FSR teams must be transdisciplinary (Dent and Anderson 1971, p. 8, and nearly every recent author). The track record of, for example, economists going it alone has been less than impressive, if not disastrous.

Implementation of socioeconomic research elements in FSR continues to evolve on essentially ad hoc or experimental lines. Everyone agrees on the importance of survey/diagnostic work but not on its style, precision and timing (e.g. rapid reconnaissance vs. the typical village studies of several International Agricultural Research Centres (IARCs)). There are analogous divergencies among practitioners at later stages of modelling (e.g. back-of-the-envelope budgets vs. multistage risk-programming formulations of farm planning problems). Not that we should expect uniformity in approach and method across the great diversity of farming systems to be researched — rather, it's a matter of 'horses for courses.'

Horses for Courses

Models, in their every aspect, come as different as their builders. Some of us even misspent our youth in trying to classify them (Anderson 1972). For the present purpose, a simple taxonomy based on whether or not the model incorporates an optimising algorithm will serve to structure our remarks. Unfortunately, no matter how simple the taxonomy, any attempted classification faces some difficulties. First, given the already vast literature on socioeconomic modelling and its rapid rate of growth, any classification is likely to be both incomplete and soon outdated. Second, there is by no means a one-to-one correspondence between model form and the purpose for which a model is, or could be, used. As a result, any classification of modelling techniques will inevitably be somewhat 'fuzzy,' with the same type of model falling into different categories according to how it is used. These provisos should be borne in mind in what follows. In addition, our emphasis is on models that imply an economic (though not necessarily financial) orientation to farming systems. Models of a purely physical and biological orientation are not considered. Nor are those of more purely social nature, such as might be oriented to questions of social status and power between the farming system household and its environment. Note, however, that a variety of non-economic considerations, such as nutritional and demographic elements, if need be may be allowed for within a farming system model of economic orientation.

A first criterion for classification of socioeconomic modelling approaches is whether the model itself incorporates an optimising algorithm, i.e., whether it directly generates a 'solution' for the system, as represented in the model, that maximises or minimises some specified objective function. The distinction is important because of the appeal of the optimum for economic analysis and because the availability of an optimising algorithm usually affects the way the model is used. At the same time, it must be recognised that optimising models tend to be more rigid in structure than other types, thereby making it more difficult to represent the real system closely. In consequence, the optimum for the model may depart appreciably from the (usually unknown) optimum for the real system.

Non-optimising models can be further subdivided according to whether the model incorporates (or is used with) a search procedure designed to identify 'preferred' solutions, so bringing the approach close to the optimising algorithms, or whether the model is constructed solely or primarily to describe a farming system.

In this latter category of descriptive models, the most widely used in FSR is budgeting. Although budgeting models are conceptually quite simple, involving merely summarisation of the physical and financial features of the selected farming system, they are nevertheless powerful, flexible and very useful (Brown 1980; Dillon and Hardaker 1980). Via repeated application with changed parameters, budgeting models can be used in an evaluative way. Their limitations arise less from the technique itself than from the limited intuitive capacity, conceptualising powers, creativity and diligence of the analyst (Anderson and Hardaker 1979). The advent of appropriate computer software, particularly spreadsheet programs for microcomputers, has enhanced the utility of budgeting models.

In this same category of non-optimising descriptive models might be placed a group of econometric models, based usually on least-squares regression-type analysis of cross-sectional farm data, that purport to describe the production system and/or consumption system of a group of farms or farm households. Such models typically involve fitting one or several equations that are intended to describe the way the farm or household resources are allocated to alternative uses or the way that different types of output are generated. Some econometric models are related to the optimising models in that they are based on an assumption of utility-optimising behaviour on the part of the farm household. However, we should distinguish and exclude from present consideration those econometric models that permit an optimum to be identified by use of differential calculus, as in production function analysis. Rather the concern here is with econometric models that are primarily descriptive (see e.g. Alamgir and Horton 1980; Deolalikar, 1985; Pradhan and Quilkey 1985; Rosenzweig 1984; Strauss 1984).

For FSR purposes, econometric models provide a good means of summarising some of the key relationships in an existing farming system. They do not, of themselves, identify causality in observed relationships between variables, but they do permit relationships, identified on the basis of theory as important, to be quantified. Their limitation lies in the limited extent to which estimated relationships can be extrapolated from the existing situation as circumstances, especially available technologies, change.

Finally, in this group of descriptive models lie some of the simulation models, especially those that are designed to represent agrobiological production processes. Such models tend to be relatively detailed and hence best suited to describing and evaluating specified farming systems or, more usually, component parts of such systems, rather than exploring the consequences of alternative management options imposed on them. In economics, there has perhaps been some disenchantment with models of this kind, probably because of the high research resource costs typically involved in model development, related in part to the need for effective interdisciplinary cooperation. Anderson (1974) provides a comprehensive review of simulation in agricultural economics (see also Dent and Blackie 1979).

Simulation also falls into the category of non-optimising models incorporating search techniques designed to identify near-optimal solutions. Search may be conducted by means of an appropriate 'experimental design' selected to span system response to the range of values of key decision variables of interest (e.g., Crawford and Milligan 1982). If the relationship between the decision variables and the value of the choice criterion is 'well-behaved,' it may be possible to identify the optimal solution with considerable precision. However, simulation models that are to be used in this way, in an experimental design, need to be reasonably simplified if computing costs are not to be excessive. This typically means some sacrifice of details that might be incorporated in agrobiological models to be used for evaluative or descriptive purposes only.

Bellman-type dynamic programming also falls on the frontier between optimising and non-optimising techniques. Although usually thought of as an optimising method, dynamic programming, as usually implemented, is no more than an efficient search technique. The so-called 'curse of dimensionality' limits the applicability of this type of model, but some important questions in FSR, such as the replacement of tree crops, can be effectively explored using dynamic programming (Jayasuriya 1976).

Monte Carlo programming, which can be thought of as a hybrid between simulation and mathematical programming (MP), has proved useful as a means of modelling farm systems under circumstances where the assumptions of linearity in the constraints and objective function, usually required for MP models, are not well satisfied (Anderson 1975; Wardhani 1976). The essence of the method, which is nearly always implemented by computer, is that a large number of possible solutions is generated at random, tested for consistency with the specified constraints and adjusted if necessary to satisfy those constraints, then evaluated in terms of a specified objective function. Typically, the score or so best solutions are stored and reported.

As noted, Monte Carlo programming is a close relative of MP. Mathematical programming models constitute the chief optimisation approach to farming systems modelling. The suitability of the method is indicated by the very large number of applications (e.g. Andrews and Moore 1976; Barlow et al. 1983; Flinn et al. 1980; Hardaker 1975; Heyer 1971, 1972; Low 1984; Ogunforwora 1970; Roth and Sanders 1985; Sanders and Dias de Hollanda 1979; Schluter 1974; Wardhani 1976; Wills 1972). The appeal of MP lies first in the fact that it is a method of constrained optimisation, which appears to match the reality of small farmers striving, with limited resources, to improve their lot. Second, the method is relatively easy to learn and to use to produce models of farming systems that appear to be reasonably realistic while simple enough to manipulate and interpret. The fact that the necessary calculations to solve an MP model are done by computer, usually very speedily, means that it is quite easy to undertake sensitivity analysis with the models.

Of course, MP, and especially linear programming, is not without its faults. The underlying assumptions are somewhat strong, particularly those of infinite divisibility of resources and activities, and of single-valued coefficients. Extensions of the basic linear programming model, such as integer programming and risk programming impose extra computational difficulties. Finally, access to a relatively powerful computer with suitable software is essential. These facilities, so easily taken for granted in the developed countries, are often not readily available in the developing countries. Even some of the IARCs have faced considerable difficulty in securing access to suitable computer hardware and software for MP applications.

Among other optimising techniques that have some applicability in FSR, perhaps only production and profit function analysis deserve mention here. These methods involve econometrically estimated functions, usually based on cross-sectional farm data, that can then be manipulated to derive the conditions for farm production to take place at maximum profit (e.g. Barnum and Squire 1978; Yotopoulos and Lau 1973). The technique is relatively simple to use and permits judgment of the scope for profitable reallocation of resources within a given set of available farming technologies. As with other econometric methods, however, production or profit function analysis is not applicable to situations where new technologies, not presently represented in the cross-sectional farm data, are to be evaluated. Nor do these methods deal as convincingly as MP with multienterprise farming systems.

In summary, two modelling approaches stand out for their widespread utility in FSR. These are budgeting and MP, which can perhaps be seen as polar extremes of the spectrum of modelling methods. The former has advantages of simplicity and flexibility, while the latter is a powerful approach to optimising whole-farm systems.

Contributions of Modelling

Expectations about what socioeconomists can contribute to an FSR program may be more or less realistic among research administrators but minimally, and as reflected in their modelling, the socioeconomists' activities, as noted by Dillon and Anderson (1984, p.181), should encompass an appreciation of such fundamental matters as: (a) the social milieu in which farm decisions are made; (b) the institutional setting and policy environment in which farming is conducted, including details on land tenure, credit and taxation; (c) the economic environment of farms, including long-term market prospects for inputs and outputs and, most importantly, understanding of the opportunity costs and transactions costs faced by farmers; and (d) the attitudes and personal constraints of farmers, including their desire or otherwise for change, for leisure, for education, for different foods and so on, and their human and other capital. The purpose of such understanding is to assist, via the manipulation of relevant models, in the identification of effective changes to, and the design of, practices, techniques, enterprises, activities and policies that are acceptable to and appreciated by the target groups in FSR. The days of the 'quick technological fix' through improved seed, fertiliser and a favourable environment have just about gone. Progress now must be won in the context of the full reality of generally resource-poor farming systems.

Understanding of the wider reality of farming systems does not come easily. But unless such understanding is gained, the construction of relevant models for FSR analysis is unlikely. Conversely, the necessity for such understanding as a prerequisite to socioeconomic modelling can have significant positive spin-off to the FSR program at large across all the disciplines involved. Ideally, social scientists glean their knowledge of such systems through long and close contact with the people of the systems. Horton (1984) documents such a recent Centro Internacional de la Papa — CIP (International Potato Center) endeavour in Peru. The ideal, however, rarely obtains and more formal methods of description and understanding must be sought. The most widely used approach is a survey that garners detailed information on what happens in the village and on farms, to whom and when. Several alternative survey approaches developed at the Consultative Group on International Agricultural Research (CGIAR) and other centres are contrasted by Chambers and Ghildyal (1984). From these, profiles of labour availability, cash flow, work demands, prices received, etc. can be built up and, if the collections run for long enough, the variability of these attributes over time, especially in response to natural hazards like flood, drought, frost and fire, can also be quantified.

Many elements sought in survey activities as a preliminary step to modelling are subtle and/or sensitive. Particular skills are required to ensure faithful description of reality. For instance, some transactions costs such as bribe payments for access to inputs may not be readily forthcoming in simple interviews, but may involve considerable inflation of factor costs. Production levels may be systematically understated if farmers fear linkage between research workers and taxation authorities. For a final example, attempts to elicit information on farmers' attitudes to risk are fraught with the danger of interviewer bias clouding the information sought. Such anecdotes underscore the costs of reliable survey work in FSR. In short, it is (a) time consuming, involving repeated contact both to develop confidence on the part of farmers and to gain an understanding of intertemporal effects, and (b) demanding of a high degree of professionalism on the part of those in direct contact with the farmers. Senior social scientists themselves must be actively involved in the direct contact, even if this is (perhaps linguistically) difficult. As a minimum, interviewers should be conversant with the theoretical underpinnings as well as the empirical applications of the data being collected — a situation that has not always prevailed in recent attempts at implementation.

All this is easier said than done, especially in the Third World, where many governments have evinced a reluctance to institutionalise a socioeconomic element in FSR. In some cases, it may prove best to handle social science aspects through new bureaucratic entities such as 'FSR Coordination Units' wherein the leads being facilitated by, say, the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in East Africa, the International Livestock Centre for Africa (ILCA) in Ethiopia, the International Center for Agricultural Research in Dry Areas (ICARDA) in Tunisia and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Burkina Faso and Niger might be implemented in national programs of rural research and extension.

Standing Back from the Field

Hopefully it will not be seen as intellectual imperialism to assert that the hands-on modelling phase of FSR — encompassed in the third component depicted in Fig. 2 — lies at the centre of the FSR approach. That is, it provides both an integrative link between on-farm and on-station activities and, along with other mechanisms, constitutes an important mechanism for the evaluative sieving of proposed system changes and the generation of ideas for potentially fruitful component research.

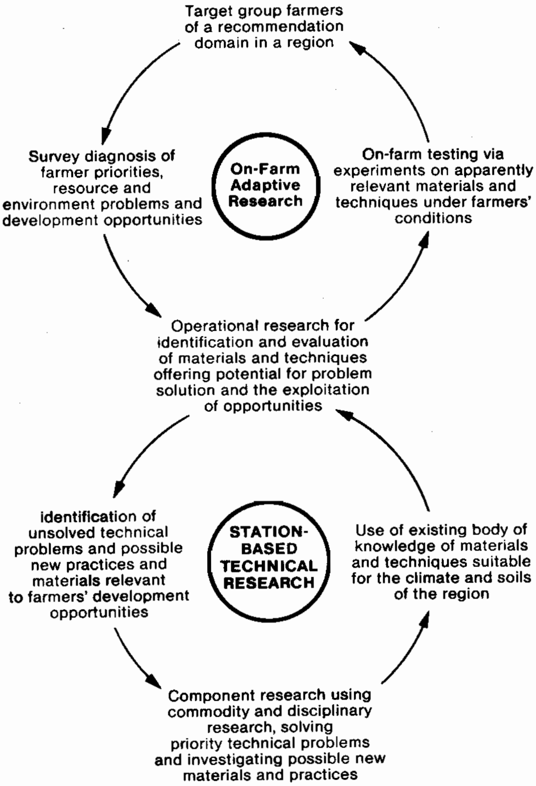

Fig. 2. Schematic view of farming systems research method (after Collinson 1982).

Modelling the existing farming system should permit the performance of that system to be evaluated in detail, with strong and weak points identified. This analysis, by itself, may well be suggestive of aspects where technical improvements can most usefully be sought. Ideas about how the system might be changed can then be incorporated in the model. While new technologies that might be proposed at this stage as potential 'solutions' may be no more than quarter- or half-baked (Anderson and Hardaker 1979), in the sense that they may require considerable research and development before they could be regarded as candidates even for on-farm testing, modelling may permit the more promising options among them to be identified and less appropriate ones to be culled. In other words, this use of modelling provides an input into the research management task, useful in deciding which lines of research should receive priority.

Modelling can also be valuable in the evaluation of the results of on-farm testing of more highly developed technologies. Usually the extent of on-farm testing is limited by practical considerations such as lack of research resources. Consequently, it is unlikely that many alternative prospective technologies can be tested on a whole-farm scale. Even such tests as are performed are likely to be restricted to a few farms that will not span the full spectrum of farms existing in the recommendation domain. Modelling can go some way to make up for these deficiencies. Results of on-farm experiments can be scaled up to whole-farm level and their resource implications and other features investigated. Similarly, the results can be 'transplanted' to models of types of farms other than those on which the trials were conducted, and similar analyses made. Conformity of the modelled results with farmers' objectives can be judged.

Modelling in this way may reveal that a prospective technology that 'works' in on-farm testing in fact needs further development before it may safely be promoted for widespread adoption by farmers. Perhaps resource needs are too great for resource-poor farmers to afford, or perhaps the associated degree of risk is too great. Such modelling results should, as part of the FSR process, lead to further on-station and on-farm development work, leading hopefully to a revised technology more suited to farmers' real circumstances. Equally, of course, it may lead to a conclusion that the developed technologies will never be adaptable to the needs of the target group until essential institutional changes are made. The needed institutional reforms may be minor — such as raising the borrowing limit for institutional credit, or major — such as wholesale land reform. Certainly, drawing conclusions about the need for revolutionary institutional reforms may present special problems for FSR workers employed by, or dealing with, governments whose political preferences (whether due to self-interest or impotence) do not include even the discussion of such possibilities.

Aggregation from farm-scale models of the results of prospective technologies can help to identify potential marketing problems or problems in the supply of inputs. Thus, for example, output-increasing technologies may be expected to have a depressing effect on market prices of the commodities being produced. If demand is very inelastic, price falls may be so sharp as to compromise any hoped-for effects on incomes of poor farmers. Or aggregate input requirements of, for instance, fertiliser or credit, may exceed the current capacity of input — supplying agencies, implying a need for improvement or expansion of these agencies if the uptake of the technology is to be unimpeded.

A Closer View of IARC Program

It may be useful to add some brief remarks about socioeconomic modelling in an FSR program. These remarks stem from the involvement of one of us (JBH), in an advisory capacity, in ICRISAT's Economics Program.

The models used were MP models, chiefly quadratic risk programming models (Ghodake and Hardaker 1981). They were based largely on the abundant stock of detailed farm-level data collected through ICRISAT's village level studies — probably the best data base of its kind in the world. Without this data base, the modelling task would have been much more difficult, perhaps impossible. Information on new technologies came mostly from the Centre's Farming Systems Research Program, including both on-farm and on-station trials.

The modelling task proved to be more time-consuming and labour-intensive than at first imagined. Initial work was held up by the lack of suitable computer hardware and software. The models developed were relatively large, reflecting the complexity of the real systems being studied as well as the generous stock of available data. The result, however, was that model-building and validation were not easy tasks. Similarly, the output generated from computer runs with the models was voluminous, creating some problems in interpreting the results. In retrospect, it might have been better to have traded off some precision in the formulation of models used against gains from greater facility in use of smaller more 'rough and ready' representations.

In use, the models did provide some information of the kinds discussed above as being potentially available from modelling (e.g., Ghodake 1983, 1984; Ghodake and Kshirsagar n.d.). Feedback to research policy was not, perhaps, as strong as it might have been, for several reasons. First, there is no sharp division in modelling between the phases of (i) model verification and validation and (ii) model use. Consequently, results from modelling must always be viewed as provisional and interpreted with caution. It becomes easy, therefore, to dismiss results that do not happen to align with current thinking about research priorities. Moreover, any analysis of the effects of prospective technologies must inevitably incorporate some guesswork as to how that technology will perform in the hands of farmers. The results of testing technologies, even with farmer management, are likely to be superior in technical efficiency to what can be realistically expected if and when the technology is actually adopted. It is too easy for the enthusiasm of scientists for their 'brainchildren' to bias upwards the expectations of how given technologies will actually perform in practice.

The existence of this potential source of bias in FSR modelling points to one advantage of MP over budgeting that was exemplified in this ICRISAT-based work. Mathematical programming involves formal representation of the constraints faced by farmers with the result that, even though the yield effects of some technologies were, in retrospect, overestimated in modelling, the constraints on the uptake of that technology were pinpointed. The chief package of technologies investigated using the models was based on the raised bed and furrow system, involving a specially designed animal-drawn cultivator. The programming studies revealed very clearly the impediments to widespread adoption of this technology arising from capital shortage of the target group of farmers.

Limitations of Modelling

The plethora of problems surrounding FSR in general and its socioeconomic aspects in particular pose a difficulty in selecting a few that can be mentioned here (see Abalu 1983). Others (e.g., Anderson 1974, p.33–36) have documented some that persist but which are not addressed here (e.g., inadequate representation of uncertainty, insufficient verification and validation, inappropriate balance in the structure of models, deficient use of feedback from on-farm trials to model specification, etc.). Rather, three categories of a reduced, albeit idiosyncratic, set of problems are considered.

Technical Problems

It is tempting to broach some of the awkward questions that modellers face such as selecting an appropriate type of model (e.g., normative vs positive, simulation vs programming), going for the 'right' level of detail, disaggregation, decomposition, etc. but, having tackled some of these elsewhere (e.g., Anderson and Hardaker 1979), we choose not to do so now. A couple of oldies are, however, worth a further look. An issue to which we have not yet addressed ourselves, but which Maxwell (1984) has raised, is the difficulty faced in FSR by the turmoil in the socioeconomic environment — what Maxwell calls 'FSR with a moving target.'

In this respect, a particularly intractable problem is that of achieving an 'appropriate balance' between data gathering, model building and model exploitation as well as vis-a-vis the other processes depicted in Fig. 2. If too much time is devoted to these tasks, the system under study may have been significantly perturbed before useful results are obtained. This seems to be an issue that is much easier to pass judgment on retrospectively than it is to make good decisions about in the hurly-burly of completing an FSR project. It is something that can be addressed in part through the modelling process itself (especially via sensitivity analysis, see Anderson 1974, p.20–23) but somewhat irrevocable data-gathering decisions may already be in train by the time of such realisation. All this puts a premium on the early availability of at least a preliminary model of the farming system before very costly data assembly is begun.

A general issue that might be classified as a technical difficulty is the 'remoteness' of some farming systems modellers from their target domains of farmers. This arises from many sources — culture, language, class and understandable lack of enthusiasm by farming systems researchers to live in the reality of such domains. This is surely one of the unstated driving forces for rapid rural appraisal methods and other 'quickie' approaches to problem diagnosis. Much less frequent, at the other extreme, is the anthropological approach whereby researchers lose themselves in a culture for several years, make millions of observations, but never emerge from the morass of information to get back into the cyclical processes of FSR.

The remoteness problem is reflected in imperfections of farming systems models largely connected to missed subtleties in understanding and modelling of the systems, that may be critical for ultimate success in the work — see Abalu et al. (1984) on the importance of securing farmers' cooperation. We do not have any quick cure for the problem (beyond the obvious). We would, however, caution practitioners that it may be better not to be in the business at all than to adopt methods out of keeping with the stated intentions of FSR that may well contribute to giving it an even worse reputation than it presently suffers, and not predispose the work to successful crossings of the threshold of relevance.

Frequent Omissions

While the philosophers of FSR pay due homage to the farmers and their decision-making roles in farming systems, in practice these are often somewhat played down in significance. Sometimes this is understandable, if not necessarily defensible. For instance, farmers' and their families' attitudes to work and leisure may meet little sympathy from an analyst who doesn't have to endure long hours of physical activity in trying conditions.

In other cases, the technology of encoding farmers' preferences and attitudes may constrain attempts to explicate them within socioeconomic models. Methods of varying elegance and restrictiveness for depicting multiple attribute preference functions are exposited by Anderson et al. (1977, Ch. 4) but, in terms of present-day FSR practice, the application of such formal methods is somewhere between the horse and buggy and the T-model Ford. If specialists can't or won't, disdain by others is probably justified.

To summarise, it is our belief, founded mostly on casual observation, that farmers' and their families' preferences are very poorly investigated, understood and represented by most FSR workers. We can understand this since, were we to be more active in the field ourselves, we would perhaps be guilty of this same sin. Notwithstanding the potential such omission has for misdirecting FSR work (including modelling) and perhaps condemning its results to irrelevancy, it pales into insignificance when compared with the next-mentioned omission.

A related serious omission is the correctly identified 'farmer.' There is a near-universal tendency to presume that, where there is one, a male head of farm household is 'the' farmer. Thus, for example, male-dominated extension services have been created to target these male heads, and researchers too often fall into the same trap of chauvinistically identifying farmers as male.

The imperative need to recognise the crucial role of female farmers arises from several considerations. Most obviously, in many regions and countries, emigration of men to work elsewhere has left virtually all farming in the hands of women. In other situations, whether by tradition or comparative advantage, economic activities in the rural sector are strongly gender-determined. For instance, as well as home responsibilities, women frequently have almost exclusive control (through management, decision-making and labour) over fruit, vegetable and herb production, small stock, fuelwood, etc. If FSR is not 'major-crop' biased, the farmer of relevance in many cases will be a woman (Jiggins 1984). Since the preferences of women are likely to be different from men, omission of the women's viewpoint is likely to lead to misspecified models.

A further related omission highlighted by Jiggins (1984) is consideration of activities beyond production per se. FSR is often claimed to be holistic in its view of the farm but how often do researchers (and socioeconomists especially) explicitly incorporate accounting of and review of technological adjustments to household activities within the farming system such as trading and the processing and preparation of produce into food? Needless to say, such activities are frequently the responsibility of women. The boundary of the system that is modelled in FSR should be drawn to include these activities if serious biases are to be avoided.

Practice and Humility

We hesitate to throw more stones lest our own glasshouse suffers damage too. If our critical remarks have any validity, however, it follows that FSR people, and certainly farming systems socioeconomic modellers, should diligently seek to be humble about what they've been up to, at least for the foreseeable future. We are still at the dawn of systematically learning from the farmers of traditional farming systems (Chambers 1983). An attitude of humility would be appropriate to the existing level of achievement and may engender less points-scoring criticism from reactionary conventional agricultural scientists who probably have nothing better to offer anyway.

The Way Forward

Relative to the further development of socioeconomic modelling of farm systems, all we can be sure of is that the way forward lies ahead of us! As ever, however, there are pointers from past experience. Chief among these are the lessons to be gained from past mistakes and failures, the high cost and often inefficient mode of conducting FSR, and the poor consideration of social relevance often given in the establishment of FSR priorities between regions and countries.

Even at a time when some sponsors of FSR are showing signs of disenchantment with the approach, perhaps because of unrealistic expectations in the first place, practitioners must strive to learn more from their mistakes. There are many obstacles to formalising such learning through documentation of case histories. People have a natural preference for sharing their successes with peers and sponsors and there are related impediments against elaboration of failures. These impediments must be overcome if FSR is to make the rapid advances that might be anticipated commensurate with the now considerable investment in such work.

The apparent high costs of latter-day FSR (see e.g., McIntire 1984) must be reduced to enhance its attractiveness and cost-effectiveness in the more impoverished parts of the world. Costs can be tackled at nearly every stage of the work and not least in modelling. The unit costs of digital computing, for instance, are continuing to fall rapidly, so that storage, retrieval and processing of data should be reducing in cost everywhere. The labour costs of FSR, particularly data collection, can be greatly reduced by having most of its research workers as nationals working in national programs — see Martinez and Sain (1983) but also the remarks of Abalu (1983, p. 34) on hardships and incentives for national researchers. Relatedly there is an urgent need for training these workers, with consequent demands on external resources and demonstration programs. But can 'it' be taught and, if so, how best and by whom? While there is no shortage of would-be pedagogues, do they know what to teach? Further, for cost effectiveness, there is a need for models to be developed as far as possible in modular and/or skeletal form that can be added to or subtracted from with maximum flexibility without being constrained by location-specificity. In other words, models should be developed in adaptable form so as to be useful for general baselines studies and for specific locations.

A continuing trade-off between social relevance on the one hand and difficulty of execution and impact on the other, makes resource allocation in FSR challenging. Credibility with those whose concern rests primarily with the poorest of the poor places an urgent obligation on FSR to address these people's problems — no matter how remotely they are located, how desperate their circumstances or how depressed their ambition. Quite apart from the obvious challenges of this sort of work, it may be difficult to encourage national FSR personnel to go to the more troubled parts of their countries. At the other extreme, 'success' may be had much more easily among those who face better technological options and opportunities, even if they are likely to be more conveniently located. Such work may have value, however, for its demonstration effect and for the political support it may generate for the more socially relevant but more difficult work in adverse locations.

Socioeconomics models should capture some of these trade-offs, so that resources can be allocated explicitly according to various social priorities. Thus, as at every other turn, models can and do play a valuable role in determining the way forward — a thought that encourages us to end with a gender-free simile (cf. Anderson and Dent 1971, p. 388): like a spouse, an FSR model takes some time to identify, takes even longer to comprehend, is surely complex but often instructive and, not exhaustively or exclusively, if treated with cautious respect, can serve intentions admirably.

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Session Report
Approaches to Farming Systems Research

Rapporteur: R. T. Shand*

THIS first session of the workshop comprised six papers that ranged widely over FSR. This report attempts to distil, from the papers and ensuing discussions, the key themes and issues raised. This is done under four main headings:

(1) What is FSR? Definitions and concepts.
(2) Why is FSR needed in developing countries (and Australia)?
(3) How is FSR undertaken? Methodologies.
(4) Issues and problems in FSR application.

What is FSR?

Norman and Collinson took on the task of characterising FSR in the first paper. For them it is a 'research method for understanding real world economic systems in which farmers operate.' A farming system results from the decisions of a farm household in allocating production factors to three categories of enterprises: crops, livestock and off-farm enterprises, within the context and limitations of the natural (agroecological) and socioeconomic environments. In FSR, the focus is on increasing the productivity of the small farmer and for Norman and Collinson the two thrusts of FSR are in developing and disseminating improved technology and practices and implementation of applied policy and support systems to facilitate the technological objective.

Conway described a somewhat different and broader approach, that of agroecosystem analysis and development. It deals with all levels of agroecological development in a hierarchy of agroecosystems, and provides a technique of analysis of technology packages that focus not only on productivity but on the additional properties of rural output stability, yield sustainability and net benefit equitability. These are descriptive of an agroecosystem but can be used normatively to evaluate its potential with new technologies. The versatility of this approach is that it will fit into the framework of FSR and thus broaden the otherwise narrow FSR preoccupation with productivity. The 'systems agriculture' or Hawkesbury Approach is akin to the agroecosystem approach in encompassing the interactive complexity of the farmer and his natural and socioeconomic environment.

Why is FSR Needed?

There was agreement among authors and discussants that FSR was needed because of the inability of the traditional or classical agricultural research approach to solve the problems of the small farmer outside of the most favourable natural environments. There was recognition of the achievements of the Green Revolution technology but it was seen as 'addressing only a subset of relations within an ideal technical system.' This has been compounded by the isolation of the researcher from the small farmer, which has induced a 'top down' prescriptive approach

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largely insensitive to local conditions. Conway sees a loss of momentum in the Green Revolution with diminishing yield increments and rising costs. Dillon et al. foresee the end of the days of the 'quick technological fix through improved seed, fertiliser and a favourable environment.' The limits of irrigation are in sight for many countries and attention must now be turned to the tasks of raising productivity in the variety of location-specific agroecosystems of less favoured environments. Conventional FSR is seen as one response to this challenge, agroecosystem analysis is another, and Hawkesbury's 'Systems Agriculture' still another.

How is FSR Undertaken?

The four main stages of FSR were clearly set out by Norman and Collinson: descriptive/diagnostic; design/planning — taking into account technical feasibility, economic viability and social acceptability; testing — evolving through on-farm stages of researcher-managed to farmer-managed trials; recommendations and dissemination;

The central reality is the farm household as the consumer of the technology to be developed and tested through FSR.

The authors agree with Shaner et al. on the major distinguishing characteristics of FSR:

(i) the farm as a whole is viewed comprehensively;
(ii) choice of research priorities is determined by initial study of the whole farm;
(iii) research on a farm subsystem is FSR as long as connections with other subsystems are recognised and accounted for;
(iv) evaluation of research results explicitly takes account of subsystem linkages;
(v) with the concept of the whole farm and its environment preserved, not all factors determining the farm system need to be considered as variable.

Norman and Collinson make an important distinction between FSR 'in the large' on one hand, 'where all system parameters are potentially variable in a wide ranging search for improvement,' and FSR 'in the small' and 'with a predetermined focus.' They ruled out the first as being 'extremely complex in implementation.' This exclusion was questioned in discussion when it was pointed out that there were instances of farmers adopting a whole new farming system, e.g. in the transmigration program in Indonesia, cash crops in Papua New Guinea in place of vegetable production, etc. It was argued, however, that while this new farming system could be modelled, it is unlikely, owing to the management jump involved, that a farmer could handle this. The normal path would be a step-by-step change from existing to the new farming system; a change in all technologies in all enterprises at the same time would be too complex managerially.

The agroecosystem analysis approach, based on concepts of ecologically oriented systems analysis, comprises a set of sequential procedures that largely appear as a development or variant of the descriptive/diagnostic stage of FRS, utilising a broader set of properties and deciding on key questions through multidisciplinary discussion and agreement. While mathematical models are not formally included in the sequence of procedures, they can, nevertheless be employed at various stages. A difference with FSR is that while the latter develops technologies specifically for the farm, agroecosystem analysis targets the key processes and decisions in agroecosystems. Group discussion centred around definition of the boundaries of agroecosystems and problems in measurement of changes in the four properties addressed within the system, particularly the problem of assessing the sustainability of new technologies. It was also suggested, however, that where land use patterns have not been stable, the agroecological systems approach is superior to the usual FSR questionnaire/survey technique in developing and characterising credible and operational recommendation domains. In Zamboanga del Sur in the Philippines, land-use maps based on geology, topography and soils proved the only reliable way of developing a proxy for land type and potential. This is less critical where established farming systems are stable, non-exploitative and the soils suitable for the development of stable land-use patterns.

The Hawkesbury emphasis is on an action (teaching) research process and uses an agroecosystem method for structuring the analysis for research purposes, deriving key questions for further research or guidelines for development. At this point other research approaches may be introduced as appropriate and needed. The aim is to improve the situation under study by 'facilitating learning and decision-making among the actors in the situation.' At Hawkesbury, it is the students who learn the action research process and subsequently become involved in the analysis of farm problems.

There were three papers presented on the role of modelling FSR methodology; two relating to biological and one related to socioeconomic modelling. The two biological papers were at variance, with Morley and White positive about the potential contribution of biological modelling, drawing mostly on their Australian experience. They argued that provided a model was closely related to an important biological system, modelling could:

— aid understanding;
— identify gaps or inconsistencies in information;
— extrapolate to new information horizons;
— aid management decisions;
— enable estimation of activity returns;
— conduct 'experiments' showing consequences of changes
— produce logically predicted effects of the system's processes and structures.

A wide spectrum of levels existed for systems analysis with modelling ranging from cellular analysis to analysis of the agricultural sector at the national level, though where interactions are complex, costs are high in terms of time, skills and finance. The authors saw a role for modelling in developing countries in a wide variety of applications without specifically considering FSR work, though some applications would fit in with the systems framework. The limits of use in developing countries were seen to be numbers of suitably trained personnel and transferability of models. At some levels the transfer would pose no serious problems (e.g. at the organism level or below). For production systems, the situation is very different, owing to differences in objectives, effectiveness of communications and different infrastructural characteristics.

There was much interest in the models described by the authors in use in Australia during discussion. In answer to key questions raised, the authors indicated many models were available in programs for microcomputers which were in increasing use in developing countries. At this stage they were made available to institutions rather than to farmers, and costs were not a major constraint for buyers. There was also some discussion of modelling courses in developing countries, and reference was made to their availability, e.g. in the Philippines. Doubts were raised as to the effectiveness in some cases owing to the lack of follow-up on students. It was also argued that if modelling was to be used in FSR in developing countries, guidelines for use should be built in at the beginning, not as a separate exercise. Microcomputers were appropriate equipment, though it was pointed out that many existing programs are badly laid out and are difficult to use.

Bennett and McPherson were less than satisfied with the 'success' of past biological modelling activities in Australia and overseas. The key indicator of success was utility of output, but few models have been evaluated especially in relation to development objectives. In the virtual absence of such documented efforts, success is rarely interpreted in terms of output utility. They quoted guidelines in designing models, quoted standards for this, but speculated as to whether any modeller had checked a problem description with a small farmer in a developing country.

Their recommendation, for a special review sponsored by ACIAR on evaluation of Australian agricultural research, agricultural modelling activities and foreign overseas aid programs, drew some criticism. It was argued that such a project might exceed ACIAR's brief, (e.g. Australian research activities) and it might duplicate evaluation work of other institutions such as the World Bank, and even in relation to Australian aid projects would be largely a waste of resources. An alternative would be a wider evaluation of some selected projects using a case study approach. This would be a discrete ACIAR project that would align with economic planning/ evaluation units in the recipient countries.

Anderson, Dillon and Hardaker graphically illustrated the centrality of socioeconomics to FSR, and argued that modelling in its various forms and levels of sophistication has been a feature of social science aspects of FSR. Reviewing the models available of non-optimising and optimising types, they conclude that a number have been of use, particularly budgeting and least squares regression in the first category (but also simulation models, dynamic and Monte Carlo programming). Of the optimising types, mathematical programming offers the best utility for FSR as it can reflect small-farmer constraints. Production and profit functions are also applicable though are not as versatile in some respects. The authors see socioeconomic modelling as contributing in most of the key areas of FSR: in on-farm/on-station linkages, in evaluating potential system changes and component research, in farming systems evaluation and evaluation of on-farm new technology testing and in calculating aggregative implications of adoption of new technologies for systems supporting agriculture.

Issues and Problems in FSR Application

A most important issue and problem discussed by Collinson is the bureaucratic biases and constraints on the acceptance and implementation of FSR in developing countries. The issue is one of how to minimise this bureaucratic constraint through institutional innovation. The procedure the authors have followed in Africa has been to 'drive a narrow wedge into the bureaucracies' and in so doing to limit the selling pitch for FSR to its use in generating more appropriate technology ... and 'to minimise the number of personalities to be initially convinced of the efficacy of FSR as a useful research tool.' Once achieved, this narrow wedge is widened by strengthening the capacity for FSR.

It was pointed out in discussion that this approach contrasts strongly with the 'full frontal' approach used by the World Bank to introduce the Training and Visit (T&V) system into Kenya. In response, the authors indicated that to their knowledge a full frontal approach had never been used for FSR nationwide by any major donor, but the methodological framework, perhaps in the last two to three years, had become robust enough to be so implemented as a package. FSR is far more complex and sophisticated than T & V which is basically a management system. There are signs that the World Bank is moving to 'front end' its T & V organisational mode with an OFR/FSP 'guidance unit' to try to ensure a flow of relevant messages into the T & V system. As well there are signs that project planning and implementation may change in form. Projects may start with a pre-project phase consisting of FSR to identify technologies to form the core of the project phase proper, and to identify the service and policy support requirements to mobilise identified technologies in the area. Finally, there are signs that OFR/FSP teams and monitoring and evaluation teams may merge, with the same teams doing both jobs.

A second issue is the set of interrelations between FSR, research, and extension. The problem was portrayed in terms of the appropriate 'point of entry' or initial attachment. FSR is seen as a linkage mechanism between research (on-station research in particular) and extension. FSR is extension-compatible but if research is separated from extension in a national system, the attachment with extension may result in a loss of contact with component research. Its location is further complicated by the approach adopted of using FSR for technology generation.

A further problem raised concerning FSR and its methodology of particular significance was the long time horizon for results and the difficulties this raises for donor agencies. This arises partly because of the institutional biases against FSR, and partly because of problems in working with NARS. Moreover, FSR is highly location-specific, involving limited numbers of farmers, so on a large scale FSR is expensive. Norman and Collinson give three key principles for minimising these problems: reducing the time taken for the four FSR stages, maximising returns by a wide applicability of results (broad target groups) and using the second best or best available solution (rather than optimising). This particular problem of time horizon presents a danger for FSR. Its youthfulness and relatively untested methodology, and the need to build credibility, is in direct contrast with the demands being made on it by donor agencies with funds, and by developing countries establishing units for FSR.

It is as well to note the types of problems encountered in socioeconomic modelling of FSR, as outlined by Anderson, Dillon and Hardaker based on Hardaker's experience. His use of a large model reflecting the complexity of real systems became very time and labour consuming. This was partly due to supply problems with computerware, but more importantly because model building and validation proved difficult. Also, with large output, there were interpretation problems, and overall there was less than desirable feedback to policymakers and a need to be cautious with provisional findings.

Dangers in modelling come from remoteness of modellers from target domains, the absorption of researchers' time in modelling, and the omission of key factors from the models. Such problems can lead to high costs and inefficient conduct of this component of FSR, though by the same token, ways can be found to keep costs down and develop effective models.

Finally, an issue of the 'limits of FSR' was raised in papers and discussion. In an agroecological sense, as Conway argued, the boundaries of FSR are very wide indeed, since they take account, inter alia, of the off-farm activities of the community under study, which may be international (with labour migration). But in discussion it was argued that the major constraints on farm performance were outside the farm. Therefore, was the whole farm model still relevant or was some model larger than the farm now more appropriate?

It was agreed that outside constraints were very serious, and there was general agreement that they should not be ignored (e.g. marketing, credit and other support services). Discussion then revolved around whether this should be a part of FSR or not. One view was that this was work for other host government agencies and was not the domain of FSR. Indeed if ACIAR was involved, it might in some instances consider these external factors were too constraining, and may reject the project proposal.

Another view was that the focus of FSR on the farm *qua* farm is indeed often too narrow, but that part of the explanation may lie in the fear of the International Agricultural Research Centres (where FSR has been largely developed) of treading on the toes of host governments. Additionally, national agricultural economists may fear for their careers if they complain too loudly about inappropriate policies. However, these are excuses, not reasons. There is a need to recognise that the notion of a technological fix for many social problems is simply wrong. Certainly technology may be a part of the solution but seldom (if ever) will it be the whole solution.

Socioeconomists have some of the conceptual tools, and some of the models, that permit a broadening of the view of farming systems problems. For example, any analyst of prospective technology would have to examine implications for input supply and marketing of output (including price effects). The term farming systems development would be a better focus of attention than FSR. A 'development' program would embrace the external factors recommended by FSR advocates, but two provisos are also spelled out:

(1) the farm/household dominates the agricultural sector in most situations, so that studying (modelling) this unit is still a central part of FSD; and

(2) if agricultural research is to be done, better to do it well (using FSR?), than badly.

Farming
Systems
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in
Australia

Farming Systems Research in Australia: Results of a Survey

Joseph V. Remenyi* and Ian Coxhead**

ACIAR is concerned to develop an effective and appropriate strategy in farming systems research (FSR). In this paper we report on a survey conducted to identify Australia's strengths in FSR and comment on related issues that arise from this exercise. We begin by reviewing what FSR means for ACIAR.

What is FSR?

FSR is a multidisciplinary approach to agricultural productivity improvement that involves the farmer in the process of research. Simmonds (1984, p.7) defines it as research directed at 'identifying the socioeconomic interests and capabilities that will cause farmers to adopt new technology.' However, this definition of FSR is predicated on the belief, which we share, that 'the business of agricultural research [is] to try to promote change in a socially favourable sense and that phrase lies at the heart of farming systems research' (Ibid., p.13).

FSR is a response to an assessment that for the purpose of resource-poor small farmers, previous approaches to research for agricultural development are excessively limited by narrow disciplinary perspectives, leading to the neglect of important socioeconomic constraints that bear on farmers' decisions and farm/household linkages between activities and enterprises. Consequently, FSR has a strongly normative flavour both in definition and in methodology. This is reflected in the way most FSR programs are described and implemented. For example, the CGIAR (1978) 'stripe' review described FSR as research that:

(i) is *conducted* with a recognition of and focus towards the interdependencies and interrelationships that exist among elements of the farm system, and between these elements and the farm environment; and

(ii) is *aimed* at enhancing the efficacy of farming systems through the better focusing of agricultural research so as to facilitate the generation and testing of improved technology.

Gilbert et al. (1980) have added that, to the Consultative Group on International Agricultural Research production-oriented concept of FSR, due consideration needs to be given also to consumption, especially as the units of production and consumption (the rural household) are often identical in developing countries. The emphasis on FSR as a 'process' is, however, unequivocal and universal.

The concept of 'component' research as a form of subsystems FSR is useful and will be extensively employed in this paper. Gilbert et al. (1980) argue that conceptually, FSR not only includes work carried out only on a portion of a farming system, but also implies the viewpoint from which research topics should be identified and evaluated: i.e., that of the farmer. A similar view is expressed in most other attempts to define FSR (e.g. Byerlee et al. 1982; Conway 1983).

Biggs (1985, p.3) has argued that one of the problems in defining FSR is 'that the term FSR can cover virtually everything that does not take place on an experiment station.' There have, therefore, been problems in arriving at an agreed definition of FSR. This is in essence an acknowledgment of the *normative* nature of these definitions, which says more about the evangelical spirit in which proponents of FSR perceive the need for FSR, than it provides a description of the everyday reality of systems research implementation. Nevertheless, a particular stress on two main features is discernible: (i) the multidisciplinary nature of the FSR approach: and (ii) the need for a 'bottom-up' research strategy, which means involving the client group in the

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research process. The key to the success of the FSR approach in realising these features is on-farm research (OFR).

Obstacles to Multidisciplinarity

The need for research combining the efforts of workers from several disciplines arises from the recognition that much research has been misdirected or neglected due to rivalry between disciplines, and rigidity in the structure of many research institutions. The Asian Development Bank (1977, p.254) in commenting on the need for more research for development in agriculture, lamented: '... researchers are rewarded for achievements within the narrow range of their disciplines. The result is not only a lack of pragmatism in research, but also an extraordinary lack of communication among disciplines.'

Dillon and Anderson (1984) have also observed that the structure of the majority of developing country research bodies offers little scope for collaboration or communication between social and physical scientists, or between either group and workers in extension services. This has provided the International Agricultural Research Centres (IARCs) with a comparative advantage in the conduct of systems research. Similarly the existence of institutional barriers to interdisciplinary work in national agricultural research systems means that in many countries FSR is (or was until very recently) practiced mainly by outsiders i.e. expatriates involved in foreign aid projects. Biggs (1985) has questioned whether these institutional barriers can be overcome in any lasting and meaningful way by foreign 'project specialists,' whose tenure in national programs is temporary and not dependent on local promotion criteria. We cannot ignore this problem if we are to propose an important role for Australian researchers in Third World FSR.

'Bottom-Up' Approach

An appreciation of the constraints facing farmers in developing countries requires: '... a much broader system perspective that integrates biological dimensions of production, heterogeneity in resources, risk factors, and the relationship of production and consumption decisions' (Byerlee et al. 1982, p.902).

Such an understanding is the product not only of collaboration between researchers of different disciplines, but also a close relationship between researchers and their target groups, the farm households that make up village communities.

It has, for the last 20 years, been a truism that, subject to informational and institutional constraints, farmers are rational in their allocation of economic resources. The normative definition of FSR as a bottom-up approach constitutes renewed adherence to the notion of rational resource use, and at the same time provides an avenue for ensuring that the feedback mechanisms and essential flexibility in research focus and design are present. Without feedback and flexibility in the research process, it is difficult to see how the information and institutional constraints can be eased, let alone overcome.

OFR serves many purposes in removing barriers to adoption of research station-developed technologies. It provides a linkage between farmers and researchers that can ensure that the focus of on-station-research (OSR) is relevant to farmers' needs. The same OFR also has a forward linkage that can help fill the void left by the lack of other channels of information about availability and performance of new technologies in farmers' fields. In this sense, OFR is a most important means of both subsidising the risk undertaken by the innovating farmer, and expanding the number of smallholders able to accept the risks of being an innovator.

What is FSR to ACIAR?

Simmonds (1984) identifies three basic types of FSR:

(i) strictly academic FSR that is highly detailed, often involving modelling but not intended to result in immediate recommendations relevant to the current problems facing farmers.

(ii) FSR that involves OFR with a 'farming system perspective' (FSP). Simmonds writes '... typically, the OFR/FSR process isolates a sub-system of the whole farm, studies it in just sufficient depth (no more) to gain the necessary FSR and proceeds as quickly as possible to experiments on-farm, with farmers' collaboration' (p.121).

(iii) FSR intended to result in radically 'new farming systems' (NFS) that will usually require substantial government intervention to provide the economic and institutional environment necessary for the implementation/adoption of the NFS.

Research supported by ACIAR tends to be applied rather than academic, so it is to the last two types of FSR that our attention will be directed. Furthermore ACIAR's mandate focuses particular attention on smallholder, subsistence-oriented farmers in the humid and semi-arid tropics. Hence, within the farm/household domain, research supported by ACIAR of the OFR/FSP and NFS types will concentrate on:

(i) system diagnosis — describing the major components of farming systems so as to improve our understanding of the rationale behind farmer practices;
(ii) problem identification and ranking — identifying the biophysical, economic, institutional and social constraints limiting profitable production; and
(iii) solution formulation — developing and testing innovations (normally an OFR activity) and verifying these using OFR techniques to minimise the unwanted effects of constraints limiting profitable production.

It is in these three areas that FSR appears to have made a difference to the success with which agricultural development has been achieved through technology transfer and adaptation. Some examples may be instructive.

(i) The use of mulching techniques by subsistence farmers in West Africa came under intensive FSR in the early 1970s, especially at IITA. This resulted in the development of direct drilling technologies using chemical suppressants on live mulches, and greater appreciation of the potential use of mulching and soil mounding techniques in the control of soil temperature, the rate of vegetable matter oxidation in the dry season, water conservation, soil impacting of heavy rain, weed and pest control and nutrient cycling.
(ii) Women do the bulk of the farming for food throughout the tropics, but especially in Africa. One would have imagined that the implications of this fact for the organisation of extension services and the training of agricultural production advisers would be obvious. However, throughout largely Moslem Africa, Western 'experts' remained apparently oblivious to the need to direct their training programs and agricultural outreach to women. This can in part be attributed to cultural blinkers on the part of Western experts, reinforced by the natural male chauvinism of village life in many developing countries. OFR/FSP made it that much more difficult to ignore reality, because this sort of FSR demands involvement in the research process of farmers — in this case, women. One result has been a growth of awareness of the important role that women play in agricultural development throughout the humid and semi-arid tropics. Another has been identification of specific sociocultural constraints to improved agricultural productivity that are susceptible to solution through the design of simple and appropriate technologies. An example is the development of physically less demanding land preparation systems based on donkey-drawn instead of bullock-drawn ploughs, for use by women farmers in southern Africa. Hitherto the women had to wait until the bullock teams had finished their circuit of contract farming. Because the women were inevitably last on the list, they missed the right planting dates, with often disastrous effect on yields. There are few constraints on women owning or using donkeys in southern Africa, and donkeys are ubiquitous in the rural areas.

Is FSR Relevant or a Passing Fad?

Until quite recently, the problems of unirrigated subsistence agriculture have been relatively neglected in agricultural research priorities. It is not to resource-poor subsistence farmers that the benefits of the Green Revolution have flowed or are likely to flow. Nonetheless, examples such as those above suggest that FSR may be an appropriate way of increasing the prospects of developing viable technology options for subsistence farmers. Recognition of this fact could explain why there has been a recent burgeoning of interest and involvement in FSR in almost every Third World country.

The less sceptical among us would welcome the spread of FSR into national agricultural research programs as evidence of a successful struggle against the institutional restraints that have hitherto made FSR the province of Western agricultural experts and scientists at IARCs. The number of national programs that are adopting the multidisciplinary OFR/FSP philosophy is increasing rapidly. Nonetheless, this should not prevent us from asking crucial even if embarrassing questions.

For example, is there really anything special about FSR? Could it not be that conventional agricultural research ought to have made the discoveries and defined the challenges to more efficient farming attributed to FSR, if only conventional agricultural researchers had been clever enough to ask the right questions? Is an FSR approach really necessary to ensure that fundamental assumptions, such as the homogeneity of rural labour supplies or the perceived inefficiency of traditional primitive agriculture, are critically examined? If it is, then FSR reduces to little more than increasing our adeptness at mental gymnastics. If FSR has some substance to offer it has to be more tangible than this.

Second, we draw your attention to the apparent preponderance of expatriates among FSR experts. Why is this so? Is it really because we in the West have been more successful in throwing off the institutional and historical shackles of discipline-based scientific research? Or, could it be another manifestation of Western agriculturalists telling developing countries what they ought to do in agricultural research and development?

Finally, how genuine is the commitment in national agricultural research programs to FSR? In almost every Third World country one can point to an FSR group or institute that has or is being formed. In the Philippines and Tanzania the process has gone so far that the whole agriculture Ministry has been reformed on so-called farming systems lines. However, this same burgeoning of interest and keeness to become involved in FSR also has a nagging air of opportunism about it that is difficult to shake off. To what extent is the rise in demand of FSR in developing countries more a response to donor requirements than a real felt need among Third World agricultural research scientists? Elliot Moess (1984) suggests that this is an all too important, if ignored, motivation, and has referred to the process of adoption as 'institutional destruction in response to perceived donor demands.' Only time will tell if this problem is in any way relevant to FSR and has been as damaging as Moess implies, but in the meantime we ought to be prepared to ask: Do Australian agriculturalists involved in FSR really have anything to contribute to developing country agriculture?

The Survey Questionnaire

In order to assess the potential wealth of FSR expertise in Australia a survey of agricultural researchers was undertaken (reprinted in Remenyi and Ryan 1984). The survey incorporated a 'thought-experiment,' consisting of a matrix (Table 1) of activities that make up FSR and the place where that research is undertaken, designed to challenge researchers to think in a structured way about their role in FSR.

Table 1. A farming systems research activity matrix.

	Research strategies		
Problem areas	Base data analysis	On-station research	On-farm research
	A	B	C
Diagnosis/ identification	A1	N.A.	C1
Solution design	A2	B2	C2
Testing/verification	N.A.	B3	C3
Extension/policy	A4	B4	C4

This matrix is a gross simplification of the variety of processes that make up FSR, an abstraction from reality. In hindsight it appears to have been excessively simplified and need not have blocked out cells A3 and B1. Also, Row 4 would have been less confusing to respondents had policy analysis and extension of research results been separated. It may have avoided confusion in the minds of some researchers had we noted that those involved in base data analysis, column A, are essentially those researchers who work with published data, or data collected by others. By so doing we may have lessened not the number who saw themselves as involved in column A activities, but those who saw base data analysis as an activity that has to be done either on the research station or on the farm. This may explain why three-quarters of the social scientists who responded to the questionnaire identified both cells AI and CI as their principal areas of FSR involvement. A good many of these researchers probably meant that their problem diagnosis related to work with farm level data available in published sources. Other changes we would make to the matrix were we to repeat the exercise would be to add a row for FSR theory development and a column for the teaching of FSR methods and practices (Table 2).

The questionnaire was sent to 250 individuals and a further 180 copies to 36 heads of

Table 2. Revised FSR activity matrix.

	FSR activities			
Problem areas	Base data analysis	On-station research	On-farm research	Teaching farming systems research
	A	B	C	D
Diagnosis	A1	B1	C1	D1
Solution design	A2	B2	C2	D2
Testing/verification	A4	B3	C3	D3
Extension	A4	B4	C4	D4
Policy analysis	A5	B5	C5	D5
Theory development	A6	B6	C6	D6

Table 3. Distribution of FSR questionnaires despatched.

		Universities[1]	Colleges[2]	Government[3]	Other[4]
Individuals in:	NSW	33	9	25	5
	VIC	13	2	10	4
	QLD	24	7	19	1
	SA	8	3	5	1
	WA	13	4	8	–
	TAS	3	–	–	–
	ACT	18	–	27	2
	NT	–	1	5	–

[1] All nineteen universities in Australia.
[2] Eleven colleges of agriculture and CAE.
[3] Includes CSIRO, BAE, BIE, ACIAR, AOPC, ADAB and state departments of agriculture.
[4] All are private consultants.

departments and research institutions at the Federal and State levels. The distribution of questionnaires to individuals is summarised in Table 3.

The questionnaires were mailed in the week beginning 22 October 1984. By 15 March 1985, 181 replies had been received, including more than 50% of questionnaires addressed to individual researchers, and eight who wrote to say they did not consider themselves to be involved in FSR. The distribution of replies by type of institution and broad disciplinary focus is shown in Table 4.

Table 4. Distribution of responses.[a]

	Plant sciences	Social sciences	Animal sciences
Universities	17	37	8
Colleges	4	3	1
Government	55	21	19
Other	2	5	1

[a] Excludes eight respondents who wrote to say that they did not regard themselves as being involved in FSR.

There is no statistical base on which we can claim to have surveyed the entire population of FSR scientists in Australia. However, we do note that the distribution of questionnaires was very extensive across institutions. Heads of departments, divisions and research institutions were asked to spread the questionnaires widely among their staff, and replies received suggest that this was done. Hence, although we cannot claim to have sent questionnaires to all the farming systems researchers in Australia, we feel confident that we have not missed the majority. The replies received, therefore, are likely to constitute a reasonably representative sample of FSR researchers in Australia.

Analysis of Responses

Our first task was to categorise responses to the questionnaire according to the respondent's type of FSR involvement. This was done by referring to the cells identified in the matrix and by reference to descriptions of current research activities and publications. In this way replies were placed in one of four categories:

(1) Pure FSR — those researchers involved in 'whole-farm,' problem oriented multidisciplinary research that clearly involves a systems or multivariate focus directed at either an OFR/FSP or a NFS framework.

(2) Component Research — those researchers whose focus is on a subsystem of the farm unit and the contribution/role of the subsystem to farm performance: e.g. livestock/pasture systems; crop rotations; constraints analysis. Component FSR involves the study of at least two interacting activities or enterprises within the farm unit.

(3) Agroecology FSR — those researchers whose focus is the longer-term stability of farm productivity and the ecology/environment of the farm region.

(4) Non-FSR — those researchers who were clearly not working in a multidisciplinary framework and concerned with a single activity or enterprise which might or might not involve farmer input: e.g. the study of crop fertiliser responses or plant breeding for salt tolerance.

Responses classified according to these four categories are summarised in Table 5.

The traditional stress of Australian FSR on component research is reflected in the replies received. Component researchers constitute more than half of all responses received. However, in keeping with overseas trends, more than half of scientists involved in pure FSR are social scientists of various types. Two-thirds of these were agricultural economists, another one-quarter were in agricultural extension and the remainder in geography, anthropology or political science. The social scientists were also well spread across the three basic categories of FSR.

We were suprised at the number of respondents that fell into the non-FSR category, i.e. those who saw themselves as doing FSR, but whose present and past research showed an absence of any systems or farm-oriented focus. This group accounted for one-quarter of all replies and reflects, we believe, the very fuzzy set that agricultural researchers perceive to be FSR. It justifies the lament: 'almost everyone who deals with farm level problems believes they are involved in FSR.'

Two-thirds of scientists involved in what we judge to be pure FSR are employed in universities or colleges of agriculture. This suggests caution in interpreting these results as respondents typically failed to distinguish between research involvement and teaching FSR. Particularly at tertiary Colleges, the predominant form of FSR was FSR for instructional purposes or curriculum design as compared with research designed to achieve solutions to well specified farm problems.

Component researchers dominate FSR in Australia, and especially so in government institutions, However, there are some interesting differences between institutions. In government services, plant scientists dominate, accounting for more than half of the group. In universities, component FSR does not appear to be the preserve of any particular type of scientist. There seem to be

Table 5. Distribution of responses by type of scientist and place of employment.

		Category			
Institution	Field	Pure FSR	Component research	Agro-ecology	Non FSR
Universities	SS[a]	14	13	5	5
	PS	1	12	0	4
	AS	2	1	1	4
Colleges	SS	3	0	0	0
	PS	2	2	0	0
	AS	1	0	0	0
Government	SS	6	9	1	5
	PS	6	31	7	11
	AS	1	8	0	10
Other	SS	4	1	0	0
	PS	1	1	0	0
	AS	0	0	0	1

[a]SS — social science PS — plant science AS — animal science

Table 6. Distribution of FSR researchers by principal discipline.

Discipline[a]	Pure FSR	Component research	Agro-ecology	Non FSR
1. Agronomy	9	30	4	7
2. Other PS	4	14	3	8
3. Agricultural economics	14	14	3	9
4. Other SS	10	11	3	1
5. Veterinary science	1	2	0	6
6. Other AS	3	5	0	9

[a] PS — plant science AS — animal science SS — social science

as many social scientists doing this sort of research as there are plant scientists. However, this may simply reflect a difference in absolute numbers in the biological and social fields, for among social scientists employed in government service, almost twice as many are involved in component FSR as in pure FSR. In universities, on the other hand, there is a similar number of social scientists in pure as in component FSR, while almost all universities and government employed plant scientists are involved in component FSR.

Table 6 shows the spread of FSR researchers by principal discipline. Among plant scientists the agronomists tend to dominate the Australian FSR scene, accounting for two-thirds of the group. In the social sciences the distribution is similarly skewed towards one discipline, with agricultural economists accounting for almost two-thirds. In the animal sciences it is those researchers concerned with pasture and rangeland management who dominate. Only four replies were received from private consultants, but follow-up discussions with others in the consulting arena suggests that most are likely to fall into the component research group with agronomy and animal science predominating in their areas of training and expertise. No replies were received from biological researchers in the fisheries area.

Patterns and Hypotheses

The distribution of replies according to the framework given in the FSR Activity Matrix by type of activity, is shown in Table 7. We see that the replies received from the 77 plant and 29 animal scientists resulted in 279 and 103 entries, respectively, in the twelve cells of the matrix. The distribution across these cells shows a concentration of interest by both groups in B2, B3, C2 and C3. This accords with our expectations. Having been given the problem, plant and animal scientists see their role as finding and testing solutions, both on the research station and in farmers' fields.

The concentration of activity among social scientists is quite different. The majority of replies fall in A1, C1 and A4, with one-third indicating no involvement in OFR. This result is somewhat disappointing in that it indicates a relatively low level of involvement by social scientists in solution design, testing and verification. The result is all the more worrying because it is not consistent with what one might expect from a group that claims to specialise especially in farm management, sociocultural adoption studies, survey work and evaluation studies, including ecology and environment programs. If one can judge on the basis of the more successful FSR ventures at the

Table 7. Distribution of replies according to the FSR activity matrix.

	Plant Sciences %			Animal Sciences %			Social Sciences %		
	A[a]	B	C	A	B	C	A	B	C
Diagnosis	8.9	0.4	10.4	7.8	1.0	10.7	18.3	1.9	17.6
Solution design	6.5	17.9	12.5	6.8	15.5	12.6	10.1	5.8	7.0
Testing/verification	0.4	17.6	17.2	0.0	17.5	17.5	2.7	2.7	8.6
Extension/policy	1.4	1.4	5.4	1.9	1.9	6.8	11.7	4.7	8.9

[a] A — Base data analysis; B — On-station research; C — On-farm research. Plant Sciences 279 entries; Animal Sciences 103 entries; Social Sciences 257 entries.

IARCs and elsewhere, OFR is crucial to applied FSR and the optimal distribution of activities for social scientists in an FSR program is a more even distribution across A1, C1, B2, C2, B3, C3, A4 and C4.

The high proportion of social scientists in Australia who do not count OFR as part of their FSR brief, suggests that in Australia there is still some progress to be made before social scientists can play a truly equal role in FSR teams. This is reinforced by the fact that many of the economists and geographers reported their involvement in FSR as being overwhelmingly in what might be judged as the essentially negative role of ex-post 'critics' and evaluators. They are badly underrepresented in the important 'positive' role of solution design. We can but speculate as to why this is so in Australia, but we suspect it will not be rectified until Australian social scientists demonstrate that they do have a positive contribution to make, other than as after-the-event reviewers. Continued specialisation by social scientists in ex-post evaluations of new technologies for farmers is unlikely to achieve this goal.

Research Activities

The activities of the researchers surveyed covered a much wider range of subjects than it is possible to discern from the summary table (Table 6). Despite the diversity, certain patterns can be discerned with respect both to type of institution and the extent of researchers' commitment to true 'systems' approaches to their research.

The majority of workers in the natural sciences (whether animal or plant) are to be found in government agencies, i.e. the Commonwealth Scientific and Industrial Research Organization (CSIRO) and State departments of agriculture. The team approach to problem-solving prevalent in Government institutions of this nature has, it appears, boosted the numbers of respondents in the physical sciences who have been classified as conducting 'component' research. By comparison with physical scientists in educational institutions, most of the work conducted in departments of agriculture and the CSIRO has a specific geographical focus, and within study areas concentrates on problems whose focuses are those of the area chosen — whether an irrigation district or a climatic belt. Among agronomists, pasture improvement, maintenance and growth is by far the preponderant concern. Similarly, research on system-modelling is devoted extensively to pasture–livestock interactions in different climatic and geophysical zones.

The second most studied set of problems in the physical sciences is, unsurprisingly, that of the long-term stability of pasture–livestock systems — ley farming, rangeland management and the maintenance of animal productivity under adverse conditions. The small number of scientists in any institution listed as conducting agro-ecological research belies the extent of activity in the field since many researchers are engaged in work on system components with clear applications in the field of agroecology.

A good number of Australia's FSR scientists have had overseas experience, usually on the projects aimed at problem solving in climates and farming systems believed to be similar to those in Australia. The semi-arid and broadacre systems of the Middle East, for example, figure prominently, as do tropical pasture programs in ASEAN and South Pacific countries. In this respect the State departments of agriculture have been prominent, and their projects have been heavily concerned with the transfer of Australian technologies, including improved livestock breeds, or salt resistant plant stocks developed in Australia.

One very clear pattern of concentration among the plant and animal scientists was the tendency to build models of farming systems. Most of these models are designed to assist farmers and extension agents in their decision-making processes, and in the main relate to crop–livestock enterprises. They clearly fall into the grey area between FSR and more conventional research. In most cases they are examples of component research of a very specific type, and often suffer from limitations of location specificity and the restricted sense in which they are truly multivariate exercises. They share with agricultural economics the penchant for examining the impact of changing a given variable, all other variables assumed constant. Though FSR cannot and should not exclude such approaches, true FSR does seek to relax the *ceteris paribus* assumption wherever possible. Simmonds (1984) argues that such modelling research is unlikely to be very useful in OFR/FSP in the Third World, but could play an important role in the development of NFS.

By contrast with physical scientists, the majority of the social scientists who responded to the survey are to be found in educational institutions;

furthermore their research interests can clearly be divided between those studying Australian agriculture and those whose work pertains to other countries. Social scientists (primarily economists) working on Australian farming systems show a marked attention to the economics of ecological issues — salinity, erosion, management of water and rangeland. This stands in contrast to their colleagues studying the agriculture of developing countries. With the notable exception of a few university or State department of agriculture-based extension programs, very few FSR social scientists who specialise on Australian farm problems are concerned with the kinds of social or institutional problems which are often found in developing countries to be the major obstacle to adoption of improved technologies or techniques. These areas of research figure prominently in the expressed interests of social scientists working overseas or in collaboration with colleagues overseas. This group tends also, in its consideration of the constraints to improvement of agricultural systems, to look for bottlenecks and 'externalities' beyond the farm gate in regional and national trade and macroeconomic policies. Nonetheless, for both groups evaluation and feasibility studies are a regular grist to the social science mill.

General Observations

We would be remiss if we did not note that the community of FSR researchers in Australia is small. Moreover, if the future strength of FSR is at all dependent on the availability of tertiary studies in FSR, then the community of FSR scientists in Australia is not going to grow rapidly. Of all the tertiary teaching institutions only six indicated the availability of teaching or curriculum design work in FSR. Three of these were colleges of agriculture — Hawkesbury in NSW, the Queensland Agriculture College in Gatton, and Marcus Oldham in Victoria. The three universities are those of New England, Queensland and Western Australia.

FSR scientists appear to be a well travelled lot. Of the 181 respondents, two-thirds had worked or had some research experience in a developing country. Among social scientists this figure was nearer three-quarters, while for animal scientists it was closer to one-half. Even at one-half, these percentages must be regarded as surprisingly high. They probably reflect the widespread involvement of agricultural researchers in Australia with some form of consulting assignment, typically with the Australian Development Assistance Bureau (ADAB) or the International Development Program (IDP) (formerly AUIDP) and less so with FAO or some other UN agency, the international development banks or private consulting firms in Australia. The concentration of countries in which Australians have some research involvement is much as might be expected. One-third listed one or more ASEAN countries, one-fifth indicated South Asia, another fifth PNG and the Pacific, 10% have worked in Africa, 5% in both North Asia (China, Taiwan or Korea) and West Asia (Afghanistan, Turkey, Middle East), and only 3% in Central or South America.

Horses for Courses: Some Cautionary Observations

At a recent FAO meeting on FSR in Bangkok the FAO convenor, J.A. Gartner, commented: 'FSR ... is in danger of losing its credibility as a way of operating' (FAO, 1983, p.4). He went on to state that the principal reason for this danger was the excessive concentration of FSR on the cropping subsystem to the neglect of the whole farm system. It is our perception, however, that this reasoning is not wholly defensible. If there is a general cause for FSR losing credibility, it is because it has been used in ways or for purposes to which it is not well suited. Moreover, it is not clear that FSR is superior as an operational strategy in any but a limited set of circumstances and problem areas. In other cases, more conventional research strategies are likely to be more cost effective, easier to manage and implement, and just as likely to result in the correct answers to the problem being addressed. FSR can be akin to using a sledgehammer to crack a peanut.

Conventional agricultural research tends to be discipline based and, therefore, narrowly problem oriented. FSR can be similarly narrow, but the nature of the questions asked is different. FSR in the developing country context, first and foremost asks: why do farmers do what they do? This is not a question that comes naturally to developed country agricultural researchers, most of whom presume that they share a common understanding of farming practices and mores with their farmer clients. In developed country agriculture, therefore, far less time is given to diagnosis. Researchers are more likely to jump in at the deep end and set directly to grappling with constraints to increased productivity and efficiency, content in the belief that they already understand 'why farmers do what they do.'

In the developing country context, no such assumption can be relied upon to guide the choice of problems for research. Here conventional agricultural research comes to the fore only after OFR has identified the 'appropriate' aspects of problems for which a technological solution, amenable to OSR during a solution design and testing phase, can be identified. In seeking to transfer Western FSR expertise, therefore, we need to be conscious of the need to give greater weight to understanding the traditional technologies that we are trying to improve. To many researchers this shift in emphasis is not as appealing as the draw of more discipline-based 'scientific research.' Cropping systems is one example of a technology that many researchers embrace with familiarity because it seems to minimise the need to be involved in the diagnosis phase of an FSR strategy. The danger is that this familiarity can generate a false sense of understanding 'why farmers do what they do' and, therefore, a diminished capacity to contribute to the design of a genuinely better set of farming practices.

FSR in the humid and semi-arid tropics has been concentrated on facilitating the process of new technology adoption by poor farmers, many of whom remain subsistence oriented. FSR in Australia has no comparable clientele in either economic profile or risk-taking capacity. In very few cases do Australian farmers have to evaluate a prospective new farming practice in risk terms that involve the extremes of starvation and plenty that is the daily reality of many subsistence farmers in the tropics. One result of this difference is the willingness of farming systems researchers in Australia to examine alternative farming practices that involve radical departures from the norm, and substantial investments by farmers if the new system is accepted. Examples include group farming, laser levelling, cooperative marketing and the introduction of new products. In developing countries such radical departures from traditional farming systems must also involve research on the compatibility of government policies, plus infrastructure and other socioeconomic and cultural constraints to adoption that are not often accepted as a natural part of the FSR brief in Australia. This indicates a tendency of Australian FSR to focus on NFS as compared with the FSR that is held to be more relevant to the situation of subsistence farmers in the tropics, namely OFR/FSP. Nonetheless, this does not exclude the possibility that the particular disciplinary strengths of Australian FSR teams could not be effectively harnessed in a collaborative research mode to the advantage of existing FSR teams in the Third World. It does indicate, however, that the demand for FSR in Australia is founded less on the need to adapt technology to the socioeconomic and cultural circumstances of farmers than is the case in poorer economies. This goes some way towards explaining why economists and other social scientists are not as prominent in FSR in Australia as is typical in most FSR programs in the developing world.

It should not be necessary to say that FSR is no panacea, but the tone of much of the FSR literature betrays an 'all things to all farmers and researchers' quality. The fact that you involve the farmer in your research program and have colleagues from complementary disciplines does not guarantee a solution to all farm-level problems. There are limits to what FSR can be expected to achieve. If farmers operate in an economic environment that is distorted by over-valued exchange rates or other exogenous factors, it is not obvious that designing a farming system that is adapted to that jaundiced economic environment is justified. Similarly, the mere act of getting farmers to explain why they do what they do does not guarantee accuracy in describing the biophysical or socioeconomic processes that are actually happening. Especially in environments that are highly fragile and subject to change as a result of changes in farming practices, it is not clear that the farmer is the source of all wisdom. Strong links back to the research station are essential and should not be dismissed in favour of less rigorous on-farm research. Moreover, many problems faced by farmers turn out to be highly location specific (Menz and Knipscheer 1981). In a world of scarce research resources, it could be that a far greater impact from research investment would be obtained by concentrating on the development of widely applicable technologies, such as biological control, that are only marginally dependent on OFR/FSP for success and rapid adoption.

In conclusion, it is our impression that Australian FSR scientists do have a capacity to contribute to FSR in the developing world. However, the transfer of Australian expertise should not be attempted without some modification in emphasis on diagnosis and explicit recognition of the central role that social science research has played in the successful design and implementation of FSR in subsistence agriculture.

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Farming Systems Research Elsewhere

Farming Systems Research in Papua New Guinea*

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THE physical and social environments in which farmers in Papua New Guinea (PNG) live and their resulting farming systems are extremely diverse. Food and export crops are grown in environments with wide ranges of rainfall (1000 to over 8000 mm per annum), altitudes (sea level to 2800 m a.s.l.) and soil types. There are some 500 species of crops grown for food (B. French, pers. comm.) for both subsistence and the market. There are no fewer than eight species used as major staple foods (sweet potato, *Colocasia taro, Xanthosoma taro,* bananas, sago, greater and lesser Asian yam and cassava). Tree crops dominate the agricultural export sector with arabica and robusta coffee, cocoa, copra, oil palm, tea and rubber all being grown. The only other export crops are pyrethrum, cardamom and a small amount of chillies. Pigs are the major type of livestock raised and they consume at least 50% of the sweet potato staple in the highlands, but less in the lowlands.

Cultural diversity influences farming systems in, for example, beliefs about food, pig management practices in times of relative scarcity of sweet potato, and the influence of male/female roles and their contribution to labour supply. There are also wide differences in the period of contact with Westerners and Asians (less than 15 years to over 100 years) and in access to markets and social services, with resulting differences in the levels of development. So although most rural people (over 80% of the population) undertake a combination of subsistence and export tree crop activities in a semi-traditional village setting, and form the dominant agricultural export sector, their development opportunities are uneven and are strongly influenced by a wide range of social, environmental and economic issues.

This diversity has several implications for agricultural research and extension. First, it is difficult for an individual scientist to comprehend the range of systems in which farmers live; this has been compounded by losses of experienced staff in recent years. Second, there has been until recently an inadequate data base with which to assess and monitor rural change and allocate agricultural research resources. Finally, the decentralisation of political and administrative functions into 19 provincial governments has separated extension services from research, making information exchange more difficult. Papua New Guinea is thus fortunate to have a relatively strong descriptive literature on many of the farming systems in the country. The following sections mention the most accessible of these studies, the present work and likely future directions.

Previous Farming Systems Research in PNG

Descriptions of Farming Systems

From the time of Parkinson (1907) and Malinowski (1935), there has existed a tradition of the description and analysis of farming systems in Papua New Guinea. This has usually been based on extended periods of residence in villages by academic anthropologists and geographers. Much of this work has also been influential in other countries. Some of the better known workers have been Brookfield and Brown (1963) and Hide (1981) in Chimbu, Howlett (1962) in the Eastern Highlands, Clarke (1971) and Rappaport (1968) in the Simbai Valley, Waddell (1972) and Wohlt (1978) in Enga and Lea (1964) in the East Sepik. This tradition has continued with recent descriptions of local agricultural systems given by, for example, Simpson (1978), Boyd (1975), Allen

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* The views expressed are those of the authors and are not necessarily shared by their respective organisations.

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(1982), Ohtsuka (1983) and Bourke (1983). The descriptive literature is voluminous, particularly for the highlands and the highlands fringe. It provides a valuable data base for reviews of components of farming systems, such as cultural practices, individual crop species and pigs. It is, nevertheless, uneven: for example, it is possible to extract numerous recordings of sweet potato yields but only a few of subsistence firewood consumption.

Studies Until 1978

Some 30 farming systems trials had been conducted on food cropping systems until the end of 1978. A list of these and a bibliography is given by Bourke (1982). Further trials on cropping systems were conducted on pulse crops and stock feeds in the Markham Valley by, for example, Vance and Sumbak (1979). Most of this work was initiated with minimal consideration of existing cropping systems and farmer practice.

In the early 1950s, crop rotation and soil exhaustion trials were laid down at Kerevat (20 m) in the wet lowlands and at Aiyura (1620 m) in the highlands. The trials were conducted to devise alternative cropping systems to the long forest fallow systems (lowlands) or grassland fallow systems (highlands), particularly for locations experiencing pressure on agricultural land from population growth and the introduction of export tree crops. Baseline data on intensive cropping systems were also sought. While none of the rotations tried proved as effective in maintaining yield per unit area of food crops as the methods in use, the trials did provide valuable long-term data and a partial basis for recommendations (e.g. Bourke 1979). The Kerevat trials ran for almost 30 years and the Aiyura ones for over 20 years. Papers by Kimber (1979), Newton and Jamieson (1968) and Bourke (1977a,b) have given results for part of the trials' duration, but a complete analysis has not been done and would be useful.

The only formal trials that have examined the interactions between export tree crops and food crops were a cocoa/bananas interplanting trial and a coconut/food crops interplanting trial at Kerevat. Results of the coconut/food crops interplanting trial (Gallasch 1976) indicated that existing farmer practices were agronomically and economically sound and that there was no basis for the then existing recommendation against intercropping. Carrad (1982) has argued theoretically in favour of the mixed coffee/food crop cultivation practices used in the highlands.

Some of the other trials before 1978 examined component technologies of farming systems, such as the effect of compost on yield or the evaluation of leguminous cover crops. A continuous cropping trial using a 'composted contour mound method' at the Wau Ecology Institute (1230 m) claimed a successful alternative to grassland fallow systems, but no data were offered to substantiate the claims (Gagne 1980).

Research Since 1978

In 1978 a 3 week multidisciplinary survey was conducted on the Nembi Plateau in the Southern Highlands Province (Allen 1984). The team sought explanations for the very high rate of child malnutrition on the Plateau and concluded that this was associated with extended periods of cropping (with minimal inputs of organic fertiliser) and very low sweet potato yields. The 1978 survey was followed up by a farm-based research program that sought appropriate technologies to increase crop yield (D'Souza and Bourke 1984). The follow-up research did not however proceed past researcher-controlled experiments in village gardens.

The 1978 Nembi Plateau survey marked a watershed in FSR in PNG, demonstrating the value of village studies by a team that combined biological and social scientists (in this case an agriculturalist, soil scientist, nutritionist and several geographers). It influenced the Enga Rural Development Study (Carrad et al. 1982) and the design of the National Nutrition Survey, conducted in 1982/3.

It also influenced the Simbu Land Use Project (SLUP), which undertook studies in land use, soils, nutrition and agriculture in both north and south Simbu. Its main objective was to assess the status of subsistence agriculture and nutrition, and likely future directions. The SLUP project, like the Nembi work, did not proceed past base data collection and description of the existing situation, as well as some agronomic field trials. As a project, its funding concluded before recommendations could be fully developed and tested. However, it provides a valuable base upon which to design a program with an interventionist objective. The South Simbu study (Hide 1984) has recently been used for this purpose.

A list of 15 farming systems studies conducted

Table 1. Farming systems research in PNG since 1978.

Study	Main linkages	Reference
1. Nembi Plateau Survey	Agriculture-land use-nutrition	Allen 1984
2. Crop Intensification, Nembi Plateau	Agriculture-land use	D'Souza and Bourke 1984
3. Sustenance, Seasonality and Social Cycles	Agriculture-nutrition	Crittenden 1982; Baines 1983
4. AFTSEMU, Southern Highlands	Agriculture-land use-nutrition-economics	Research concludes September, 1985
5. Tari Land Use	Agriculture-land use-soil fertility-nutrition-health	Wood 1984; ongoing (Allen)
6. Simbu Land Use	Agriculture-land use-nutrition-soil fertility	Hide 1984; Harvey and Heywood 1983; Humphries 1984
7. Enga Subsistence Team	Agriculture-land use-nutrition	Ongoing (Wohlt)
8. Coffee FSR Project	Economics-agriculture-nutrition	Carrad 1981
9. Land Use, Inland Madang Province	Agriculture-nutrition	Spencer and Heywood 1983
10. Variation in Subsistence Food Supply	Agriculture-human behaviour	Ongoing (Bourke and D'Souza)
11. Crop Intensification, Lowlands	Agriculture	Leng 1982
12. Wau Ecology Institute	Agriculture-forestry	—
13. Atzera Range	Agriculture-forestry	—
14. DPI/CSIRO Resource Potential Study	Land use-agriculture-cartography	McAlpine et al. 1982 (ongoing)
15. DPI/QDPI/ACIAR Export Tree Crops Study	Economics-agriculture-nutrition	ACIAR (1984) (ongoing)

since 1978 (excluding descriptive work) is given in Table 1. The strong links between agriculture, land use and human nutrition are apparent, as is the slim economics input in the work so far. Most studies have concentrated on the highlands and relatively little work has been done in the lowlands.

Lessons

Much of the early research into food and export crops was component not systems oriented. It was undertaken on research stations and extended to the community with a standard set of cultivation recommendations. As the client groups were only broadly identified (smallholders or largeholders), without the benefit of systematic grower surveys, recommendations were based on station experience and not oriented toward specific needs or management constraints.

Where *food crop staples* were concerned, the methods of conducting selection trials for improved varieties were often at variance with the range of on-farm practices, and paid little attention to variations in soils, planting densities, mixed cropping practices and the labour constraints that apply at village level. It is probably fair to say that the number of successful innovations in this area has been limited as a result, and most success has come from introductions of new crop species and new cultivars of existing crops. The introduction phase is virtually over, however, for new species, and future growth in farm productivity and incomes from food crops will rely on management improvements. This research, however, laid the foundation for future work, for example, by identifying technologies that are not suitable for PNG conditions, such as legume rotations in the wet lowlands.

Export tree crops on the other hand, have enjoyed more success from experimental station-based component research. In particular, hybrid cocoa and oil palm breeding in PNG has resulted in improved farm incomes, even though larger-scale farmers have benefited most to date in these industries. For smallholders to benefit fully from, for example, new hybrid cocoas, research will need to pay specific attention to the trade-offs between yield and disease resistance. Where higher yielding but disease susceptible cocoas are planted by smallholders (as is happening at present), research is needed to develop appropriate input delivery systems and recommendations (Moxon 1983).

However, as we noted earlier, there has been village-based research conducted as well. The village work of the 1950s and 1960s which led onto the early 1980s work in the highlands (Table 1), has given insights into the diversity of farming practices. Yet where agricultural practices have been described, quantitatively in some cases as a result of surveys or longitudinal village observations, this work has not usually then been used in technology development. The one exception we know of has been on the Nembi Plateau, and this work was halted before early positive signs could be fully supported. The reason is that this recent work has been done on projects with limited life spans. The survey and descriptive phases have dominated project work and before the findings could be used as a basis for trialling innovations the projects had finished.

So where component improvements have been developed they have been rarely based on any systematic prior assessment of grower practices, resource endowments or market opportunities; where such assessments have been made they have not then been used for improved technology development. The main reason for this situation is that institutionalised government services have been doing the former, while fixed life projects or academics have been doing the latter; only rarely (e.g. Nembi Plateau) have the two approaches come together. This is not to say that there has been no contact between the two approaches; the work of Brookfield in the 1960s influenced government research thinking and subsequent priorities, and the project experience of the early 1980s has influenced the decision to establish multidisciplinary highlands and lowlands food crop research teams within the Department of Primary Industry.

Although agricultural practices have been described in many cases (section 2.1), they have rarely been evaluated in terms of *grower objectives and returns to critical inputs such as labour.* Land use researchers are only now developing methodologies for appraising smallholding systems in the South Pacific (McAlpine et al. 1982). In view of the dominance of the smallholder sector in the major export tree crop industries and the widely held view that this is a 'low productivity' sector (e.g. Howlett 1973; Ward and Proctor 1980), therefore with potentially high returns to productivity improvements (Hardaker et al. 1984), these are important gaps in the work to date.

Another lesson from past work has been the lack of analysis of *off-farm influences* on farmer decision making. For example, there has been very little research into smallholder supply response to prices, risk, credit, the influence of seasonal employment opportunities on investment and production decisions or the influence of education on aspirations, although more has been done on market access and rural-urban migration. One reason for this has been the lack of economic inputs into agricultural research.

The strong social inter-group and intra-*group links* that feature reciprocal gift giving and important non-market influences on production behaviour in most social groups, mean that analysis of the individual household outside the group context is risky. Definitions of 'a household' and 'a family' likewise require reference to the group context.

Concern with the *human nutrition* consequences of economic development has been a feature of the research work of the past decade. Agricultural researchers have combined with nutritionists in several provinces (Chimbu Province, Southern Highlands Province in particular) and in the National Nutrition Survey. The work of Harvey and Heywood (1983) has suggested that broad-based smallholder cash cropping was associated with improved growth of children over the period 1956-81 in Chimbu Province. It is now generally considered that smallholder cash cropping has had a positive influence on nutritional status in PNG. More detailed study of this relationship is scheduled to be done as a part of the ACIAR funded Export Tree Crop Study, once the results of the National Nutrition Survey are available. Deciding this issue is obviously important for policy, as previous anecdotal evidence of a negative association between cash cropping and nutrition (e.g. Lambert 1979), which has been strongly criticised by Hide (1980), has had wide-ranging influences both in PNG and overseas (e.g. IFPRI 1984).

While farming systems type work has had a long history in PNG, it has not followed the overseas methodologies developed at institutes such as IRRI or ICRISAT (e.g. Flinn 1978). Labour and other resource constraints cast some doubt on the appropriateness of these approaches for PNG, but it is fair to say that they have not been given a serious trial. The FSR work that has taken place *rarely involved interactive teamwork.*

The need for *training* of research staff in the principles and methods appropriate to farming systems research, beyond the disciplinary studies normally undertaken, stands out if FSR is to become institutionalised in PNG. Related to this, there would be value in institutional support for the present and planned work, a topic ACIAR could consider.

The Present

Presently agricultural research is in a transitional period. Large research projects have either finished (e.g. SLUP) or will soon do so (e.g. Agricultural Field Trials Extension and Monitoring Unit (AFTSEMU) (Table 1). They have demonstrated the value of multidisciplinary inputs to address key provincial issues, but have suffered from the time constraints imposed by project funding. They have also provided much improved information with which to accurately focus future research and extension work.

The Department of Primary Industry's research services are being rebuilt after a number of years in decline, and industry-based research in the export tree crops has commenced. Joint industry/government funding of research has recently been endorsed by the Cabinet and under the Medium Term Development Plan (1986-90), agricultural research funding is likely to increase significantly. Although farming systems research has been nominated as an important area (Moxon 1983; ISNAR 1982), it is likely to have a less important role than either component research or cropping systems research. The present role of FSR can be summarised as follows:

Export Tree Crop Research

The need for FSR programs has been recognised in cocoa, coconuts and coffee, but not yet in oil palm, rubber or the other export tree crop industries. However, the pro-FSR view has come principally from government researchers, and government will probably provide less funding than industry under the new proposals for industry-based research, although the exact relative roles are not yet clear. Although smallholders contribute more than larger producers to research levies in cocoa, there has been an apparent bias in the work so far and in research thinking towards crop improvements, which may not be best suited for smallholders; 'trickle down' effects are still given credence by the research advisors to that industry (Turner 1982). Any FSR program development seems to presuppose the appointment of agricultural economists to the research institutes. These appointments have lower priority than biological scientists and will probably require aid funding to become a reality.

Food Crops Research

There has been a definite recommendation to government that FSR become a part of an overall cropping systems thrust in the highlands and lowlands food crops research teams (ISNAR 1982). While accepting this in principle, government to date has been concerned to set up the teams.

The first, at Kuk in the highlands, is currently recruiting staff. Once the team is assembled, priorities will then be set. It is likely, however, that these teams will need to concentrate their resources on high priority areas only, such as areas under increasing population pressure or areas with food supply, nutrition or low income problems. It seems possible that an FSR approach to priority setting and problem solving may be at least partially adopted. The Department of Primary Industry (DPI) is presently reviewing all past food crop research, which will be then used as a basis for deciding future priorities.

Other FSR-Related Work

There are two other projects underway at present that include studies related directly to assessing farming systems. These are the DPI/CSIRO Resource Potential Study and the DPI/Queensland DPI/ACIAR Export Tree Crops Study (Table 2).

The outputs of the DPI/CSIRO study will include the mapping and description (physical and agricultural) of over 5000 resource units, their present resource use and the development of a methodology to assess the capacity of these units to support increased populations and intensified land use.

The outputs of the DPI/QDPI/ACIAR study will include the development of efficient and low cost methodologies for monitoring and assessing the economic situation and trends in large-, medium- and small-scale coffee, cocoa and coconut production, and developing indicators on the relationship between smallholder cash cropping and subsistence, including the effects on nutrition from increased production of cash crops.

Table 2. Major national data sources and reviews since 1980.

1. 1980 National Population Census	National Statistical Office
2. CSIRO Resource Potential Study (ongoing)	McAlpine et al. 1982
3. 1982–3 National Nutrition Survey	Analysis ongoing
4. 1983 Review of Subsistence Agriculture	UNDP/DPI, 1983
5. 1984 — Rural Household Survey (ongoing)	National Statistical Office
6. 1985–7 Export Tree Crop Study (ongoing)	ACIAR/DPI/QDPI
7. Analysis of CPI Food Price Data in 5 Urban Centres, 1970–84	DPI 1985 (in prep.)
8. Topographical Maps of PNG (1:100 000)	National Mapping Bureau
9. Food Crops Research Review	DPI 1985 (in prep.)

What Has FSR to Offer PNG

This has been a frequently asked question in recent years. The answers given have been just as frequently vague. Although we have noted the long history of agricultural/social farming systems type research, we have also noted the limited amount of interactive team involvement, systematic surveys of client groups to determine priorities, and the lack of development, testing, and evaluation of technology under village conditions. In other words a complete *FSR approach* as developed in other countries, has not been tested in PNG. However, aspects of it have been tested (e.g. Nembi Plateau, AFTSEMU, SLUP) and the positive results from these experiences suggest that this kind of approach, modified to suit local resources, may well be superior to its alternatives.

An FSR approach would seem to offer greater opportunities for asking the *correct research questions.* There are several reasons for this:

(a) The FSR approach starts an enquiry with an *open mind* to the issues involved, narrowing these down as a result of on-farm surveys and other inquiries that call on data available now or in future, at a local and macro level. As there is such a useful array of recent macro level data and resources available (Table 2), it will soon become possible to place areas and farming systems into a nationwide context and to broadly see the results of the present systems in terms of cash income, level of reliance on subsistence and nutritional status. Individual researchers will be able to undertake analysis from many of the above sources of their particular location and needs, and therefore be able to focus an enquiry more skilfully.

(b) Local level FSR enquiries take into account on and off-farm influences. In PNG *on-farm* influences to food and cash crop production include the size of pig stocks at any time, the demands (sometimes delayed) of reciprocal exchanges, and a steady round of social obligations, apart from the normal influences of the quality of planting material, labour and land availability and seasonal tasks. Off-farm influences include market access for sellers and buyers, information flows with respect to price, demand, cultivation techniques and inputs, and security issues, particularly from inter-group fighting in the highlands.

(c) FSR inquiries would *integrate* cash and food crops as well as the animals raised in a village. This would prevent the separation of food and cash crops research, which will be a natural tendency following the decision to establish specific research institutes for the major export tree crops. Preliminary work has indicated that the practices of integrating tree and food crop production are basically sound, but further research is needed on such systems.

The above list of macro and local level influences, which is far from exhaustive, is a good deal wider in scope than yields of staple foods or export tree crops, which could be said to have dominated research priorities to date. Yields may indeed turn out to be the most critical area for focus, but to determine this, researchers should look beyond the biological and ecological determinants of crop yields to decide their priorities.

But is this list too wide already, ruling FSR out in practical terms for PNG? This question has been rightly asked by experienced government researchers for the foods area. It may be that the time involved in accurately specifying a set of priorities (given the inordinate real world constraint of rapid staff turnover and recruitment delays) is so great that politicians and others will become impatient for action. Better, it could be said, to concentrate on getting some results as quickly as possible: therefore the focus would be predetermined, and the decision to concentrate on quality improvement (higher yields especially) in food crop staples and export tree crops appears obvious.

These are the main issues surrounding FSR at present: it seems attractive, but appears long winded and may be beyond the resources available. Our conclusions are that an FSR approach should be tried and evaluated as it offers a better chance of accurately focusing research resources on the most relevant issues.

For the immediate future we suggest ACIAR become involved to assist in the *planning and monitoring of FSR:* Of particular use would be advice on methodologies to determine priorities, on-farm research needs and the experiment station/on-farm research relationship. During the period of research startup in the food and export tree crop areas, an FSR collaborative input could be very useful to assist local researchers to establish a viable research program.

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Farming Systems Research in Indonesia

M. Sabrani*, F. Kasryno** and C. Peacock*

INDONESIA is the world's largest archipelago and, having 164 million people, is the fifth most populated country in the world. It contains within its borders striking diversity in physical, economic and social characteristics. The highly fertile islands of Java and Bali support some of the highest rural population densities known, while Sumatra, Kalimantan and Irian Jaya – the 'outer islands'– are less fertile, much less densely populated, and much of the land is unsettled and underused. This dichotomy between Java and Bali and the outer islands is essential to appreciate when considering agricultural development and research for that agricultural development.

Java, containing 85% of the total population, has managed to support a large and ever increasing population by intensifying its rice production through improved irrigation, allowing double cropping with high yielding varieties. Although this intensification of rice production has been successful, the Government of Indonesia has encouraged the permanent movement of people from Java to the outer islands, under various transmigration schemes. Many of these schemes have been unsuccessful because of poor selection of settlement sites, a lack of basic farm inputs and lack of extension advice relevant to the unfamiliar environment in which the new migrants find themselves. As a result there has been a high return rate of migrants to their original homes. Thus there are two separate sets of agricultural problems for researchers to tackle for small farms in Indonesia. How to improve the efficiency of resource use in heavily populated Java and Bali and sustain the already high production, and in the outer islands, how to develop new farmimg systems that make the best use of the low fertility soils on which migrants are normally settled.

Structure of Agricultural Research

All agricultural research is under the administrative direction of the Agency for Agricultural Research and Development (AARD). This agency administers the activities of seven autonomous research institutes which are differentiated according to commodities. Within several institutes (Food Crops, Animal Husbandry, Fisheries, Industrial crops and Forestry), there are farming systems type programs that carry out systems research relevant to the mandate of their own institute.

Interdisciplinary research may take place when the institutes work together in a specific target area. The selection of these target areas is normally based on existing development activities, e.g. a transmigration scheme with a specific problem.

Examples of FSR

Centre for Agro-Economic Research

Although not formally designated FSR, the national farm management surveys and case studies carried out by CAER have provided detailed and extensive information from small farms in all provinces in Indonesia. The data bank developed has formed the basis for policy research that has guided the policy made in the Ministry of Agriculture. The detailed analysis of all household enterprises in the Centre's Rural Dynamics Study provides a comprehensive account of changes in the economics of small farms in Indonesia (Kasryno 1981).

Central Research Institute for Food Crops

The first research institute to conduct FSR was CRIFC under their cropping systems research program begun in 1973. Cropping systems research has now been carried out in the major edaphological land areas in Indonesia. The greatest potential for immediate yield increases exists in the lowland rice areas, which have the infrastruc-

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ture to allow intensified agricultural production. Rapid increases in yields of rice were made through the introduction of early maturing and improved crop varieties, direct seeding of rice, reduction in turn-around time between crops and improved management techniques (McIntosh 1984).

The second target area for cropping systems research was the rainfed uplands used for transmigration schemes in Sumatra, Kalimantan and Sulawesi. Problems with soil management, pests and diseases needed research specific to these problems. Cultural practices were developed that encouraged stable and sustainable crop production. These practices have been incorporated within packages extended to farmers (McIntosh 1984).

Central Research Institute for Animal Science

Livestock component FSR for smallholders is a relatively recent development in CRIAS (Sabrani et al. 1983). Technology already exists for the development of large-scale capital intensive livestock enterprises, e.g. broiler production and dairying, but the definition of technology appropriate to small, capital-starved, livestock rearers does not exist. Much time has been spent collecting baseline data on the present productivity of village livestock in order to identify the major problems and test simple solutions to those problems (Kingston and Creswell 1982; Petheram et al. 1982; Sabrani et al. 1982).

Most progress has been made with sheep and goats through the activities of the Small Ruminant Collaborative Research Support Program (SRCRSP) which is field testing a package of improvements for small ruminants in West Java. Other innovations being field tested include the vaccination of village chickens and the introduction of forage species to 'spare' land in villages in Java.

Other Institutions

Many universities in Indonesia also conduct FSR: these include Bogor Agricultural University, Brawijaya University, Malang and Gajah Mada University, Yogyakarta.

New Directions in FSR

FSR in Indonesia is now at a stage when each institute has developed sufficient competence in FSR methodology in its own field that fruitful research will result from collaboration between institutes on specific problems. Increasingly, FSR is collaborative and targetted to specific issues of national importance. A major research thrust is in crop/livestock research and one of the first sites of collaboration is in the Batumata Transmigration Area in South Sumatra. Emphases will be placed on the development of stable cropping patterns, maintenance of soil fertility, efficient utilisation of land and labour through the use of animal power and provision of cash income through livestock enterprises.

AARD is also collaborating in developing a sound base for soil and water conservation programs in upper river watersheds in central and east Java. This includes the introduction of forage species as stabilisers for terraces in steep terrain and research on the management and use of these grasses, as well as the testing of crop varieties on different slopes and at different altitudes.

It is important that each centre conduct its own FSR to develop technology relevant to its own mandate, but it is also necessary that relevant institutions (government and non-government) work together on specific problems that require a more holistic approach than one institute can offer by itself. At present the necessary organisation to plan, execute and coordinate this type of research within AARD is being developed as the first collaborative projects get underway. There is also a great need to extend this cooperation to include extension services, local government and farmer organisations.

Future Needs of FSR

Personnel

There is an urgent need for more professionals to enter FSR in Indonesia, particularly in the non-food crop institutes. There is a scarcity of scientists, competent in their own discipline, who have a broad understanding of mixed farm systems and sympathy with small farmers. This is partly due to the poor reward system for those who work in FSR. Rewards in government research institutions depend mainly on the number of publications in scientific journals. The painstaking collection of basic farm data, or running of simple farm trials are considerably harder than research station experimentation. This causes FSR publications to be slower and consequently FSR scientists' progress tends to be slower. At present FSR scientists' personal commitment to working directly with farmers is being exploited. There is urgent need for more publication channels for FSR research.

Funding

Experience has shown that the most effective coordination of FSR is realised if the budget is allocated directly to the FSR program and is distributed to other commodity programs participating in FSR activities.

Regular Research Evaluation

It is extremely important that FSR programs are regularly evaluated by other scientists, extension workers and farmers themselves. It is only in this way, through free communication, that research objectives can be clarified, technical soundness established and practical applicability of results maintained.

In-Country FSR Network

There is an urgent need to establish a nationwide FSR network among government and non-government organisations conducting FSR research. The sharing of experiences, methodology and results can improve the quality and efficiency of FSR. For this purpose an inventory of projects and expertise working in FSR is an important first step. The second step is to develop a data base that contains basic agroclimatic, soil and socio-economic information for various parts of the country. Annual workshops would help to improve understanding and generate better relationships among scientists from different agencies.

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Farming Systems Research in the Philippines

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THE development of the agricultural sector in the Philippines is basically pursued through the implementation of commodity-oriented programs. This commodity approach to development is dictated by the necessity to concentrate limited financial and labour resources on priority commodities such as rice, corn, sugarcane, coconut and livestock (poultry, hogs, cattle).

Accordingly, research, institutional, and other infrastructure support services were organised with specific focus on these national commodity programs. This approach is best exemplified by the Masagana 99 rice production program, which brought the country to self-sufficiency in only a few years.

On the basis of national figures for such measures as average yields, total production, export revenues, and production acreages, one can conclude that the commodity-oriented strategy has been effective. However, grave concern developed about the commodity-oriented development approach because of the following observations:

(1) Growing disparity between experimental yields and farmers' yields;
(2) Limited adoption of recommended component technologies such as variety, fertiliser and crop protection;
(3) Increased yields do not seem to translate into improved economic well-being of the Filipino farmer particularly with the increase in price of inputs;
(4) The proliferation of commodity-focused support services appears to have reached a point where coordination has become increasingly difficult, preventing the economic and efficient use of financial and labour resources.

These observations point to the need for review and reorientation of the strategy to properly address the needs of the agricultural sector, particularly the small farms, which constitute the bulk of farms. Furthermore, increased production to meet the needs of increasing population demands that resource-limited farms be brought into the mainstream of the country's economic development.

Farming Systems Program Development

Research aimed at developing appropriate technologies and strategies for optimising small farm productivity and profits was started by various agencies particularly the UP College of Agriculture Los Baños (UPLB-CA), in the early seventies.

Similarly, pilot projects were started by the Ministry of Agriculture in coordination with other institutions like the International Rice Research Institute (IRRI), UPLB, and the Farming Systems Development Corporation. The following projects will give an idea of these activities.

National Multiple Cropping Production Program

From 1972 to 1978, UPLB with the assistance of IDRC implemented a pilot multiple cropping project in several villages to study the adoption and impact of some intensive cropping patterns. Selected vegetables and upland crops were introduced into rice- and corn-based production systems. Trained technicians stayed in the pilot areas and assisted the farmer cooperators in the preparation of farm plans and budgets. In addition, credit and marketing institutions were tapped to support the project.

The success of this pilot project led to the launching of a National Multiple Cropping Program, utilising existing personnel of the Bureau of Agricultural Extension and Bureau of Plant Industry, under the general coordination of the National Food and Agricultural Council (NFAC). The program attempted to apply a total farm approach to extension. Each extension worker was

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trained to provide assistance to the farmers on any agricultural activity instead of only a single commodity. The farmer, with the assistance of the production technician, prepared an annual farm production plan and budget, which served as the basis of loan approval, disbursement, and repayment.

The effort to institutionalise the farming systems approach to extension did not prosper at this time because of institutional constraints. Coordination was hampered by the fact that the field personnel belonged to five separate bureaus of the Ministry of Agriculture. These bureaus still exercised direct control over the personnel and the activities being pursued were remote from the commodity-oriented mandates of the bureaus.

Nevertheless, the program provided insights into the organisational requirements of a farming systems-oriented strategy, apart from the development of important cropping systems technologies, many of which were accepted by the farmers involved. One noteworthy accomplishment was the development of an integrated agricultural financing scheme, which enabled the granting of loans on the basis of a production plan instead of on a single commodity basis.

Rainfed Agricultural Development (Iloilo) Project (RADIP)

A package of technology to intensify land use in rainfed areas was developed in 1974 by IRRI in coordination with the Bureau of Agriculture Extension and the Ministry of Agriculture. The technology essentially involved the production of two crops of rice plus an upland crop (legumes, feed grains and vegetables) in areas that traditionally grow only one crop of rice. This cropping pattern is made possible by early and thorough land preparation, the use of high-yielding and early-maturing rice varieties, and a short turn-around period. As shown in Figure 1, the first crop is dry seeded at the onset of the first rain in April or May and harvested in August.

The second rice crop is planted either by wet seeding or transplanting within 15 days from harvest of the first crop and is harvested in December with the third crop planted in January.

The project to introduce the technology was launched in 1976 in Santa Barbara, Iloilo, covering 13 villages involving 169 farmers on 382 ha. This pilot extension phase was known as the KABSAKA project. The dramatic results led to the expansion of the project to cover the whole province of Iloilo with the assistance of the World Bank. The expanded project was known as RADIP, involving a target area of 60 000 ha.

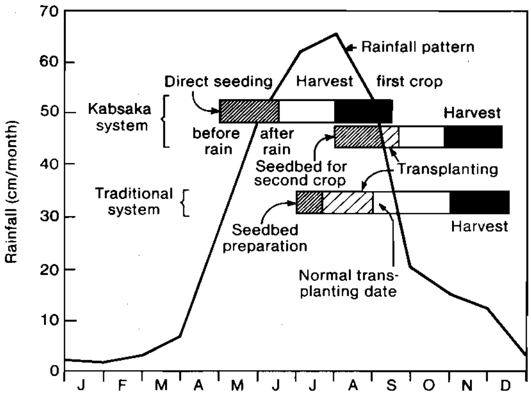

Fig. 1. Old system vs the new as practiced by Iloilo, Philippines, farmers who adopted a two-crop system for rainfed wetland rice in the Kabsaka 1977 project.

The strategy was to establish demonstration plots a year before a locality was declared part of the project. This allowed fine tuning of the technology, while showing the benefits. When the site was declared part of the project, the local farmers were convened by the extension worker assigned to the area and briefed on the technology. Participating farmers were required to attend a meeting conducted 2–3 weeks later, which provided detailed instruction on the technology. This voluntary participation is felt to have contributed a great deal to the highly successful rate of adoption.

Extension specialists were trained at IRRI on rice production and at the UPLB on upland crop production. The technicians are required to live in their work area. They conduct farmer classes on specific technical topics such as weed control, pest and disease control, short turn-around time, establishment of the second crop, production of legumes, etc.

Table 1 shows the progress of the project and the yields obtained by the farmers. Note the dramatic increase in the number of farmers adopting the technology when the project was expanded to cover the whole province of Iloilo.

While the project initially centred on intensifying cropping in rainfed areas, other components were later introduced in response to the needs of the communities. These include cattle-fattening, seed production and marketing, nutrition and

Table 1. Progress of the KABSAKA/RADIP project and farmers' yields.

Project	No. of farmers	Area (ha)	Average yields (t/ha)	
			1st crop	2nd crop
KABSAKA, Iloilo (20 municipalities)				
1974–75	2	1	3.0	4.0
1975–76	9	25	4.8	5.0
1976–77	54	89	5.2	4.0
1977–78	88	141	4.9	1.5
1978–79	276	477	4.4	4.6
RADIP				
1980–81	1 040	1 500	3.2	3.5
1981–82	4 562	6 302	2.8	1.9
1982–83	9 750	13 000	2.5	1.5
1983–84	25 624	34 694	3.4	4.4

health, water supplies and pilot village development.

The pilot village development component of the project was an attempt to help communities resolve problems that arose because of the project. As an example, with increased productivity there was an increased need for better roads. Pilot village development is an attempt to teach communities to solve collectively their problems and keep them aware of existing government agencies' assistance programs that they can tap. It was also seen as a strategy to ensure continued viability of the program objectives beyond the life of the project.

RADIP's success can be attributed to the following:

(1) Relevant, simple, and well-tested technology. On-farm or adaptive trials to fine-tune the technology as the project was expanded were a major component;
(2) Strong support from the local government;
(3) Improved support and supervision of extension technicians brought about by the reorganisation of the Ministry of Agriculture, which merged the bureaus and gave the Regional Director direct control of field personnel.
(4) Well-trained and very well-motivated project staff.

Important lessons which can be drawn from this project include:

(1) The importance of clearly defining the client, which then serves as the basis for integrating project strategies;
(2) Demonstration of a feasible organisational structure to mobilise effectively an inter-agency approach to development;
(3) The need for good monitoring and evaluation;
(4) The effectiveness of the pilot village development concept to mobilise collective efforts and encourage participation from the farmers.

Agusan del Sur, Bukidnon and Capiz Resettlement Project

This project supported by the World Bank involved the initial testing of component technologies and cropping patterns on farms and subsequent piloting of a production program to introduce developed technologies, with the Bureau of Agricultural Extension and the Ministry of Agrarian Reform providing the lead roles.

Acceptance rates of the cropping patterns were low, but the average yields of rice and corn, which are the major components of the pattern, increased substantially (Table 2). These results indicate ready acceptance of small bits of technologies compared with a total package such as a cropping pattern. Such a response indicates farmers' ability to select suitable parts of a technology package and hence the importance of involving them in developing the packages.

Table 2. Production profile (t/ha) of three major crops in the Agusan de Sur, Bukidnon and Capiz settlement project (1978–81).

Crops	Agusan[a]		
	BM	Current	Pilot
Lowland rice	1.50	2.60	3.33
Upland rice	0.43	0.90	1.42
Corn	0.68	1.60	1.84

[a] BM — Benchmark Data (1978–79); Current — Current average production in the area (1981–82); Pilot — Average production of farmer-cooperators in the pilot areas in the settlement (3–4 barangays).

Agricultural Support Services Project (ASSP)

The launching of ASSP in early 1982 marked the beginning of a massive effort to strengthen and systematise the development and dissemination of agricultural production technologies appropriate to the various agroclimatic and socioeconomic conditions prevailing in the country. The project provided the necessary technical and financial resources to enable the 12 political regions of the country to work with farmers in adapting and utilising technologies from the various research centres. In each region, a Regional Integrated Agricultural Research System (RIARS) has been established. Technical backup is being provided by the Farming Systems and Soil Resources Institute (FSSRI), established in 1982, which is implementing the Small Farm Systems Component of ASSP.

Through the ASSP, various innovations were introduced, such as:

(1) Involvement of extension workers in the RIARS in the verification, adaptation and packaging of production technologies. This arrangement is seen as strengthening the link between research and extension;

(2) Decentralisation of the Ministry of Agriculture and integration of regional offices (Bureau of Plant Industry, Bureau of Animal Industry, Bureau of Agricultural Economics, and Bureau of Cooperatives Development);

(3) Involvement of farmers as key participants in RIARS activities to adapt technologies to the specific conditions of the region;

(4) Active involvement by FSSRI in the development of farming systems methodologies and technologies and directly linking these activities to the RIARS (Fig. 2).

Farming Systems and Soil Resources Institute

The Institute was created to provide a coherent framework of research integration by using the farming systems research (FSR) approach. It was intended to enhance the programs on countryside development at UPLB.

FSSRI is tasked with the promotion of farming systems approach as a strategy for agricultural development, and the development of farming systems technologies appropriate to the various production settings in the Philippines. It has as its primary focus the improvement of the standard of living of small farmers, through the development of more productive, profitable and sustainable production systems compatible with farmer aspirations and resources, farming environments, community institutions and structures, and long-term national goals.

More specifically FSSRI has the following objectives:

(1) To package existing and future component technologies and develop production modules to bring about intensified and integrated commodity production systems appropriate to the various agroecological zones and farm conditions;

(2) To integrate livestock production (including fish culture) with crop production schemes, and to expand efforts at utilising non-traditional crop and livestock commodities to broaden the range of alternatives;

(3) To identify solutions to soil resource

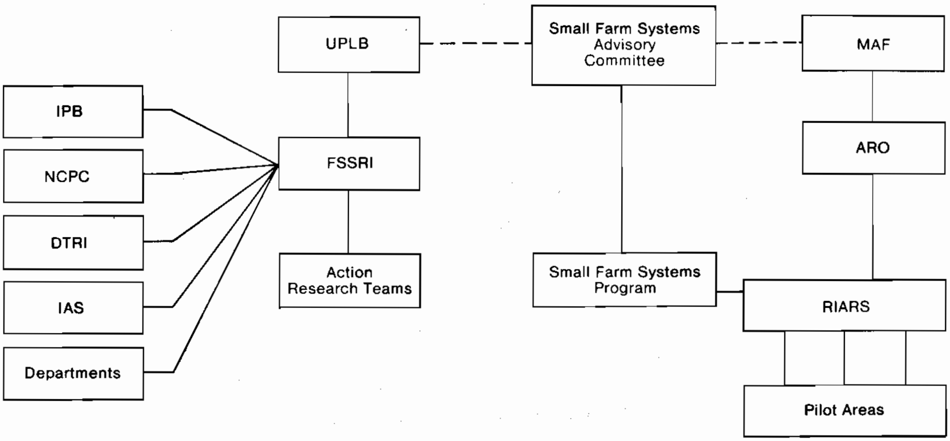

Fig. 2. Operational relationships between UPLB/FSSRI and MAF/ARO/RIARS in the implementation of the small farm systems program in the ASSP Program. IPB — Institute of Plant Breeding; NCPC — National Crop Protection Centre; DTRI — Dairy Training and Research Institute; IAS — Institute of Animal Science; MAF — Ministry of Agriculture and Food; ARO — Agricultural Research Office.

constraints and develop soil management systems appropriate to various farming schemes. This involves the development of interpretative techniques that integrate the various components of the soil-air-plant system, and development of an accurate inventory and system of soil classification to provide comprehensive information on the potential for more rational land uses;

(4) To develop and promote recycling systems/farm by-products utilisation and efficient fertiliser and energy management;

(5) To develop production/management systems to use marginal/special problems areas such as the saline soils, wetlands, flood-prone areas, and nutrient deficient soils;

(6) To develop and conduct appropriate training programs in support of the farming systems program of the country.

Within FSSRI there are five farming systems teams responsible for the four major agroecosystems in the country, namely: the hillyland, irrigated/wetland, sugarcane-based and coconut-based farming systems. The team is interdisciplinary, comprising specialists in agronomy, soils, animal production and economics. Depending on needs, other disciplines such as agricultural engineering, forestry, and food processing are included. These farming system teams are considered to be the action teams of FSSRI. Their major activity is verification and packaging of farming systems technologies within each RIARS of the Ministry of Agriculture.

The Agrotechnology Transfer Program represents the main contribution to basic research at FSSRI. The program thrust is the assessment of the various farming systems determinants and their interrelationships. Ultimately, it is our hope that a system of resources and agroenvironmental zoning can be evolved to facilitate farming systems technology transfer while minimising the cost of site-specific trials.

Problems and Outlook

In the Philippines there is still a great deal of controversy about FSR — what it is, what it can do, how it can be put into practice. I think this situation is not unique to my country because, apart from the fact that the concept is relatively new, the approach differs from country to country. Nonetheless, we have already taken a bold step to institutionalise the process in the Ministry of Agriculture's organisational structure and programs, and in the national research systems with the creation of FSSRI. There is still plenty of room for improvement because national research institutions on sugarcane, cotton, tobacco, coconut, and forestry have not yet taken a serious interest in FSR. This situation limits our ability to optimise farm productivity and income.

The farming systems program as it is being implemented in the Philippines is focused on enhancing technology adoption and utilisation in resource-limited farms by strengthening the national capability for on-farm trials, which effectively links extension and research. This I feel is strategic, because we have already a relatively developed research structure that has produced commodity-oriented technologies, which when properly harnessed would immediately rebound to increase productivity and improvement in the welfare of the farmers. In the short term, this is also the thrust of FSSRI. The Institute is currently helping the RIARS to adapt technologies to the specific conditions in each region. At the same time, FSSRI is working towards strengthening the farming systems orientation in the agricultural research system in the country. In the long term, FSSRI will concern itself more and more with developing alternative integrated production models to optimise productivity and income in our various agroecological settings.

Opportunities for ACIAR-FSSRI Collaboration

Given the present state of FSR development in the Philippines and considering the strengths of the Australian scientific community, the following are suggested areas of collaboration.

Agroecosystem stratification or zoning — FSS technologies are site-specific, but we believe that some system or a model of agroecosystem stratification can be developed to facilitate transfer and extrapolation of farming systems technologies. FSSRI already has an agrotechnology transfer team working on simple modelling. The team can be reinforced by Australian experts and given the proper support, they can together develop a feasible scheme of agroenvironment zoning and classification directly relevant to agrotechnology transfer processes.

Infusion of Australian expertise — Improvement of existing farming systems in terms of productivity, stability and sustainability through the infusion of Australian expertise on: (a) crop-livestock integration; (b) soil and water conservation; (c) minimum tillage; and (d) semi-arid agriculture. This effort will broaden the horizon of small farmers by giving them improved options.

Policy studies — Policy studies are needed with specific focus on the infrastructure supports (credit, marketing, pricing, etc.) for small farmers.

Developing countries pursuing FSR are in need of institutional development support, particularly in the area of labour resources development. Australia has recognised experience in systems orientation and multidisciplinary work arrangements. Training of Third World staff in these areas is necessary to promote productive FSR pursuits.

Indeed, Australia through ACIAR has a lot to offer in promoting FSR as a tool to improve the well-being of resource-limited farmers in Third World countries. In return, the Third World countries can offer the Australian scientists two things: a challenge to make science and technology work under trying conditions; and fullfilment in seeing a soul liberated from the bondage of poverty and starvation.

Farming Systems Research in Malaysia: MARDI's Experience

Hashim Mohd. Noor*

DEVELOPMENT of small farms has traditionally been commodity-oriented, with development efforts being focused on the individual commodities on a given farm. These efforts have had their measure of success in increasing productivity of the single-commodity farms, but have had much less impact in increasing the productivity of those small but multi-commodity farms prevalent in the country.

A more holistic approach to small farm development is therefore required in order to lift the productivity and income of those small farms. This new approach, appropriately called the farming systems approach to small farm development, would involve development programs that encompass the total farm or the varied mix of crops and livestock on a given farm or a group of farms. A significant advantage of this approach is that it allows for a more optimal utilisation of the farm land and labour resources for higher productivity and income.

A major contributor to the high incidence of poverty among farmers in the country is the small average farm size of around 1.2 ha. This, coupled with the production of a single commodity, means that increases in productivity are unlikely to bring these farmers above the poverty line. But through the introduction of the farming systems approach there is a better likelihood of lifting these small farmers above the poverty line.

Definition of Farming System

The identification of focus and methodology in farming systems research (FSR) presents difficulties arising from the varied understanding and thus definitions of farming systems. Perhaps there are as many definitions as there are people and agencies involved in FSR and development.

Insofar as MARDI is concerned, a farming system is defined as the farming pattern or combination of enterprises practised on a given farm. It is a production system that provides an opportunity for farmers to exploit the full productive potential of their farm through the optimal use of ecological and economic resources over a longer time frame. In MARDI's context, this period is 5 years. Within this broad definition, farming systems include such practices as crop-crop and crop-livestock combinations.

Concepts of Farming System

A farming system practised by a given farmer is the result of a complex interaction of a number of interdependent variables or components at the centre of which is the farmer. More specifically, this system involves the allocation of production resources: land, labour, capital, and managerial skills, to the production of crops, livestock and off-farm and non-farm enterprises in a manner that provides for the attainment of the family's goal(s).

The functioning of the farming system requires decisions about the qualities and quantities of inputs to be used to produce the desired combination of products. These decisions are largely influenced by the total environment in which the farmer operates: the technical and human environments. The technical environment refers to the natural environment, which defines the potentially possible systems in a given area, such as soil, water and climate.

The human environment comprises exogenous and endogenous factors. Exogenous factors are largely outside the control of farmers and include community structure and values, and external institutions for both inputs and outputs. Endogenous factors, on the other hand, are those over which farmers can exercise some control, and the resources at their disposal, attitudes, goals, needs and priorities. These factors influence the manner in which farmers allocate resources, subject to the constraints imposed by the technical and the exogenous human environment.

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Existing Systems in Malaysia

A characteristic feature of the smallholdings in this country is the mixed nature of the crops grown on a given farm. For instance, smallholdings classified as paddy farms may not necessarily have paddy as the sole crop nor even have paddy as the main source of income. In fact of a total of some 300 000 smallholdings growing paddy, only about 140 000 (47%) are 'specialised paddy farms' i.e. farms on which 75% or more of the area is devoted to paddy cultivation. It is estimated that only about 58% of the paddy farmers are dependent on paddy as their main source of income.

Farms classified as rubber, coconut, fruit or other holdings also grow a variety of crops. It is pertinent to note that the development of these mixed cropping systems on the smallholdings was not based on the conscious efforts of farmers to optimise the use of resources and maximise income. Rather, the motives were to minimise and spread risks and to ensure that at least some basic food needs were met. Consequently, most of the farms are not economically and agronomically efficient in terms of resource use and income generation.

The four main production systems are based on rubber, orchards, coconuts and rice.

Rubber Based System

Rubber, which covers some 1.9 million ha in Malaysia, provides ample opportunity for intercropping of cash crops during the first two or three years after planting. Beyond this period intercropping ceases as the spreading canopy tends to limit the amount of light reaching the ground.

Intercrops normally grown with the young rubber trees include bananas, pineapples, watermelons, chilli, maize, tapioca and groundnuts. Intercropping has become increasingly popular as it brings in alternative income during the non-productive period of the rubber trees. Smallholders also integrate livestock with their rubber.

Orchard Based System

The fruit industry in Malaysia is relatively underdeveloped when compared with rubber and oil-palm. Mixed cropping is prevalent on fruit farms. This is evident from the fact that on fruit farms or *dusuns* in most States less than 50% of the area produces fruit. In fact, many of these *dusuns* are mixed with other farm enterprises, with fruit cultivation being a supplementary activity during the fruiting season only. The other enterprises are mainly livestock and to a lesser extent coconuts, bamboo and some short-term crops.

The mixed nature of fruit farms is not confined to the mixed production of fruit and non-fruit enterprises on a given farm. Even in the areas of the farms under fruit, monocropping (i.e. production of a single fruit type) is uncommon and not favoured.

Coconut Based System

Mixed farming in coconut areas primarily involves the cultivation of cocoa, coffee, pineapples and bananas as intercrops, as well as the rearing of livestock. However, the choice of crops to be intercropped with coconut depends on a number of factors, notably soil conditions, shade levels, holding size and labour resources.

Since coconuts are considered a low income crop because of old and unselected stands, the intercrops provide a good source of income to the coconut farmers. In fact, usually the intercrops become the primary crop in terms of income generation, while coconuts become the secondary or supplementary crop.

Currently, cocoa is the most suitable and remunerative intercrop under coconut, as the coconut palms provide the shade necessary for the cocoa plants. The coconut-cocoa farming system is prevalent on the coastal clays, while in slightly acidic soils or areas with shallow peat, coffee and pineapple are intercropped under coconut.

The prevalence of coconut-cocoa mixed cropping is evident from the fact that about 77% of the 80 000 ha of cocoa under cultivation in Peninsular Malaysia is intercropped with coconut.

Paddy Based System

As indicated earlier, holdings classified as paddy farms need not necessarily have paddy as the sole crop nor even have paddy as the main source of income. Other crops are either grown simultaneously with paddy (outside the paddy plots) or grown in rotation with paddy after the harvest.

The dominant farming system is the paddy-upland crops rotation system. Paddy is grown during the monsoon season when water is sufficient, followed by upland crops when insufficient water is available to support a second paddy crop. Upland crops grown in rotation with paddy include maize, groundnuts, sweet potatoes, tobacco, vegetables and watermelons.

The paddy-upland crops system is well-accepted among farmers in the rainfed areas, as it provides substantial additional income to them, and in many instances the income from the upland crops, particularly vegetables, forms the main income while that from paddy is relegated to the supplementary source.

Farming Systems Research in MARDI

FSR or the whole-farm approach to small farm development is a recent development and was initiated in early 1982 by MARDI. The Rubber Research Institute of Malaysia is also conducting studies on the integration of livestock, particularly goats and sheep, under rubber.

However, on-farm research is not new to the country. MARDI under its Project Development Division initiated the on-farm research program as early as 1973. This aspect of research involves the verification of component technologies developed by the commodity divisions of the Institute on the farmers' land. An important feature of the on-farm research is that labour is provided by the farmers themselves, but under the guidance and supervision of the researchers. On-farm research however, is not categorised as FSR because it is still very much single-commodity oriented.

In MARDI's context, FSR encompasses studies on the development of farming patterns using component commodity technologies that optimise the use of land, labour and capital by particular farmers with a view to maximising their income. In other words, it involves the 'packaging' of these component technologies on a given farm. The systems developed are built upon, or are improvements of, the existing systems, and are not a replacement of these traditional systems. These traditional systems evolved through years of experience with the ecosystem and the socio-economic conditions under which the farmers operate.

Because of the prevalence of multi-enterprise farms, FSR involves the whole farm approach as opposed to the traditional single commodity or enterprise approach. The whole farm approach treats the enterprises on a given farm as variables, as well as recognising the interactions of the technical and human elements in developing appropriate farming systems.

It must be recognised that the farmers' knowledge and experience play an important role in farming systems research particularly in improving their existing farming systems. Thus in FSR the farmer is the central figure, fully involved in the whole research process right from the planning stage. This is to ensure that any system developed or evaluation criteria adopted are in line with the values (both economic and social) important to the farmer, and do not merely reflect the researchers' perceptions. In this respect the researchers need to be sensitive to the existing systems and the cultural values attached to these systems.

Due to its multi-faceted and farmer-oriented nature, FSR is undertaken by a multidisciplinary team of scientists. In MARDI the team comprises an agronomist, an economist, a sociologist and an animal scientist. However, researchers from other disciplines are co-opted when necessary. The team maintains close collaboration with the participant farmers in all phases of the research.

Objectives

The broad objective of MARDI's farming systems research is to improve the efficiency and productivity of the existing enterprises on the given farms, and to introduce additional enterprises where feasible, to enable the optimal utilisation of farm resources, particularly land and labour, and thereby increase farm income.

Specifically the objectives are to:

(i) Understand the existing farming systems and the rationale underlying them;
(ii) Identify the objectives, goals, and motivation of farmers in their decision-making;
(iii) Identify the technical, social and economic constraints to increased productivity of the existing systems; and
(iv) Evaluate alternate systems and practices which would enable the optimal utilisation of available resources and which have a likelihood of being adopted by the farmers.

Methodology

Due to the varied understanding and interpretations of the concept of farming systems and consequently farming systems research itself, there have been various methodologies used in the conduct of this area of research. At MARDI the following approach has been adopted.

AREA IDENTIFICATION

In selecting the possible areas for FSR, several criteria are used. These criteria include low farm productivity and income, low level of technology adoption and good potential for increasing farming intensity.

AGROECONOMIC PROFILE OF THE AREA

Following the identification of the area, a survey is carried out to identify the agroeconomic profile of the area. This survey involves discussions with village leaders, extension agents, farmer groups and observations on the farming environment. Information collected is integrated to construct a composite picture of the agroeconomic situation of the area, focusing on existing farming systems, constraints to increasing productivity and possible areas for improvement and/or expansion.

SELECTION OF FARMERS

The agroeconomic profile forms the basis for selecting farmers to participate in the FSR project. The farmers in the selected area are fully briefed on the objectives of the research to be undertaken and are made fully aware of the duration and magnitude of their involvement in the project. Only those farmers who have the capacity and show keen interest are selected.

In selecting the farmers, we give preference to groups of farms that are contiguous. This helps management of the project as well as the undertaking of group enterprises, if and when opportunities for such enterprises exist. Moreover, a contiguous area for FSR raises the visibility of the results and aids marketing of the products from the project.

SOCIOECONOMIC SURVEY

A socioeconomic survey is then undertaken to gather detailed information on the selected farmers, their farms and the agronomic and socioeconomic environments. Among the data collected are those pertaining to farmers' age, level of education, number in household, resource availabilty and patterns of utilisation (particularly labour), existing enterprises, management and cultural practices, sources of income, marketing practices and their attitudes towards increasing farm productivity and income.

The results of the socioeconomic survey are used to identify possible research activities to be undertaken as well as provide a bench mark to be used for gauging the performance and impact of the research project over time.

SELECTING THE PROGRAM

The results of the socioeconomic survey and the identified possible research activities are discussed with the farmers to sensitise them to the types of research activities that could be undertaken and get their response, agreement, commitment and cooperation in the activities to be undertaken. This is considered a very essential step in FSR.

The identification of the research activities is followed by their listing in terms of priorities by both the researchers and the farmers. At this stage, the participant farmers are made fully aware of the division of farmer-researcher responsibility, i.e. what the researchers are expected to do and what is expected of the farmers themselves. A clear notion and acceptance of this division of responsibility is essential in order to avoid any researcher-farmer frictions that might arise later and adversely affect implementation of the project.

DEVELOPING WORK PLAN

A detailed work plan is drawn up jointly by the researchers and farmers. This plan emphasises the following aspects:

(i) Physical coverage of activities — whether the activities to be undertaken cover the whole farm or portion of it;
(ii) Scheduling of activities;
(iii) Specifying the types, amount, time and sources of the required inputs; and
(iv) Activity cost estimates and financial responsibility — what costs are to be borne by the researchers and what costs are to be met by the farmers.

IMPLEMENTATION AND MONITORING

During project implementation, constant farmer-researcher interactions are of the utmost importance in order to ensure that any problems encountered during implementation are quickly resolved. The constant interactions will also facilitate modifications to the work plan if this becomes necessary.

Monitoring of the research activities is undertaken to assess the progress and problems of the project. A farm record-keeping format is prepared for the farmers with the help and guidance of the researchers. The farm record-keeping exercise is undertaken on a daily basis to gather and analyse such data as each participant farmer's daily farm expenses and receipts, and the pattern of labour utilisation for farm, off-farm and non-farm activities. These data indicate changes occurring as a result of participation in FSR. They also enable each farmer and the researchers to determine the enterprises or combination of enterprises best suited to that farm.

FSR Pilot Projects

FSR pilot projects are currently being undertaken in four areas, two of which are rice-based systems while the other two are coconut-based. The project areas cover 16-60 ha, involving 22–32 farmers.

Each of these areas generally goes through the following phases:

(i) Detailed socioeconomic survey of the area;
(ii) Improving productivity of the main crop;
(iii) Improving productivity of minor crop components;
(iv) Introduction of additional crop/livestock enterprises;
(v) Planting of economic crops around the homestead, e.g fruits and vegetables; and
(vi) Introduction of small scale agro-based industries to process available agricultural produce in the area.

Each of these projects is at a different phase. However, since FSR was only initiated in 1982, none has gone beyond phase (iv).

In the coconut-cocoa areas, research pertains to shade requirements of the cocoa plants, fertiliser and liming studies, pruning and clonal improvement of the cocoa stand through mature-budding. Additional enterprises being tested are vegetable production, poultry rearing, and apiculture.

In the rice-based project areas, agroeconomic studies on the production of upland crops in rotation with rice are carried out. Upland crops include vegetables, groundnuts, tobacco and watermelons. These studies are additional to those directed at improving the paddy crop itself through varietal and cultural improvements.

Conclusion

This paper briefly discusses MARDI's limited 3-year experience in farming systems research. It is based on MARDI's own interpretation and understanding of the concepts of farming systems and FSR. It must be admitted that since FSR is a relatively new field, MARDI, perhaps like many other research institutions, is still groping in the dark as to these concepts as well as to *the* methodology to be adopted. It is fervently hoped that this FSR workshop will result in a clearer and more unified understanding of the concept and methodology of FSR.

Farming Systems Research in Thailand

D. Chandrapanya*, Ed B. Pantastico**, P. Suwanjinda**, N. Thaipanich**

THIS paper is a consolidation of our experience in conducting research in farming systems in Thailand. It includes some past failure and some of our promising results. However, research on farming systems is barely off the ground. Hence, in this paper we review our approach to farming systems research (FSR) and how we feel this may help our farmers (Pantastico 1984, FAO/RAPA 1982).

For more than a decade now, our group has been cooperating with the International Rice Research Institute (IRRI), doing rice varietal testing as a part of the Asian network. We worked at research stations and on farms. This highlighted several questions to which we had no ready answers. These questions included: Which farms are supposed to benefit from our work? Can the farmers live by rice alone? Can our rice-breeding program solve most of the problems of our small farmers?

Our subsequent enquiries showed that we had been helping only 20% of our farmers who happened to be in irrigated areas, and neglecting the other 80%. We found that our rice growers also depend on a variety of other crops, such as field crops, vegetables and fruit, fish from small canals, pigs and chickens. We discovered that we need disciplines other than agromony and animal husbandry to help our small farmers.

Hitherto, no single Institute, Division or Department in the Ministry of Agriculture and Cooperatives was organised to answer these problems. And so in late 1982 the Farming Systems Research Institute (FSRI) was born. The Institute has responsibility for work on crops other than those covered by the existing Institutes (i.e field crops, rice, horticulture, rubber and sericulture). It can also conduct livestock and fish research, as it relates to crops or cropping systems.

Early FSR in Thailand

Our first involvement in FSR started in the late 1960s when the (then) Technical Division of the Rice Department began field testing 'packages of technology.' These were essentially combinations of new rice-growing practices. In 1974, the International Development Research Centre (IDRC) provided grants for cropping systems research. The research was rice based but we tried to intercrop or relay crop some annual legumes. In 1976, IRRI set up the Asian network on pilot production, during which we began to assess the costs and returns of the programs.

It was also during this period (1972) that the FAO Regional Conference on Asia and the Pacific reviewed the problems of rainfed agriculture in the region. The diversity of agroecological zones occupied by rainfed agriculture was recognised, each zone requiring location-specific technology to overcome its problems. Our Soil Science Division was heavily involved in this discussion.

As a result, the scope of our work was progressively enlarged from cropping systems to farming systems, encompassing crops, fish and livestock in an integrated holistic approach.

Our Present Strategies in FSR

FSRI has employed four stages in its work. The first we call an Area Based System during which the target area is defined in terms of soils, climate, cropping system employed, and range of on-farm trials that could be undertaken. As a result, we build up a picture of the agroecological zones across the country and their relative stability in terms of yield and crop. In this way we seek to determine the environmental limits and range of agronomic options open in any given location.

The second approach homes in on the principal crop in the smallholder's farming enterprise. Our aim is to build up a sufficiently detailed picture of the crop-based system that prevails to enable constraints to be identified and the crop-based

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infrastructure (i.e. supply of inputs, marketing, processing, government controls) to be examined. In the main, we have found most in Thailand to be rice-centred, despite the variety of crops grown by smallholders. As a result, of the hundreds of experiments conducted by FSRI in any given year, the majority are rice based. Some examples of non-rice based experiments currently being undertaken by FSRI are:

(1) Cassava-based cropping pattern trials in farmers' fields at Mahasarakham;
(2) Soybean intercropping with upland rice at Chiang Mai;
(3) Sugarcane-based intercropping with peanut and mungbean;
(4) Intercropping upland crops with young rubber trees at Nakhon Sri Thammarat; and
(5) Highland rice cropping for opium substitution.

The third strategy recognises that most farmers in Thailand have one kind of animal or another as part of their farm enterprise. It is essential, therefore, to conduct FSR experiments that we describe simply as 'crop-livestock integrations' into a livestock-based system. We restrict our attention to smallholders, not big commercial farms. Our aim is to develop domestic markets for crops (such as cassava and coarse grains) that could support increased domestic livestock production, and to encourage more efficient utilisation of Thailand's abundant supply of crop by-products, especially rice straw, sugarcane tops, and bagasse. In some regions, especially the semi-arid parts of Thailand, livestock could also increase the certainty of livelihood by utilising drought-tolerant grasses and fast-maturing legumes. In other regions, livestock-based systems will place greater emphasis on the opportunity to incorporate fish rearing into the system.

The fourth type of FSR is the most difficult. It is the multidisciplinary, agricultural systems approach, in which we attempt to cast off our narrow professional biases in agronomy, soils, plant breeding or whatever, and inquire how we might improve the overall situation of the farm family. Agricultural economists love this kind of approach because their focus is on improving the income of the farmers, but even their contribution is only one piece in the puzzle. In order to ensure our ability to be relevant to the farmer, we have found it necessary to go beyond the individual in agricultural systems approach and to adopt a multidisciplinary team approach to FSR. We are still at an early stage in this process and have only one team project launched — the 'whole farm approach at Mae Jai'. The project involves a team of eleven and their objective is to raise the income of eight target farms in Mae Jai. The result is expected to involve an integrated crop-livestock system. The project involves what we describe as 'research on development at farm level' (Chudleigh 1984).

Some Selected Achievements

Trials with jute-rice cropping systems at Mahasarakham in the Northeast Region of Thailand indicate the possibility of growing jute before the main rice crop in the low-lying area under rainfed conditions. A planning exercise in connection with field trials on farms showed that planting jute before rice (low or high input) can improve the gross margin. Further multi-location trials covering a wider area with the same agro-climatic conditions and land type will be launched to prove the suitability of the system before expanding the program for extension to farmers. Support services are needed, including extension services, finance and a supply of production inputs (Chandrapanya 1983.)

Another new system, of growing mungbean before low or high input rice under rainfed conditions in Phayao (Northern Region) may soon be widely adopted. From field trials over the last 3 years we conclude that mungbean can be planted in late April or early May, utilising the early monsoon rains, and be harvested before the main rice season begins. Again, our calculations show that gross margins will be improved. However, we need special early mungbean varieties possessing even maturity to fit the length of the early period of the wet season, to fully exploit the technology. A multi-location test of the system is required, and support services must be provided to permit adoption of the technology.

Some Lessons From Our FSR

Sampling Problems

Our economist friends are quick to remind us that 'if your samples are wrong, your experiments also are wrong.' However, it is not easy to identify 'representative farmers' and to get their commitment as cooperators. In our on-farm trials, we choose our cooperators at random from a list of families in the target village. Our budget allows only 10 cooperators per village. Cooperators receive seeds, fertiliser and chemicals and they get all the harvest. When we go to the village to explain the trials, the village headman usually calls a meeting of prospective cooperators. Then come the problems: cooperator no. 1 is sick, cooperator no. 2 is in the field, cooperator no. 3 simply does not like to come. We end up explaining our technology to a dozen or so women and a lot of noisy but curious children. One housewife commented 'If you are going to give us free fertiliser and chemicals, I will ask my husband to be your cooperator.'

Whose objectives?

Although we have an agreed objective, which is usually 'to improve the income of farmers using our technology,' when we cooperate with a number of people, from extension workers to local farmer leaders, politicians, bankers and private companies, that objective is usually lost. One can easily feel the superimposed objective of the agency, of the company, of the party or simply of the individual.

To narrow down but not to remove these superimposed objectives needs a great of effort among our FSR leaders. An example is the project that involves introducing fast-growing hybrid animals in on-farm trials. Perhaps selected local breeds will stand a better chance of a successful integration with crops and crop by-products, but the pressure is to be 'modern' and try the hybrids favoured by distributors and commercial importers.

Balanced Nutrition for Animals

When we try to integrate crops with livestock, the farmers tend to think the animals will settle for crop by-products and left-over human food. That has been their experience. When we explain that the livestock need vitamins and minerals, they cannot understand. They cannot afford such supplements for their children, so why should the pigs have them?

Planning of Integration

In implementing FSR, we have to do a lot of planning with participating local agencies, especially when the project is externally funded. While it is good to plan together before starting work, there are drawbacks. Each agency would like to have an equal share of the fund, which when finally allocated may amount to little more than a hand-out. Equal budgets imply an equal share in responsibility, and an equal share in accountability; however, too often, equal shares means *no accountability at all.* This can adversely affect the project and its objectives.

On the other hand, when we present to the participating agencies a master plan with a budget based on the contribution of activities, we usually get skin and bones but no meat. Maybe a better approach is to study the interests of the participating agency and see if the project objectives are compatible. If not, another agency, even a lesser one, may be preferable. In the national system this needs a considerable amount of explaining.

Workload on Research Staff

In a team approach, the lead agency bears the heavy burden of implementing FSR, even if the funds are shared equally between participating agencies. In Thailand it is not easy to hire new staff for a specific project. Most of the time, new projects are an additional burden on researchers. They are not given incentives to take up the additional work. Hence, we have to struggle to find researchers whose regular assignments coincide with the new responsibility. In this way the additional work can be credited to their main function. This is easier said than done.

Conditions for Success

The expansion of direct seeding of rice at Dok Kamtai, Phayao, is a good example for the successful transfer of technology. We started with six farmer cooperators in 1982 and by 1984 we had more than 100, with an area of about 160 ha (Sirisup 1984). Some of the contributing factors were:

(1) We had a good research leader who likes to associate with farmers; he is highly motivated and very receptive to new ideas;
(2) The mechanical seeder used in direct seeding saves labour in planting. We identified labour as a major constraint in traditional rice cultivation;
(3) The extension workers were enthusiastic, even replicating our trials before we asked;
(4) The Provincial Governor of Phayao assumed responsibility for the project;
(5) The Chief of the local Rice Station pushed to make the project a success;

(6) The new technology is agroclimatically and socioeconomically suited to the area;

(7) The farmers are actually looking for alternative technology in rice cultivation because of many past failures.

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Farming Systems Research in South Asia

R. N. Byron*

THIS paper must begin with a serious disclaimer. I am not an expert in FSR anywhere, and certainly not throughout South Asia. As is the customary procedure in such instances, I shall re-interpret the assigned topic in such a broad way that I can offer some personal views and observations about the state of FSR in parts of South Asia, and the relevance of Australian expertise to that matter.

I must explain the origins of my limited observations as a key to the biases they contain. I have recently spent almost 3 years in Bangladesh as Project Coordinator of an FAO/UNDP/ Planning Commission of Bangladesh Forestry Sector Planning Project. In the process of preparing a 5-year Sector Plan for Agriculture (including Forestry, Fisheries and Livestock as well as Crops) it was realised that over 80% of all forest products consumed in Bangladesh were produced from the homestead gardens (and most were consumed) in the villages. This immensely valuable resource was being rather skillfully managed by over 10 million peasant farmers and their families, without any government recognition or assistance (technical or financial) but faced serious pressures and seemed headed for severe depletion, for a variety of demographic and economic reasons beyond the individual farmer's control.

In the process of devising a strategy to support and extend indigenous tree-husbandry practices, I was co-opted by the Secretary of Agriculture as part of a multidisciplinary think-tank to re-evaluate all the major issues and options for agricultural development in Bangladesh. Hence my introduction to farming systems research (FSR) was when the Secretary was told by the Bangladesh Agricultural Research Council that FSR was a must and he asked his advisors what FSR was, had it worked anywhere else in the region and could it help Bangladesh Agriculture?

I shall apologise in advance for the emphasis on Bangladesh, but will try to incorporate observations from India, Sri Lanka and Nepal where relevant, and the rest of my comments will have, I hope, rather general applicability.

What is FSR?

It would be extremely arrogant and redundant for me to define FSR halfway through this conference, but I refer you to the statement in the ACIAR background to this meeting: a more holistic approach: one that seeks to harness the strengths of existing farmer practices and methods to ensure that productivity gains are stable, broadly distributed, environmentally acceptable and achieved at reasonable cost to farmers and society at large.

However, my understanding of the term has a slightly different emphasis. Conducting research into integrated systems of farm management seems to me a very useful step forward from broad-acre, mono-crop research, and even cropping systems research and basic multi-cropping. In the Bangladesh context, it seems infinitely more useful to farmers than 19 independent (non-cooperating) agricultural research institutes (sugar, rice, wheat, tobacco, tea, forests, etc.) with 19 different, independent extension services.

But I think that more important than the administrative reorganisation of research and extension that follows the introduction of FSR, even more important than the concept of a farming system, is the implicit recognition it gives to the fact that even 'dirty, illiterate barefoot' peasant farmers are extremely competent professional land managers. After all South Asian farmers have been operating farming systems for centuries and, although they do not conduct replicated trials analysed statistically by computers, there is a very substantial body of indigenous technical knowledge, which has been passed on and refined over generations. Thus one

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of the first questions I ask myself is whether FSR is just a case of western 'experts' rediscovering a wheel that Asian farmers have used for centuries. Is it just a trendy term permitting donors to off-load vast quantities of loans and grants and expatriate agricultural experts while basically offering more business as usual, or can FSR really help farmers, and if so, which farmers? It seems to me that the application in South Asia of this concept (like a lot of extension work also) has been a response to the supplier's needs and perceptions, rather than a response to farmers' requests for additional technical knowledge.

Thus the optimists' interpretation of FSR is that it is genuinely aimed at improving delivery of better farming practices to assist those in need. The pessimists' interpretation is that it has been invented to divert attention away from the poor results of technical (component) research in application so far, by promising a new better order. I am an optimist.

The Small Farmer as a Professional

If I am allowed one anecdote to illustrate my assertion of small farmers as professional land managers, utilising their indigenous technological knowledge efficiently in response to the total environment, it would be this. A modest Bangladeshi farmer, not at all well-off by his village standard, but holding his own financially (quite an accomplishment per se), owned almost 1 ha, which was fragmented into 17 dispersed plots within 3 km of his (bamboo/thatch) homestead. While many expatriate agriculturalists might immediately curse Muslim inheritance laws for this chaos and recipe for disaster, in this farmer's situation it represented great opportunites. On his 17 plots he cultivated up to 12 different cash and subsistence crops — some plots were flooded/irrigable/dry; they were on varying soil types, etc. Not only was he matching each site to the crop best suited to it, but he was exceptionally diversified against market risk and price fluctuations, and furthermore against the horrendous climatic unpredictabilities. His labour input was staggered, the draught-power required for ploughing from his two small milking cows was staggered, fertiliser inputs were minimised by rotation with leguminous crops, etc. Each plot produced three, occasionally four crops per year. The system he managed also included goats, chickens, ducks, fish, fruit + fodder + firewood trees and medicinal plants. It seems to have been very stable, productive and well-balanced, and had been achieved without (or in spite of) official government agricultural extension or assistance. I defy anybody to do better with 1 ha and a linear programming model, given the relative prices, input constraints, etc. that the farmer faced.

Numerous similar anecdotes could be told from my work on tree husbandry in the villages, and from many other fields, but the main point is the existence of indigenous know-how. I have met only a few agricultural scientists and extension officers in South Asia who really understand much at all about how and why farmers do what they do — most are urban and middle class. Many of these experts are 'boys' when it comes to helping farmers improve yields of net incomes, and I suspect many expatriate experts are further behind.

Is it not possible that the potential gains from bringing more/all farmers up to the standard of the current best known farming practices could be even greater than those of expanding the frontiers of knowledge with western science, for the benefit of the few who have access to it?

Another anecdote illustrative of farmer rationality, misunderstood by experts, partially explains the widespread 'failure' (or refusal) of peasant farmers in Bangladesh to adopt proven Green Revolution techniques that could take a paddy yield from 1.2 t/ha to more than 5 t/ha. While a great deal of effort was focused on giving farmers access to water, credit, fertiliser and seed (on the assumption that these were the constraints) less regard was paid to farmers' attitudes to risk. While nobody denied that the new technology certainly worked, and was economically very attractive (even at the very high input prices most farmers still faced) in a normal year, many Bengali farmers who declined to adopt it said they could not remember when they last had a normal year. It was always floods or droughts, early or late monsoons, etc. and few were willing to risk all by mortgaging their only asset, land, in the hope of a lucrative normal year. Futhermore, about 60% of Bangladeshi farm land is cultivated by share-farmers, and the basis of their tenancy is that the share-farmer pays all input costs and receives 50% of the harvest. This type of arrangement certainly discourages any intensive techniques, but given the relative availabilities and prices of farm land and farm labour, the Government has been unable to modify the long-standing share arrangements.

I have not come across any farmers, in any of the four countries of South Asia I worked in or visited, who did *not* want to learn more, who were not interested in new technical knowledge. I met thousands who felt they could not afford to innovate and risk everything, and some who could and earned handsome quasi-rents on many occasions. But I suspect that all farmers are very quick to switch-off when some 'fancy city boy' starts talking garbage, because he doesn't understand what the farmer does or why. All the stupid peasant farmers in Bangladesh are already dead — long ago! The survivors manage by constantly juggling scarce resources, looking for new opportunities and responding to expected prices and input costs. Farmers are very efficient users of very scarce resources, and of their known (considerable) technology. Thus the real trick of FSR and extension, is to understand the indigenous system, and then use the external knowledge, imagination and lateral thinking to *graft* a new component onto the system, increasing incomes without overstraining resources.

But to do this, we must recognise all the determinants of the system, and that there are many social cultural and institutional factors that affect farmers' decisions, over and above biological factors and relative prices. ACIAR's charter for the transfer of scientific skills reflects and incorporates the biologist's/engineer's/technocrat's perspective of the causes of underdevelopment and the appropriate remedies. Social anthropologists or political scientists have a very different set of concerns, explanations and remedies, viz., power structures or who gets what and why, rather than increasing production or changing relative prices.

If one accepts that every discipline has something useful to offer to FSR, from their various perspectives of the determinants of farmers' decisions, then the system under study becomes much wider than biology, soils and agriculture, or input costs and market prices, but includes a total set of influences. Hence professionals from the Indian Institute of Management at Bangalore who deal with FSR and land-use planning call themselves socioecologists, and elsewhere we find agro-socioeconomic surveys (Hildebrand 1980).

This wider set of concerns includes: the *homestead* as part of the farm system, e.g. there is evidence of tree cultivation in support of agriculture, and fruit and vegetables are managed to seasonally complement the nutrition from field crops; *women* are frequently co-managers of the farming system. Even in apparently male-dominated societies, we know that farmers' wives have a major say in selecting which crops will be cultivated in which fields, though the men usually do the actual work. It is women who select and separate seed rice from rice for cooking, who germinate, plant and protect tree seedlings, who manage the goats, chickens and children (each of which interact with her tree husbandry activities); who produce fruit and vegetables for sale or barter and for improved family nutrition and hence productivity, and so on. Thus, all factors that affect farm home and the farm family also interact with the rest of the farming system. Cultivation of farm crops is not a discrete, independent activity.

Not only should FSR tackle the entire set of factors influencing the household/farm management system, but the extension service should be equally comprehensive. My experience has been that when South Asian farmers find agricultural extension workers who seem to know what they are talking about, the farmer will not only ask for and accept advice on crops, but also on trees, livestock, etc. and invariably this will lead to questions of access to credit or water supply, and eventually to nutrition, health, hygiene and family planning. My point is that what seem to us to be discrete topics for individual specialisation, are all synthesised and mutually interdependent to the small farmer and his household.

Status of FSR in South Asia

Again it would be absurd for me to present a list of projects, research trial locations and results here. I would prefer to comment on the structure of what is done and how that affects the prospects of success. By success I mean an increase in real living standards for farmers of all socioeconomic groups as a result of the application of the new knowledge so gained, not the gaining of knowledge per se nor the employment of expatriate consultants, the construction of a new building or creation of new bureaucratic empire, even though these are all terribly important to many of the people involved in FSR.

From my view of farming in South Asia, it would be imperative even just to know where to begin one's FSR, to stop, observe, listen and learn from the farmer, how and why he manages his integrated farm/homestead/garden unit in certain ways; what economic and social forces he responds to and what he perceives as his major constraints. Yet how often, if at all, has socioeconomic research or monitoring over a number of seasons preceded technical assistance projects?

FSR thus needs to be diverse, flexible and localised, to respond to local needs and opportunities, but the administrative structures established to conduct FSR in South Asia generally are centralised and rigid, ideas move down from the top of bureaucracy but rarely upwards, and many of the ideas and research topics are what interests or serves the needs of the researcher, not the farmers. The work done by non-disciplinary generalists rarely has the respect and status of finely-focused, intensive specialised research within one discipline, partly because the former is so location-specific to agro-socioeconomic conditions.

Government officials and aid experts usually have a very patronising view of farmers on the sub-continent, as if the benevolent dictator in headquarters must tell the farmer what is good for him. Yet this is despite overwhelming evidence from so many centres, in so many respects, that farmers do innovate, and can be very aggressive and quick in responding to new opportunities, frequently opportunities that never occurred to the experts (Brammer 1980). When the extension experts talk about the need to motivate farmers to adopt new technology, that is usually a clear signal that the technology package they are trying to sell is inappropriate.

Those who have been working on FSR in India report significant advances — at least in terms of multi-cropping two or more field crops, and in the socioeconomic dimensions I have referred to. There is considerably more work in pulses and goats, for example, in a systems context, than 5 to 10 years ago. I do not know whether this is also true in parts of Pakistan, but in Bangladesh, Nepal and Sri Lanka, there is very little evidence of FSR at all.

Even where it is under discussion, that discussion is often only up to cropping systems level. The Bangladesh Agricultural Research Council advised that 'only 30% of farmers own big enough holdings to be able to respond to improved technology, the rest are too poor or are absentee landlords, not interested in investing' (BARC 1984). The implication of this statement is that there is only one improved technology to be offered. If socioeconomic conditions preclude its acceptance, bad luck! Obviously the idea of appropriate research for small farmers has not filtered through yet, and their research has been oriented towards another type of farmer.

Underpinning much of the discussion of FSR in South Asia, has been the liberal democratic tradition of 'tinkering' or gradualist adjustment, adapting research (and other government assistance) to moderate the effects of inequality and social constraints, as opposed to the radical philosophy of removing the cause. While many agriculturalists and economists I met equate increased agricultural productivity with increased welfare, I am not interested at all in productivity per se *unless* it contributes to improvement in the quality of life of the rural household. The example of share-cropping quoted above suggests it may be essential to overcome inequities in the society (land reform, access to credit, water, etc.) *before widespread and self-sustaining increases* in production can occur. In many of the countries in which increases in agricultural productivity occurred under conditions of relative scarcity (not the pioneering, staple-export model) such as Japan, Korea and Taiwan, there were major and radical reforms of rural power and resource allocation. It could be argued that if FSR is not at least partly concerned with redirecting the means of production or enhancing those of selected groups, very little may be achieved.

Australia's Potential Contribution

There is no question that Australia has immense agricultural expertise. However, in view of ACIAR's emphasis on FSR as *multidisciplinary*, the transfer of technology to *small farmers* in the humid and semi-arid tropical developing countries and the recognition that this technology is rarely scale-neutral, let us consider carefully what Australian agricultural research has to offer subsistence and smallholder cash cropping in rural South Asia.

Australian scientific knowledge tends to be very compartmentalised, where specialists in the cultivation of different crops rarely interact. Entomologists, geneticists and nutritionists working on the same crop may not interact. While Australia has recently acquired technical expertise in *Cajanus cajan* and *Sesbania bispinosa*, and there is a wealth of experience in eucalypt cultivation, for example, in each instance the Australian experience is with broad scale monocultures with minimal labour input. The development of Australian agriculture has exploited economies of specialisation, which exist by reason of the structure of our society and economy. For example, multi-cropping is often too labour-intensive to be viable; mechanised harvesting is suited to (and requires) large farming units. Because so many of the underlying features in South Asia are the opposite to Australia's, it would be remarkable if agriculture developed in identical directions in both.

In Australia, crops and livestock are not interdependent as in South Asia, because we don't use draught cattle, and rarely apply manure to the field crops. Cattle in South Asia have to be dual (or multi-) purpose. While principles of animal health and nutrition are universal, I imagine the husbandry practices for producing tender beef differ considerably from those where lack of draught power is becoming a major constraint on agricultural intensification. Virtually no research into the role of goats in farming systems has been conducted, here or in South Asia, because scientists seem to be biased against them. While goats can produce excellent milk and liveweight gains, breed easily and well, scavenge and help recycling around the farm, in Australia we find fences are too expensive or the market is too thin. Yet in South Asia, fences are unnecessary (either children with jute rope, or 'social fencing' are more effective) and goat mutton is extremely desirable. Is anybody in Australia working on micro-farming of guinea pigs or rabbits, for example, or the philosophy of very small livestock for very small farmers?

Poultry research has been concentrated, here and in Asia, on big poultry farms; centralised with commercial inputs of protein/meal/ multivitamins, etc. with apparently little regard to the relative cost effectiveness of free range chickens and ducks within the small-scale Asian farming system, e.g. the contribution of ducks to the control of snails in paddy fields.

I look forward to meeting an Australian scientist working on a robust, cheap, fast-growing scavenging fish for the ponds and tanks of millions of South Asian homesteads, someone who can explain the fertilisation and feeding of the fish and its role in recycling within the farm ecosystem.

Even with the legendary Australian expertise in the use of eucalypt firewood, and the rural energy crisis of household fuel for cooking and warmth through much of South Asia, we have generally forgotten two important features of the role of trees within the farming system. First, while we visualise firewood as say 15-20 cm diameter (cut with a chainsaw and split with an axe) 90% of the *chulas* in South Asian households could not utilise that material. For them, cooking fuel is 2–5 cm diameter and cut with a machette or broken off by hand. Related to that, farmers virtually never plant a tree just for firewood — firewood is an essential and valuable by-product of fruit, fodder or timber trees, mainly from pruning and tops. Consequently, farmers (or their wives) will virtually never cut down a tree just for firewood, they will lop it heavily for fodder and fuel.

Minor by-products of cash crops, like jute sticks, rice and wheat straw, or bagasse are generally *not* minor in South Asia, but rather are valued as joint outputs, and may be crucial to the farm economy. There is virtually no single-product crop or animal in the farming system, yet this is so different from Australia where such 'by-products' can incur waste disposal costs. Agro-industries to generate employment and off-farm incomes can be based on intensive utilisation of by-products.

Summary

To summarise these comments, it seems to me that agriculturalists from outside Asia have much greater technical or scientific knowledge about individual farm crops or activities, but far less knowledge and expertise in intensive, integrated farming systems. Even if Australian scientists can develop an improved farming system (meaning greater productive and economic efficiency) without overstraining resources, would it be adopted? Will it fit into the small (or even large) farmer's complete context, as outlined above? When an Australian scientist or extension worker deals with an Australian farmer, most of the social, cultural and institutional factors influencing farm decision-making are shared mutually and understood. Yet when we talk to South Asian farmers, not only do we not understand these factors, but we probably do not know what they are. Even more dangerous is when we fail to even realise that these factors exist and are very different from ours. So we take with us into the field implicit and unspecified assumptions about farmers and their behaviour, including the basis of their decisions of what and how to cultivate. This point can be summarised as 'science is not practiced in a vacuum.'

The experience of improved wood stoves bears out this point. There are literally hundreds of designs for more efficient stoves in South Asia, all of which work in a technical sense but all virtually useless because they were developed entirely by experts in laboratories. The engineers and scientists were isolated from their clients, physically and socially, and so failed to realise, for example, that the stove would cost 6 months income, or would occupy half the floor-space of the dwelling, or would require purchased rather than scavenged fuel, or would not suit the style of cooking, the posture of the cook, the shape and material of the pots, etc. In contrast to the experts' assumption that 'stupid' peasants are profligate in their use of fuel, there is now overwhelming evidence of their overall efficiency in the use of all resources known and available to them.

Nor do economic axioms exist in isolation from society. When I was being taught about common property resources, certain features were described as axiomatic: over-exploitation, overly rapid exploitation and under-investment in conservation and management. While I still accept that these are all valid in a competitive society with a market or barter economy, they may simply not be applicable in a subsistence, cooperative society, where one harvests only what one family can eat. There is no point in over-exploitation if one cannot store, trade or use the excess.

Thus I suggest we all carry with us some intellectual baggage — a product of our society and culture — which influences what and how we observe, and react. Just as choosing appropriate technology requires going back to the basic underlying logic of why developed countries use capital-intensive techniques, to understand why developing countries should not, so finding appropriate institutions and conducting appropriate research involves comparing the basic premises and structures of western society, with those in the Third World.

My suggested agenda for FSR in South Asia requires, first, a change in researchers' attitudes — a willingness to learn from farmers. There needs to be a conscious elimination of some of our biases — which crops we find interesting to work on, which farmers we accept as being the clients of the research, which locations we work in, and so on. Finally, we have to learn to think outside disciplinary specialities, the way the client does, and consider his complete environment. I should add that a team of specialists from various disciplines is only likely to achieve FSR if they can work closely together and communicate to share understanding. A set of highly-focused pencil beams rarely gives broad illumination.

FSR, as we have defined and discussed it, has a very clear and explicit concern with equity, the focus being the quality of life and household income of the small farmers (hopefully not at the expense of non-farming households). Apart from the obvious humanitarian basis of a bias towards the poor, there is a strong argument on economic efficiency grounds. It is now widely accepted that greater food production in LDCs may have unexpected, adverse regressive effects, e.g. if prices fall due to higher yields, those who were unable to adopt Green Revolution technology may suffer considerably. Without additional effective demand for that product, the price and supply elasticities will frequently be such that all farmers end up worse off. Since income elasticities of demand flatten off fairly quickly along the income scale, then the best way to create effective demand is to generate income for the people with a high income elasticity of demand, the poor. Since most of these will be small farmers, our efforts should be concentrated there.

Finally, let us assume that we have developed an improved farming system as described above, as the product of (Australian assisted) truly multidisciplinary research, focused on improving the quality of life of the small farmer. To achieve the desired distributional impacts, requires that it was the target group's present farming system that was taken as the rootstock onto which to graft this improved package of technology. If the FSR is to benefit small farmers, it is *their* resources, constraints, knowledge and attitudes that must be the starting point for research. If we assume that the client of FSR has access to credit or can afford lumpy inputs (in terms of cost or duration), is healthy, is profit motivated, is not risk-averse, and has other attributes in common with farmers back home, the outcome will only be acceptable to such clients.

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from peasant farmers, and also Bob Chambers, who wrote the book while we were still talking about it.

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Farming Systems Research at the International Agricultural Research Centres and other International Groups

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FARMING systems research (FSR) is an activity of most of the International Agricultural Research Centres (IARCs) supported by the Consultative Group on International Agricultural Research (CGIAR). It is also a part of the programs of other regional and national research agencies. Expenditure on FSR in the IARCs now accounts for up to 10% of budgets of different IARCs, a total of US$10–15 million per year for CGIAR centres as a whole.

Only a few of the 13 IARCs undertake their own systems research without formal collaborative links with national agricultural research systems (NARSs). Collaborative work accounts for the major part of the overall IARC input to systems research. The systems research activities of the IARCs are diverse. They range from specific on-farm component research, to research station studies of radically new whole-farm technology packages, to support of regional training and research support networks for specific crops, and to providing advice to governments on the reorientation of their research institutions to achieve greater relevance and impact in their work. FSR at the IARCs has been reviewed twice within the last decade, first by Dillon et al. in 1978, and by Simmonds in 1984 as part of a global review of FSR. These reviews provide a wealth of details on methodological issues and on the systems-related activities of the centres.

Expenditures to date on FSR by NARSs have been largely ad hoc and on projects supported by outside donors. However, several NARSs have recently accepted large loans to restructure their research establishments to accommodate the institutionalisation of FSR into their programs.

Rwanda, Malawi and Senegal, for example, have recently received major loans from the World Bank to strengthen their national research organisation, which would include a system component. The effectiveness of these major changes is not yet known. Other countries are also considering restructuring their research systems to adopt the systems approach to research.

Some years will need to elapse before adoption of the 'new' approach can be shown to be relatively more effective than the traditional mode of research in addressing and solving farm production problems. For example, in Africa, CIMMYT has only recently finished its first in-country training course. While there is good reason for optimism, the design of the 'new' institutional models has drawn heavily upon the experiences and recommendations of the IARCs. However, because the IARCs and the NARSs are importantly different as regards resource endowments, objectives and operations, it is appropriate in this paper to highlight aspects of the IARC experiences as they affect the adoption of the systems approach by the NARS.

Simmonds' (1984) recent classification of FSR is a useful departure point for the discussion. This is followed by overviews of the FSR in progress at several IARCs and a resume of activities of 10 centres involved in FSR in Eastern and Southern Africa. The issues in adoption of FSR by the NARSs are then discussed.

Classification of FSR

The literature is increasingly convergent upon a definition of FSR. Also, while methodological differences exist across institutions and practitioners involved in FSR, there is sufficient commonality to suggest that future FSR will be concerned less with methodology development and more with the application of methodologies to greatest advantage in a particular context. Chambers and Ghildyal (1984) provide useful summaries of the different methodologies in use. The maturity of definitions and methodologies is

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largely attributable to authors such as Norman (1978), Dillon et al. (1978), Byerlee and Collinson (1980), Gilbert et al. (1980), Shaner et al. (1981), Hildebrand (1981), and Raintree and Young (1983), among others.

Drawing general conclusions about the transfer of the FSR experience of the IARCs to the NARSs requires grouping the diverse range of activities of the IARCs into a manageable number of classes. Simmonds identified three main types of FSR, distinguishable mainly by the usefulness of the activity in achieving production gains, and by the magnitudes of the changes necessary to existing farming systems (and agricultural policies) to enable adoption of innovations by farmers. His classification was as follows: (1) Farming systems research in the strict sense (FSRSS); (2) On-farm research with a farming system perspective (OFR/FSP); (3) New farming systems development (NFSD).

According to Simmonds, FSRSS is principally an academic activity and of little practical relevance to agricultural research. It is oriented towards description and analysis of farming systems and of acquiring an in-depth understanding of how they function. Simmonds contrasts this with OFR/FSP which he argues, and we agree, will be the main focus of FSR in the coming years. OFR/FSP is problem-oriented research that recognises that changes to farming systems must be adapted to the circumstances of the intended users of the changes. Furthermore, it recognises that on-station experimental results have matched poorly with the results obtained by farmers using the 'same' packages of changes. OFR/FSP also stresses the incremental nature of changes to farming systems rather than revolutionary changes. The majority of FSR to date can best be classified as OFR/FSP.

Simmonds' third class, NFSD, concerns FSR where radically different systems are conceived. tested and implemented. While the distinction between OFR/FSP and NFSD may often not be clear, it is useful to classify NFSD separately as it highlights the need that in many farming systems, at least in Africa, only radical changes to existing systems will enable even the basic food needs of future generations to be satisfied.

FSR in IARCs and Elsewhere

Some Examples

The Green Revolution effectively raised rice and wheat yields per hectare within the space of a decade, largely by exploiting genotype-environment interactions. Those successes have not been followed by similar yield increases in other important food crops. Despite the best efforts of agricultural researchers, many of the innovations they tested on-station were not being adopted by farmers. Generally the reason for non-adoption was that the innovations were not suited to the need and circumstances of the farmers for whom they were intended.

As a consequence, it was concluded by many observers of agricultural development that the research-push approach to change which characterised the Green Revolution would need to be modified radically for agricultural research to have the impact on production so urgently needed in many parts of the world. These considerations were major stimuli to the expansion of FSR activities in the IARCs.

The International Rice Research Institute (IRRI) and the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), as leading institutions in the making of the Green Revolution, recognised early on that their limited resources did not allow their active involvement in more than a token number of different farming systems. Partly for this reason both institutions quickly developed collaborative links with NARSs in Central America, Eastern Africa and Southeast Asia, to extend their technologies.

They also recognised explicitly that their technologies had to be tailored to local farm conditions to favour adoption. For this reason and because of the shortage of researchers skilled in the application of FSR methodologies, both institutions highlighted the training of national program staff in their collaborative work with the NARSs. Both institutions established and now lead regional research networks aiding the delivery of their technologies in these regions.

As a result of their prior research, CIMMYT and IRRI were able to offer network collaborators a range of innovations for testing under local conditions. This, combined with extensive knowledge of the conditions applying throughout their respective target regions, meant that they had innovations adaptable to most farmers' circumstances within a relatively short time. This collaborative research model has been shown to be a practical and efficient means of delivering new technologies to farmers. It has also greatly enhanced the effectiveness of the research programs in both centres through the feedback of information from the network collaborators and outposted centre staff to the researchers in IRRI's and CIMMYT's core research programs.

Several new IARCs were established at approximately the time IRRI and CIMMYT were developing their OFR/FSP links with NARSs. This was some 15 years after both IRRI and CIMMYT began operations. By this time it was widely acknowledged in both the old and new centres that any technologies they developed would need to be adapted to local conditions in their mandate areas to have an impact on farm production. However, at the time of their establishment the new centres (for example, the International Livestock Centre for Africa (ILCA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the International Centre for Agricultural Research in the Dry Areas (ICARDA)), had only limited opportunities for collaborative OFR/FSP because they first had to develop and test new technologies and methodologies appropriate to their needs.

IRRI's experience was principally with high-yielding irrigated rice systems, and methodologies appropriate to those farming systems were not directly applicable to semi-arid rainfed farming systems or to livestock production systems in Africa. Furthermore, the national research systems in Southeast Asia were more advanced in most respects than those in Africa or west Asia. The general paucity of farm-level and regional-level data required the new centres to allocate substantial resources to identifying, classifying and describing their target systems.

ILCA, for example was established on the bold assumption that it could draw upon known technologies, assemble them into tested packages of innovations, and through early collaboration with NARSs, have these improvements made available quickly to farmers and pastoralists. ILCA's sub-Saharan mandate area includes arid, semi-arid, sub-humid, humid and tropical highland zones. Close examination of available knowledge showed that the research results available to that time did not lend themselves to widespread diffusion. Also, the descriptions of production systems in the different zones were inadequate to support the needs of technology design.

For these and other reasons ILCA was obliged in its first years to be concerned principally with systems description and problem diagnosis. Fewer resources than originally intended were committed to the design and testing of innovations. Furthermore, because the OFR/FSP methodologies available at the time originated with the crop research institutes, ILCA had to develop appraisal and testing methodologies for livestock systems.

Only in the last few years has ILCA directed substantial resources to component research which, when combined with the acquired knowledge of its target systems, will allow the results of that research to be diffused with confidence through collaborating NARSs. In support of this process, ILCA has initiated research networks on important production problems that will be the major vehicles for technology transfer via governments to farmers and pastoralists. ILCA has operational production-oriented networks on the utilisation of agricultural by-products and trypanotolerant livestock. It has also initiated a network on livestock policy issues for policy makers and administrators. OFR/FSP methodologies for dealing with livestock research have now been developed and tested at ILCA, and are now being made available to the NARSs of its mandate area.

Systems research at other centres began at an intermediate stage between those characterised by IRRI and ILCA. ICRISAT, for example, was able to draw heavily for its crop-breeding programs upon the long-term research results and systems knowledge produced by the Indian research system. In this way ICRISAT was able to provide new varieties well adapted to conditions in a range of situations in its mandate area — the semi-arid tropics — and in India especially. Conventional OFR/FSP methods have been an integral part of ICRISAT's approach in both South Asia and West Africa in the design and testing of its innovations.

ICRISAT had, however, to take a novel systems research approach when addressing the challenge of increasing the farm-level productivity of Vertisols, which are a key resource in its mandate area. The institute combined research station work at Hyderabad with parallel benchmark site studies at several locations in collaboration with NARSs, and with operational scale tests of new systems on farmers' fields. The selection of sites and technology packages for testing was backstopped by multi-year village-level studies. These latter studies provided comprehensive data on farm resources and production and allowed appraisal of constraints on and opportunities to increase production. The Vertisol research program at ICRISAT has many of the characteristics of NFSD, insofar as the production gains achievable and the resource use implications of farmers adopting the new technology package are substantially different from current practice. In summary, ICRISAT has had a 'conventional' OFR/FSP program and experience with NFSD. Strong links with NARSs are viewed by the institute as essential to transfer of the technologies it is developing.

The International Institute of Tropical Agriculture (IITA) provides the final example given here of systems research in the IARCs. NFSD had been a major part of IITA's systems research in the humid zones of West Africa where IITA has invested substantially in developing alley farming systems to allow sustained cropping on fragile tropical soils. ILCA has collaborated with IITA on the livestock aspects of the alley farming technology. Major changes to traditional land use and management will be needed to sustain the alley farming system. Some more years of research will be needed before the NFSD phase is completed, and before practicable, profitable farming systems are available that can be widely promoted through the NARSs for adoption by farmers.

These few examples illustrate the diverse FSR activities of the IARCs. Despite this diversity there is a strong agreement among the centres on the objectives of FSR and the most appropriate tasks to be undertaken to ensure efficient transfer of the centres' findings to farmers via the NARSs. The following section highlights the commonalities of objectives and approaches by reference to the activities of 10 IARC's working in Eastern and Southern Africa. (CIMMYT, ILCA, ICRISAT, IITA, and IRRI mentioned earlier, plus the Centro Internacional de Agricultura Tropical — CIAT, the Centro Internacional de la Papa — CIP, the International Food Policy Research Institute — IFPRI, and the International Laboratory for Research on Animal Diseases — ILRAD, and the International Service for National Agricultural Research — ISNAR).

A Summary of IARC Activities in Eastern and Southern Africa

An inter-centre consultation on OFR/FSP was held in Nairobi in October 1984 to report upon and examine the commonalities of their OFR/FSP strategies and activities in the Eastern and Southern African region. Clarification of these topics would facilitate collaboration with the NARSs of the region and identify activities where inter-centre linkages would aid the overall effectiveness of the centres' programs.

The major conclusions of the consultation with regards to OFR/FSP were as follows:

- That OFR offers an effective way to identify relevant solutions to important farmer problems;
- That OFR is most effective when it draws on and feeds back to experiment station research;
- That OFR offers great potential for linking research with extension;
- That effective OFR requires a systems perspective often involving a multi-commodity approach; and
- That the OFR approach can be used by national program researchers and that assistance to the national programs in this activity should have high priority.

Five main objectives of the systems-based OFR/FSP in the region were identified:

- Diagnosis of constraints relevant to the development of centres' technologies (CIAT, CIP, ICRISAT, IITA, IRRI, ILCA);
- Development of prototype technologies under farm conditions, often at benchmark sites, to meet centres' mandates (CIAT, ICRISAT, IITA, ILCA, IRRI);
- Methodology development and training of centre personnel (CIAT, IITA, ILCA, IRRI, ICRISAT);
- To test, monitor and understand adoption and adapt technologies to local situations (CIAT, CIP, ICRISAT, IITA, ILCA, IRRI); and
- Building up the capability of NARS personnel to do OFR for improved relevance in technology generation (CIAT, CIMMYT, CIP, ICRISAT, IITA, ILCA, IRRI, ISNAR).

The Eastern and Southern African region includes a complex range of farming systems, many of which are in need of urgent and dramatic improvement. To this extent, it is likely that a similar listing of objectives of FSR applies for other parts of the globe. Note here that all Centres in the Eastern and Southern African region identified the last objective of their involvement in systems research as their main goal, namely the urgency of building up NARS capacities to do OFR. What are the key factors impinging on achieving this objective? These are discussed in the following section.

Adoption of FSR by the NARSs: Some Issues

The adoption of the systems approach to research by several NARSs has already been noted. With few exceptions this has been done with outside funding. The discussion in this section is addressed to issues in the 'voluntary' adoption of the FSR approach by NARSs.

The IARCs are well supported with research funds compared with all but a few NARSs in developing countries. At this time, for example, several national research systems in Africa have over 90% of their research budget committed to staff salaries, leaving grossly inadequate sums for operations. Furthermore, many of these same countries tend to have highly centralised research structures and give minimal decision-making authority to outposted staff. As the essence of FSR is ability to identify and respond to farm-level problems, limited operational funds and centralised decision-making both militate against developing effective FSR programs. It is perhaps for these reasons that national program researchers seeking to work more closely with farmers in an FSR context are soliciting support for their research from bilateral and multilateral donors. In the short run this is understandable and appropriate. However, in the longer term these sources of funds will be inadequate and will not meet global needs for farmer-oriented research. Longer term funding for FSR will need to come from NARSs budgets.

There are substantial theoretical and practical difficulties of assessing the impact of FSR (see Anderson 1985). However, for NARSs to direct funds from traditional-type research to FSR-type activities, research managers and policy makers will need to be persuaded of the comparative merits ('impact' under another name) of such a reorientation. Unfortunately little definitive evidence is available to support such a change. At this time it is an article of faith that the FSR approach is worthy of expansion at the expense of traditional research.

Furthermore, special project support to FSR in the NARSs has often been for studies outside the mainstream activities of the NARS in which they are undertaken. For this reason, while they have been and are undoubtedly excellent training vehicles for national program research staff, they tend not to produce results to which research establishments can respond. In this regard the responsiveness of NARSs to the findings of FSR will depend directly upon formal, functional links between the FSR units and the overall research system of which they are a part, and between these units and extension service. To the extent that these links are necessary, special project work outside the formal institutional framework will reduce to FSRSS and be of little more than of academic interest.

In summary, it is argued that FSR must be institutionalised to be effective. The IARCs can assist in this process by providing case study material to favour adoption of the necessary institutional changes. ISNAR, through the reviews it has made of many NARSs in different parts of the world, has played a major role in creating awareness of the need for institutional change in the NARSs. Expanding networking activities of the IARCs in FSR will also provide important support for these changes. However, a note of caution is needed. The IARC system has invested substantial resources over almost a decade in FSR methodology development. Overall they staffed the field operations in these studies at levels higher than that possible in NARSs, given the latter's limited research resources. Furthermore, in many situations, the IARCs emphasised systems descriptions rather than design and testing of interventions to improve the target systems. This was especially the case where the centres were studying systems where limited information was available. While there has been substantial methodological development during that decade, for example in the form of rapid diagnostic survey techniques, replication of the centres' emphases on description would be inappropriate for the NARSs. FSR in the NARSs will need to be done using minimal research resources. Achieving a scaling down of inputs to FSR from the IARC models without diluting the impact of the research will be a major challenge. Both the crop and livestock institutes in the CGIAR system are now actively concerned with this issue. A useful discussion on this general topic of institutionalisation of FSR in the NARSs is given in Heinemann and Biggs (1985).

There is a strong consensus that most future FSR will be concerned with identifying and testing incremental improvements to existing farming systems, i.e. more concern with OFR/FSP than with NFSD, to use Simmonds' classification. Certainly this will be the case in national programs where it is impractical to expect usually conservative research systems to endorse proposals for 'risky' FSR. Risk is used here in the sense that the expected results may not be achieved even after major and long-term research investments. Furthermore, achieving quantum jumps in production tends to be associated with the application of more complex technology packages by farmers than technologies expected to provide only incremental gains in production. Together, these considerations favour the continuation of NFSD mainly in the context of the IARCs rather than the NARSs. IARCs can more readily accept the risk of 'failure' than the NARSs. NFSD will, for these reasons, tend to be expanded in the IARCs in the coming years. This will be especially the case in those centres serving regions where only substantial increases in agricultural production will enable even basic needs to be satisfied. The current food crisis in many African countries highlights the absolute need of developing new, stable and vastly more productive farming systems that will be adaptable by millions of resource-poor smallholder farmers. The lead time to conceptualise, design, test and extend radically new farming systems may well exceed a decade for some of the production systems urgently in need of improvement. The IARCs will play a central role in this task of NFSD.

NFSD contrasts with OFR/FSP in one important respect. OFR/FSP is done from the perspective that innovations are designed to fit farmers' socio-economic circumstances. NFSD assumes that the adoption of the new farming system will ordinarily require significant changes to the farmers' economic policy environment. The limited capacities (willingness?) of governments to make major and untested changes to agricultural policies to support adoption of novel farming systems will place a heavy burden of proof of the merits of the new farming systems upon those concerned with their development. NFSD, while supported and executed mainly by IARCs, will need to be done in close collaboration with NARSs in all phases of the research to facilitate the revisions to policy necessary to enable adoption by farmers.

Formal training in FSR is offered in several degree programs (undergraduate and postgraduate) in developing country teaching institutions. This training tends to focus on FSRSS and only limited opportunities are given to students to apply their skills to real-world problems. The IARCs have responded to this shortfall in training opportunities by having programs where developing country nationals can participate in the FSR undertaken at the Centres. IRRI, ICRISAT, ILCA, IITA and ICARDA all offer such training opportunities. Involvement of developing country trainees has ranged from attendance at short courses on particular topics to some years of field research required for doctoral studies. The IARCs also support regional training programs in FSR. A good example of work is the Eastern African FSR network led by CIMMYT. Here, CIMMYT supports regional workshops and training seminars, produces a regular newsletter and provides substantial leadership in crop-related FSR in the region. The activities of the network concentrate on maize production problems, but the interests of network participants are eclectic and livestock issues are increasingly being included in network activities.

The Future of FSR

The IARCs have played a leading role in the development and application of the farming systems approach to research. This has been complemented by the work of other international agencies. As a result of these collective efforts there is widespread awareness that the gains in production so necessary in developing countries will more likely be achieved by adopting the systems approach to research, rather than the traditional reductionist and discipline-oriented approach now entrenched in most developing country NARSs.

The FSR activities of international research institutes have been instrumental in inducing several NARSs to make major changes to the structure and functioning of their institutions. However, in most instances it has only been done with outside financial support. There are few cases where the systems approach has been adopted and institutionalised without such assistance. A conclusion that can be drawn from this apparent reluctance to modify existing institutions is that the evidence available to research managers and policy makers is not yet sufficiently compelling for them to risk making the necessary changes. The burden of proof that the changes are desirable will lie principally with the IARCs.

However, before the time when the FSR approach is widely adopted, the IARCs and other international agencies will continue to support the development of FSR in the NARSs through their networking activities and training programs. These will remain the areas of greatest involvement in FSR of the international institutes.

Some examples of new farming systems development research have been outlined. Incremental gains in production can only provide short-run solutions to the problems and needs of many farming systems and radically new farming systems will be an absolute necessity. Development and testing of those new systems will require research resources ordinarily beyond the capacities of individual NARSs which are also necessarily more concerned with immediate research problems. For these reasons, the development of new farming systems will remain mainly the responsibility of the international institutes, with inputs as needed by NARSs to test them for their appropriateness to their particular circumstances.

Lastly, the challenges to researchers to increase farm production and achieve equity in the distribution of these gains are great. In the past, most FSR has been undertaken with only faint concern about the policy environment in which farmers produce. Gains in production, as the efforts of the past decade have shown, will be progressively more difficult and expensive to achieve. If only for these reasons, FSR in its various forms and related policy studies are assured places in applied agricultural research for the forseeable future.

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Discussant's Report

Shankariah Chamala *

In the eight papers covering five countries presented at this session, (PNG, Indonesia, Philippines, Malaysia and Thailand), FSR was offered as an alternative method of developing technology to solve a multitude of small farmers' problems. The concept of FSR was not the same in each country, which reflects the fledgling models that are evolving side by side with classical research and development. Methodological and some institutional problems were critically analysed and graphically presented. *Byron* provided interesting observations on FSR in South Asia. His thought-provoking observations may surprise some economists when he says 'Science is not practised in a vacuum; nor do economic axioms exist in isolation from society.'

Anderson and Dillon presented a useful summary of voluminous works on FSR at the international centres (IARCs). They argued that FSR must be institutionalised into national agricultural research systems (NARS), and the international centres can assist in the adoption of necessary institutional changes. They also suggest that IARCs should concentrate on research into new farming systems, while the NARSs must be concerned with on-farm research.

Descriptive/Diagnostic Stage

Quite a few papers covered this stage and clearly documented the problems of past research or lessons learned. I have extracted some statements that reflect the problems encountered:

- 'Where component improvements have been developed they have rarely been based on any systematic prior assessment of grower practices, resource endowments or market opportunities — lack of analysis of off-farm influences, such as inter-group-intra-group links, which feature reciprocal gift-giving, and improvement of non-market influences on production behaviour in most social groups' (PNG, *Carrad and Bourke*).
- The first weakness in the implementation of the FSR procedures is problem formulation (Indonesia, *Sabrani*, personal comment).
- 'RADIP's success in the Philippines was, inter alia, because of the importance of clearly defining the client which then serves as the basis for integrating project strategies' (Philippines, *Rosario*).
- 'Whose objectives are we talking about?' (Thailand, *Chandrapanya*).

Because of the socioeconomic concerns in Malaysia, MARDI uses a four-member team comprising an agronomist, an economist, a sociologist and an animal scientist.

One major policy issue that needs discussion is how to link the local problems discovered in this stage to the national or regional programs.

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Design/Planning Stage

I would like to draw attention to a few aspects of this stage:

- Should FSR focus on incremental gains in production to provide short-run solutions to the problems and help minimise the evolutionary changes? In Indonesia this would be considered in the design stage.
- Should FSR focus its technology on new and radically different farming systems? *Anderson and Dillon* suggest it should.
- *Hashim Mohd Noor* suggests another radical approach to alleviate problems of poor or small farmers. MARDI charted the phases of FSR projects:
  (1) Improving productivity of the main crop;
  (2) Improving productivity by minor crop components;
  (3) Introduction of additional crop/livestock enterprises;
  (4) Planting economic crops around the house; and
  (5) Introduction of small scale agro-based industries.

Where should the focus be — local, regional or national? What should be the ultimate goal of bringing about change in agriculture and the rural community? Should society adjust to new technology or should technology be designed to suit the people? The sociological aspects of technology need to be discussed.

Another issue is who should be doing the design/planning? Some choices are:

(1) A network of research/extension personnel;
(2) Universities; and
(3) Agribusiness.

What is the optimal mix required for effective development?

What should be the link between farming systems research institutes and commodity research? Should each country establish a new institution as in the Philippines and Thailand, or establish a network within the existing system as in MARDI, RRI in Malaysia and CAER in Indonesia?

Many participants stated that the organisational issues were crucial for the success of FSR. This raises the involvement of a variety of social science disciplines (not just economists).

Testing and Extension

Problems and issues mentioned in the previous stages continued to appear and act as constraints for these two stages. Should extension organisations and personnel be brought in at the end of FSR as in commodity research and development models or should extension workers be actively involved in on-farm as well as on-station research? The following issues are worth discussing:

(1) How to link the results of demonstration trials to on-farm research;
(2) What are the appropriate training facilities required to upgrade extension to take new roles in FSR?
(3) To what extent should extension personnel be recognised and rewarded in implementing these new roles? This is crucial for staff motivation; and
(4) Who should monitor the performance of research and extension? Should this be internalised, done by an independent body, or by participating organisations?

Organisational Issues

Indonesian participants felt that 'An organisation without the necessary institutional base is like a body without life, like a computer without a program.' Management by committee seems to be the order of the day. The RADIP program in the Philippines was successful because of good organisational support. The World Bank had a major workshop to discuss Training and Visit extension approaches and research linkages in Southeast Asia in 1984. To what extent can one learn from these exercises? This area of study is very sensitive, but some participants from Asian countries and IARCs stated the need to examine them more systematically. If FSR and extension have to succeed in helping the rural poor, these issues must be studied and resolved.

Role of Agribusiness in FSR

In Thailand, direct-seeding instead of transplanting was found to be useful in rainfed areas. They gave the design to local manufacturers. Should FSR involve local/regional agribusiness after or before the development of simple technologies, such as modified machinery, seed, etc? In Australia, technology is efficiently transferred because of successful involvement of local agribusiness in appropriate stages of rural development. The role of agribusiness in manufacturing and servicing appropriate machinery or multiplying improved seed needs to be discussed.

Concluding Comment

I believe a useful response to the FSR needs of Asian countries could be achieved in two ways: (1) working with existing FSR institutes or other research stations in these countries; (2) by supporting the research and extension needs of many rural development projects implemented by consultants, universities and State departments of agriculture in Southeast Asia. Effective linkages between aid-supported farming systems, development projects and research at national agricultural research centres are necessary if Australia is to make an impact in designing technology for smallholder development.

Session Report
Some Farming Systems Research Experiences Overseas

Rapporteur: J. Lindsay Falvey*

THE papers of the session introduced FSR as it is understood and practised in key countries in Southeast Asia and South Asia and contrasted this with FSR programs in other countries. The papers, presentation by discussants, and general discussion focused on the appropriateness of the FSR approach, methodology of its implementation, difficulties and the role of Australians and ACIAR in collaborating with FSR programs in developing countries.

Two recurring themes in papers and discussion were (i) the difficulty of implementing FSR programs where national goals are based on short-term requirements and regional research programs on, at least, medium-term funding, and (ii) the elevation of FSR to an almost religious status. In this latter context the meeting was told that some aspects of FSR are accepted 'as a matter of faith' and that advocates of the approach have been 'proselytising' in developing countries. From the perspective of developing countries, the only rewards offered to Australians involved in FSR in developing countries were seen to be 'a challenge' and 'a feeling of well being'.

The terminology used indicated the difficulty of the subject for open discussion, which introduced concern over whether FSR could assist in alleviating food crises in Africa to a greater extent than alternative approaches. This prompted comments to the effect that droughts and political directives are obviously beyond the influence of FSR programs and that FSR is no more a panacea than any other research approach.

The FSR Approach

Discussion concerning the approach was unstructured although some consistent arguments were presented. In particular, distinctions between an FSR approach to current constraints to the development of alternative farming systems ('NFSD' in the paper of *Anderson and Dillon*) were discussed, as were the relative roles of international research centres and national research programs based on an FSR approach.

Flinn presented additional information concerning the methodology of FSR with particular respect to this as an area in which Australia can contribute. The procedures of FSR were analysed on the basis of the common technology divisions utilised in disciplinary research programs with the additional perspective of households (or other socioeconomic units) and agroindustry being included. In order to facilitate discussion, four stages in the methodology were introduced, namely diagnosis, design, evaluation and transfer. Diagnosis included constraints and opportunities in the design phase. Evaluation appeared to address the determinants of impact on the farming system in the short and long term and included sane value judgement on social benefit. The critical phase of transfer

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includes building the process into institutions, establishment of market linkages and addressing of processing requirements of the raw products.

The methodology described applies particularly to international agricultural research centres (IARCs) and reflects the relationship of those centres to national programs in their regions. An important constraint to the methodology is the ability of the international centre and, particularly, the national programs to manage the more complex research approach implied in FSR. Implications extended to training in an FSR approach and institutional issues.

Discussant *Chamala* presented perceptions of linkages between research and extension-based personnel within the FSR approach. The skills referred to in the early stages of an FSR program exist to some extent in extension officials who are, for example, commonly engaged in baseline data analysis. They are similarly involved in assessing the primary constraints of farmers although they might not be authorised to work toward removing non-agricultural constraints. After the problem-formulation phase, linkages between research and extension in the public and private sectors are examined and this information employed for the design and planning of the program. Questions arising in the subsequent stage of testing and extension relate to the training of staff in the approach, the monitoring process and the continuing problem of rewarding field workers in accordance with their success in the program.

Management of a complex approach such as FSR requires wider skills than those common to research program coordination in Australia. Integration of sociologists, economists, biological scientists and planners requires an understanding of the approach and the system being examined. It was presented that Australia is able to respond to FSR needs in Southeast Asia, South Asia and probably elsewhere through the research skills of organisations such as CSIRO, departments of agriculture, and universities, but that coordination, design and monitoring of such programs should involve the institutional development and management skills resident in the private consulting sector.

New Farming Systems Development (NFSD)

NFSD was introduced in the formal presentation as the development of an alternative to present farming systems. Group discussion determined that the original definition put forward by Simmonds (who documented the subject on behalf of the World Bank and to whom various workshop authors have referred) was based on the need to develop new systems for marginal lands forced into agricultural production where no established farming system previously existed. This is clearly different from the development of alternative systems for areas farmed traditionally.

The FSR approach pays homage to the involvement of social scientists in research program design and implementation. To suggest that an alternative farming system be developed in isolation from the farmer and, once perfected, introduced to the farmer, offends the role of social awareness implied in the FSR approach. However, despite the apparent misinterpretation of NFSD by part of the meeting, the need was seen to design research programs to meet prospective future problems separate from farmers. Arguments supporting this approach were based on the problem that farmers, while intimately familiar with their day to day problems, are not able to focus on alternatives or longer range problems. Thus a dual approach to research was implied; one developmental (NFSD) and one applied (OFR/FSP).

In practical terms, persons involved in development projects and research felt that farming systems cannot be developed independently from farmers and then introduced successfully. This belief was based on the need for farmer knowledge on interaction in the system in social, economic and environmental terms and the resistance almost universally exhibited by farmers to large changes in their life and production systems. It was further expressed that agricultural scientists should be and are usually aware of how their discipline relates to other aspects of the production system and that such scientists are most useful where they employ their skills to assist farmers to remove identified constraints. An approach of defining the environment and then testing possible crops for the area before discussing the concept with farmers was advocated as a means of integrating farmer experience with theoretical technical knowledge.

Basic Needs Approach

The differences in opinion about initial steps in the FSR methodology can be attributed to the perspectives of the researchers. In attempting to make ongoing research more relevant, involvement with farmers may become a means of selecting part of the ongoing program as more relevant than other parts; this is not regarded as determining means of removing constraints from the farmer. The alternative approach is one of returning to first principles and determining the relative status of the basic needs of food, energy, shelter, raw materials for home industry, cash and community integration and then seeking to address primary constraints. In circumstances where basic needs are unrelated to agriculture then FSR may still be appropriate (if not of interest to the ACIAR brief). The role of sociologists and economists is implicit in this approach.

Relative Roles of IARCs and National Programs

The role of IARCs was considered to be a general one that covered problems common to a region. The NFSD approach (as interpreted in the Anderson and Dillon paper) was seen as a responsibility of IARCs; such programs would be modified regularly after redefinition of problems through farmer surveys. The less disputed definition of FSR, i.e. OFR/FSP was seen as the primary responsibility of national programs where site specificity was a major determinant of successful research.

The question of training of Farming Systems Researchers comes into perspective when the above division is discussed. Researchers in developing countries are commonly trained in western systems of disciplinary research. Hence, adoption of an FSR approach requires additional training and an increased commitment to following the approach through over a long period of time. The interim solution of forming multidisciplinary teams is being followed in most of the countries discussed in the workshop, and the constraint to wider use of the approach appears to be the shortage of coordinators with the breadth of perception and leadership ability to maintain an FSR approach in the group.

Utilisation of the farm knowledge of nationals who have graduated in a relevant subject area is used as a means of assisting understanding of expatriate researchers and of focusing the team on the farm perspective. However, this approach is quite limited and appears to be aimed primarily at correcting the biases of expatriate researchers; it may therefore be more suited to IARCs than to national programs (conducted by nationals).

Concluding Comment

The fact that the discussions failed to concentrate on national programs can be seen as a natural bias toward those areas with which Australians are more familiar, the IARCs. Nevertheless, ACIAR has a responsibility to assist agricultural research to the benefit of national governments and, with its limited funding, cannot expect to have any large impact on international centres.

Further discussion of the national programs would have determined further roles for Australian involvement through common problem-oriented research programs, some of which may have fallen within the definition of FSR. As the papers from individual countries present the perceptions of FSR by client countries, it behooves those seeking to collaborate with (and assist) such programs to adapt to the FSR definitions implied in those papers. In fact, the practical approach taken in those papers suggests that the differences in approach may be cultural to some extent and that national researchers are best placed to determine the approach relevant to their own country.

Involvement of ACIAR in FSR will provide an increased coordination role above that expected for adding a further disciplinary research area. Management and coordination of such programs and the requirements for social, economic and environmental inputs implies that ACIAR will require resources not confined to the traditional research institutions in Australia. If ACIAR cannot extend beyond these institutions, then involvement in FSR in developing countries will be limited.

A Role for Australian Researchers

Constraints to the Transfer of Australian Farming Systems Research to the Third World

R.J. Petheram *

FROM Indonesia where I received the title of this paper, I could see little application in the Third World for most farming systems research (FSR) endeavours within Australia. Australian farming systems and FSR practice seemed very location-specific to Australia.

In contrast to this apparent non-transferability of FSR practice, the 'philosophy of FSR' as expounded by certain Australian economists (and educationists), seemed very relevant to Third World problems. In addition, Australia has, I believe, specialist knowledge and skills that could be invaluable in Third World countries, if utilised within an FSR framework.

Of course, the concept of FSR is not Australian. It has, though, been described, reviewed and recommended by certain Australians in a most convincing way, as an approach to agricultural research especially valid for the Third World.

In this paper, the 'transfer of Australian FSR' is taken to mean: the transfer and implementation of FSR philosophy, as expounded by Dillon (1973); Dillon et al. (1978); Chudleigh (1978); Anderson and Hardaker (1979); Menz and Knipscheer (1981); Ryan (1983); Bawden et al. (1984); Dillon and Anderson (1984).

The FSR approach may be presented in part as a 'philosophy of research,' but also as a 'process' that arises from the philosophy. Both these elements have existed for a long time in agricultural research: FSR is new mainly in the way it attempts to formalise the research process (Wright 1973; McClymont 1982).

The FSR Philosophy

Before the advent of systems thinking, scientists tended to derive their understanding of the functioning of the whole from the mechanical structure of the parts (Dillon 1973). In agriculture, this reductionist approach became traditional: it emphasises commodities and disciplines but places little importance on their place in farming systems (Dillon 1976). This approach was inherited by most Third World countries but has largely ignored the research needs of the majority of (small) farmers (Dillon and Anderson 1984).

As a research philosophy, FSR is concerned more with the development and adaptation of technology than with 'discovery' in the sense of pushing back the frontiers of knowledge (Dillon and Anderson 1984).

FSR involves the application of knowledge available from the physical, biological and social sciences, in a systems context. It must, therefore, be conducted in some sort of multidisciplinary framework, which involves both close contact with farmers and trials on research stations. It recognises and emphasises the interrelationships amongst elements of farm systems, and aims at enhancing efficacy through better focusing of agricultural research to facilitate the generation, testing (and adoption) of new technology (Dillon and Anderson 1984).

'New technology' has been simply defined as a 'different way of doing things on the farm' (Anderson and Hardaker 1979). Other useful definitions of FSR terminology were provided by Dillon et al. (1978) and McClymont (1982).

The FSR Process

Despite the wide range of conditions under which FSR is practiced, considerable agreement on the research process has emerged (Norman and Gilbert 1981). In the FSR process activities flow sequentially from the descriptive stages, through diagnosis to the design and testing of technology. There is, though, considerable overlapping of activities and forward and backward interaction across all phases of research (Dillon and Anderson 1984).

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Constraints to FSR Transfer

The question that this paper attempts to answer is: 'what constraints are likely to be met in attempting to transfer FSR and to support its implementation in the Third World?'

A basic feature of FSR is its deliberate consideration of farmers' socioeconomic and cultural circumstances (Norman 1980). In defining constraints to FSR, I must assume that Australian FSR advisers in the Third World would adopt an FSR philosophy, and not make the mistakes that scientists working in a non-FSR way have often made, e.g. failure to take into account the socioeconomic milieu in which farmers operate (Vierich 1984; Remenyi and Coxhead 1985).

Thus the following discussion of constraints concentrates on the main problems experienced in implementation of FSR programs in the Third World — and not on the hazards of Australian specialist scientists becoming involved in Third World agriculture. Where specialists do become involved within an FSR approach, the FSR process itself should (by definition) ensure that they are made aware of socioeconomic factors important to the task or research topic.

In Table 1, common problems and limitations in the development and conduct of FSR are listed, and grouped under nine main categories of constraint that occur in the literature (e.g. Norman and Gilbert 1981; Winkelmann and Moscardi 1981; Casey and Barker 1982; Collinson 1983; Chambers and Ghildyal 1984; Petheram 1985). The constraints faced by a particular FSR program depend on its institutional ties, and on its stage of development. Constraint categories in Table 1 are listed from top to bottom in approximate order of occurrence in the development of an FSR program.

Potential for Australian Support in FSR

Because FSR programs are multidisciplinary and mostly relatively new, the categories of constraint most commonly mentioned in the literature are those near the top of Table 1, i.e. program organisation and management. Methodological problems are viewed by most FSR scientists as part of the FSR process. They are, however, constraints in that poor methods can reduce efficiency of FSR.

The wide range of constraints likely to be faced in developing and strengthening FSR in the Third World, means that there is scope for involvement of numerous disciplines (many of which are not associated with FSR in Australia). Some of the potentials for use of Australian expertise are discussed briefly under headings of each of the major constraint categories listed in Table 1.

Table 1. Main constraints in implementing FSR.

Category	Common examples of constraints
1. Program organisation and structure	Poor inter-disciplinary/inter-agency contact Poor leadership of FSR, or of parent organisation Imbalance of on- and off-station activities
2. Staff motivation problems	Inappropriate reward structure for FSR staff Obstacles to adoption of FSR by scientists e.g. lack of suitable publication media
3. Problems of acceptance of FSR philosophy	By senior agriculturalists and government By other agencies (e.g. extension) By specialist scientists — local and consultant
4. Limited program resources	Lack of suitable (selected) staff Budgetary restrictions e.g. on staff travel Lack of suitable vehicles
5. Staff training problems	Need for training in FSR concepts Need for specialised skills training
6. Communication problems	With administrators/specialist disciplines Farmer-scientist communication problems Difficulties with publication
7. Technical skill limitations	Paucity of ideas for new technology Limited technical skills for testing technology Data processing/statistical problems
8. FSR methodology problems	New techniques need development e.g. (a) socioeconomic research methods (b) crop or livestock research methods
9. Limited specialist research facilities	Lack of research stations/equipment/skills

Institutionalising FSR

Unless FSR is set up correctly initially (e.g. with the necessary links between disciplines and agencies, support from above, enlightened leadership, flexible budgeting) progress is likely to be slow and even damaging to the credibility of future FSR.

Australians are already involved in advising on the setting up of FSR programs, and in assessing FSR progress. In many Third World countries, this area of involvement may be the most valuable contribution that can be made at present. To date, this field has remained the domain of mainly agricultural economists. If the FSR approach could be more widely explained in Australia (e.g. through good films on FSR, teaching of systems concepts) scientists from other disciplines might be recruited to share this important advisory role.

Advisory efforts in the management of FSR could be enhanced by improved accessibility of papers and reviews on FSR programs in Third World countries. The establishment of an international literature and data base in Australia on FSR could be of benefit not only to Australians but also to FSR scientists and educators overseas.

Staff Motivation Problems

This area is closely related to the program organisation topics discussed above. For effective FSR, there has to be a departure from the traditional reward structure in agricultural research, i.e. where rewards depend largely upon publication in scientific journals, and often on the level of scientific excellence (Casey and Barker 1982).

Because trials on farms are generally harder to design and run than those on research stations, scientists involved in FSR find progress slower and publication more difficult than their specialist counterparts. Advice (or joint research) on FSR methods, and support for FSR publications are thus important areas in which Australia could stimulate FSR in Third World countries.

Problems of Acceptance of FSR

Even where FSR has been officially accepted as part of the agricultural research process by a department or government, there can be strong opposition to the concept from various sectors. This makes involvement of specialists from other disciplines in FSR difficult to arrange, and slows the research process.

If the concepts are clearly explained, most people involved in agricultural development accept FSR as a logical approach to research. However, powerful means are needed if FSR philosophy is to be communicated to the specialists who control agricultural research in most countries.

FSR support programs can improve the acceptance and hence the functioning of FSR through production of, for example videos, films and other aids to communicating the philosophy, methods and the potential benefits of FSR (e.g. Farming Systems Support Program 1984). In this context, the unnecessary use of the jargon that has accompanied FSR development has to be avoided, as it seems to invite scepticism from the specialist scientists whose support FSR must enlist.

Limited Resources

Most new FSR programs have to compete with well-established specialist programs for funds, staff and resources. Provision of adequate resources for the FSR task in hand depends on an understanding of and commitment to the FSR approach by administrators and leaders of the research organisations.

One common resource problem is lack of vehicles for village work, yet there is often reluctance by aid organisations to supply vehicles for FSR because they fear misuse. Such problems can be overcome and are no reason to avoid supplying vehicles as part of support programs when, in most instances, transport is a basic condition for the conduct of FSR. Transport and travel allowances are as basic a need in FSR as are, for example, animals and feed to the livestock scientist.

Recruitment of staff to FSR programs can be difficult for reasons of poor incentive, discussed above. However, selection and training of suitable personnel (and especially leaders) for FSR may be as important as providing suitable rewards in ensuring motivation of FSR staff. The characteristics of a good FSR worker include the ability to work as a team member, an interest in people and their problems, and good communication and observation skills.

Staff Training Problems

Because training in FSR philosophy and methods has been difficult to arrange, there are many people involved in FSR who have little or no training in FSR concepts. Training requirements in FSR range from short in-service courses in particular skills (e.g. sheep handling) to courses in FSR concepts for scientists, and professional training in FSR at the graduate and postgraduate level.

Developments in agricultural training in Australia (Bawden et al. 1984) suggest that university courses in FSR may become available soon. If FSR is to attain the status it needs, these could be most valuable if extended to the masters and doctorate level. However, there is an immediate need in Third World countries for a wide range of in-service training courses for existing FSR staff, e.g.: joint courses on FSR approach for extension and FSR workers; courses on FSR approach for administrators; courses for FSR field staff in socioeconomic methods; courses for FSR field staff in technical skills; and courses on FSR approach for Australian specialists who are drawn in to assist an FSR program overseas.

Any FSR support program in the Third World would require a training aspect. Training in FSR itself could be partly in Australia but may be developed in Third World countries by training FSR trainers. Postgraduate FSR training should include field work in the home country.

Communication Problems

Ideally FSR programs are backed up by a communication unit, with facilities to produce posters, pamphlets and other visual aids for farmers. This is not for extension per se, but is essential where farmers are asked to become involved in farm trials of new ideas.

There is also need for films and publications on tested technology in a suitable form for extension agents. Other requirements (mentioned above) are for support for publication in FSR, and production of films and other aids to communicating FSR (philosophy and successes) to administrators and others involved in the development process. Good communication in FSR is so important that any FSR support program would need at least some input in terms of equipment and expertise.

Limited Technical Skills

Various technical skills are required at the early stages of FSR, i.e. in the collection of base data, or study of existing farming systems. However these skills (e.g. data analysis, soil or blood sampling) are of a type for which training can usually be arranged.

Starting from the technology design stage in FSR, there is a need for special technical skills (e.g. for design of simple new implements or methods of feeding), which may be rare in developing countries. They involve two main types of personnel: a) experts who can act as innovators, to design possible solutions to farmer problems; and b) technicians with skills (e.g. carpentry, welding) who can try out, modify and develop ideas provided by experts.

Ideas for new technology can often be generated by short-term consultants in a specialist field (e.g. an animal behaviour specialist, or a practical farmer). Technicians who must build and modify new ideas need to be located on site to work with farmers and local scientists for extended periods. A special interest in people and their problems would have to be combined with sound practical ability in this role.

FSR Methodology Problems

When FSR starts in a new area, it may be necessary to develop new methods of conducting research. Very often, though, the same problems have been solved in similar areas by other teams. Australians could strengthen FSR by documenting methods used in various FSR programs, and making this information available to advisers and to Third World countries. Cropping systems methods are fairly well documented (e.g. Zandstra et al. 1980) while livestock methods are not.

In all FSR programs, however, there is a need to develop more efficient methods at each stage of the research process. An Australian FSR support program could make useful contributions to methodology by providing expertise from various disciplines, e.g. remote sensing experts for advice on site selection; socioeconomists for advice on study of farming systems.

Improvements in FSR methods could be achieved through Australian FSR support for visiting consultants, arranging visits for FSR staff to other programs and areas, and again through improving access to information and literature on FSR. There may also be scope for joint research projects to tackle FSR methodology problems.

Specialist Limitations

Where on-farm research has reached the stage of yielding ideas that need testing on research stations, the availability of specialists, equipment or stations may become limiting to FSR progress. This is an area into which Australian expertise may increasingly be channeled, as FSR becomes better developed in the Third World. This may be through advice, joint Australian research projects in the particular country, or even (carefully designed) research conducted in Australia.

A major criticism of previous Australian scientific involvement in Third World agriculture has been the lack of a well defined farming systems framework in which to operate. Until FSR is better developed in a particular country, the logical approach may be for Australia to place emphasis on supporting FSR, rather than to risk wasting further resources on poorly conceived specialist research topics.

Conclusions

An attempt is made in Table 2 to summarise the main areas of potential support needed in Third World FSR. This picture may be more applicable to developing national FSR programs than to FSR in the well established international research organisations.

The main constraints to implementation of an FSR approach in the Third World are related to organisation and management of programs, at this

Table 2. Constraints in implementing FSR.

		Main areas of potential support for FSR				
Constraint categories	Examples of support needed	Advisory personnel	Communication, information, publication	Training	Equipment	Joint research projects
Organisation and program structure	Advise on organisation of FSR	....	....			
	Establish literature bank on FSR		....			
Staff motivation	Provide publication media for FSR		....			
	Advise on FSR staff management	....				
Acceptance of FSR philosophy	Produce films etc. for key administrators/for scientists	....	....			
Program resources	Provide vehicles and equipment				....	
	Provide key personnel					
Staff training	Provide training in FSR approach			....		
	specialist areas			....		
Communication	Provide or support communication units		....	....	....	
	Provide equipment and training					
Technical (innovative) skills	Provide experts in special fields	....				....
	Provide technicians for practical field work					
FSR methodology	Establish data bank on FSR methods	....		....		
	Support joint research projects					....
Specialist research facilities	Support joint research projects	....				....
	Conduct specialist research in Australia					....
	Provide equipment and training			....	....	

stage. Australian advisers and scientists involved in transferring FSR therefore require knowledge about organisation of FSR, as well as the ability to assess needs and arrange support in other constraint areas, such as training, publication, communication and technical expertise.

The broad analysis presented suggests that Australian support programs for FSR would need to utilise five main types of personnel:

1. Advisers on FSR philosophy, organisation and management.
2. Training specialists for courses in FSR/specialist topics.
3. Information specialists, to
    (a) develop literature and data bases for FSR,
    (b) edit or support publication media for FSR,
    (c) produce films and pamphlets on FSR,
    (d) produce aids for scientist/farmer communication.
4. Specialist technical personnel to
    (a) help generate new ideas for technology on farms,
    (b) build, modify and develop new ideas on farms.
5. Specialist scientists to undertake joint research in Third World countries and possibly in Australia.

The scope for the more usual type of ACIAR support (i.e. in the form of joint research programs on particular topics) is fairly limited at present, but should increase steadily as FSR programs of farm research develop, and particularly if FSR is supported in the required (non-research) areas.

So Australia's potential for strengthening FSR in the Third World does not all lie in areas covered by Australian farming systems researchers. On the contrary, it is obvious that, in order to transfer Australian FSR, ACIAR must involve expertise from a wide range of disciplines — not only in a joint research framework, but in well coordinated programs, including communication, training, and other types of support.

If ACIAR is committed to strengthening FSR in the Third World, a logical approach would be to build its proposals for joint agricultural research onto research needs defined by existing or new FSR programs wherever possible — so that there is good opportunity for results of ACIAR research to be tested and put to use by farmers.

As to the 'morality' of Australia encouraging an FSR approach in The Third World (Remenyi and Coxhead 1985; p.12), I have no qualms at all. These countries have adopted so much of the Western specialist approach to agriculture research with little return to date. In the past, Australia has offered little or no advice or training in the way in which research needs to be organised. FSR can thus be viewed as 'the rest of the technological package,' which is essential if effective use is to be made of the Western ideas already taken up by Third World countries.

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Comment On: Constraints to the Transfer of Australian Farming Systems Research to the Third World

B. Carrad *

I liked the paper very much and agree with the thrust of the argument. The ordering of the constraints to farming systems research (FSR) implementation, where project organisation and structure were prominently mentioned, seems correct. These issues are clearly dominant in developing countries. I would, however, have ranked communications and training problems higher. Australian FSR workers will find it difficult to communicate with their clients and other in-country organisations, even when sufficiently well briefed and experienced. Training of counterparts and support staff will likewise be a major hurdle.

There are several extra constraints from a developing country's point of view, apart from those given in the paper. I should preface these remarks by mentioning the narrowness of my experience, mostly PNG, and I may not be speaking accurately for the other developing countries represented here.

Knowledge of Skills and Needs

The recipient needs to know what Australia has to offer. I, for one, don't know the extent of FSR-type skills available and where they are located. The ACIAR survey reported by Remenyi and Coxhead at this conference is a step in the right direction. However, the broad categories of skills given in their paper provide little guidance for a developing country.

Australia needs to know what developing countries need. These needs will vary from country to country, but there may also be strong similarities. It would be worthwhile for ACIAR to do more in the area of specifying demand before attempting to further determine the supply of Australian skills.

Skills Development and Experience

It is very difficult for Australians, especially young people, to gain professional experience in developing countries. There is nothing linked to the Australian aid program to develop Australian skills and experience in any discipline, including FSR. Removing this training constraint would improve Australia's chances of successful FSR transfer.

Papua New Guinea was the traditional training ground for Australian development workers. This has changed rapidly in the last decade since PNG independence. As a result of higher Australian wages and better employment opportunities, very few Australians are working in professional positions in agriculture in PNG; in agricultural economics, no Australian has been hired by the PNG Government in the past seven years.

The situation is better in some donor countries. For example, the British Government Overseas Development Institute Fellowship Scheme offers competitive opportunities for graduates as replacements for personnel from developing

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countries who are studying abroad. This has the twin advantages of training British nationals while also preventing temporary staff shortages in the developing country. Once the 2-year fellowship is completed, every effort is made to offer contract employment on a British Government aid project, but many find other employment in developing countries. The scheme has a high success rate and gives a professional start to highly motivated and well educated young people. Australia could well consider such a scheme.

The British and Canadian volunteer schemes are also of a much higher quality than their Australian counterpart. With no reflection on the quality of Australian volunteers, they are poorly served in comparison, suffer from more restrictive selection criteria, and, in PNG at least, lack personal and professional support.

Expanding the educational aid provided in Australia for citizens of developing countries to include FSR training would also assist development and transfer of Australian FSR.

Long-Term Perspective

It is a truism that a long-term perspective is needed in this type of work. Continuity of relationships and the quality of a project (e.g. the care with which it has been set up, the consistency of its objectives, the experience of its personnel) require time for learning, mistakes and changes of course. The FSR 'process' described in the paper implies gradualism, which, in terms of budgeting and implementation, is an overriding constraint that needs acknowledgment in project design.

Comment On: Constraints to the Transfer of Australian Farming Systems Research to the Third World

Ian Aberdeen *

FSR starts and ends with the farmer, but the initial relationship between the local FSR workers and the local farmers is often not conducive to good communication. The researcher considers that his education and life at an office desk make him better and smarter than the farmer. He likes lecturing the farmer, but not listening to him.

The farmer is not impressed with the researcher because he does not understand the workings of the local farming system and he has no technology developed or proven in local trials to teach to the farmer.

However, the FSR exercise can rapidly improve this relationship. We find that young graduates who come from local farms make good farmer interviewers. Once they learn to pursue a line of enquiry with the farmer, rather than ask pro forma questions, the researchers develop an understanding of farming and its problems. As better farming systems emerge from research and are adopted, the farmers begin to respect the government researchers.

There is often poor understanding of the problem-solving scientific approach. Science is not well taught in local secondary and tertiary institutions. There has often been no worthwhile local research on crops, livestock or economics. It can take some time for the problem-solving approach of FSR to be understood in these circumstances.

In the Philippines we have trained research agronomists to lay out trials, impose treatments, measure and statistically analyse results, but they tell us that they still have difficulty in two areas:

(a) the identification of farmer problems that could be explored in crop trials;
(b) the interpretation and formulation of research results into extension recommendations.

The bureaucratic inertia and parallelism found in most countries, including Australia, may prove an initial constraint to achieving the multidisciplinary interdepartment cooperation required in FSR. It is not unusual for FSR to identify inappropriate aspects of current government farm programs, but find difficulty in getting the programs changed.

However, FSR does provide a communications bridge between departments. If departmental administrators support FSR they may respond to FSR results and adjust their policies.

Australians working in developing countries on FSR can themselves become a constraint.

Not all of them will come from a strong Australian background in FSR. They may be commodity-based researchers, economists or extension workers. If so, they may need to be managed.

Ongoing training for the Australians and their counterparts on FSR theory and practice may be desirable. They will certainly need to be given clear goals and be monitored regularly to check progress towards those goals.

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Comment on: Opportunities for and Problems of Transferring Australian Farming Systems Research to Developing Countries

Derek Byerlee *

IN this note, I will address the opportunities for transfer of Australian farming systems research (FSR) to developing countries, from the perspective of agricultural research programs in these countries. I shall by and large assume that Australia does have viable FSR programs with the potential to make a contribution to the developing world. However, I suspect that from the point of view of many Australian farmers there is a great deal of potential in Australia for further developing its own FSR programs. For example, on a visit to the South Australian dry wheat-sheep zone in 1984, I was struck by the extent to which farmers are experimenting with more intensive rotations and chemical fallowing, both with major implications for weed and disease control and fertility maintenance. In general, there seemed to be little integrated applied FSR to support farmers' efforts in this direction and certainly the contribution of agricultural economists was notably absent.

The transfer of Australian FSR can be discussed at three different levels 1) direct transfer of research results, 2) transfer of research methodologies and 3) transfer of disciplinary expertise.

Transfer of Research Results

The direct applicability of FSR results from Australia depends on the extent to which both the agroclimatic and socioeconomic circumstances of the receiving region parallel Australian conditions. I am sure it will be amply demonstrated in this workshop that Australia, more than most other industrialised countries, shares similar climatic conditions to many developing areas — particularly the Mediterranean and subtropical/tropical climatic zones. Nonetheless, about half of the population in the developing world live in the intensively cropped, irrigated areas of Asia for which Australian agriculture has no obvious counterpart.

But even in those areas where Australian agroclimatic conditions are relevant, socioeconomic conditions are usually quite different. In developing countries, the price of labour relative to capital is much lower, nitrogenous fertiliser is usually cheaper relative to land and often the price of livestock (and hence fodder and crop by-products) relative to grain prices is much higher. For example, the price of mutton relative to wheat in Algeria was 3–4 times higher than in Australia in 1979 (Byerlee and Winkelmann 1980). Moreover, non-economic factors such as communal management of grazing land are also often quite different from Australian conditions. Hence there is likely to be little opportunity for direct transfer of research results even where agroclimatic conditions are similar. For example, CIMMYT conducted several years of research to introduce medics to wheat-sheep areas of Algeria. These efforts met with limited success, in large part because of different socioeconomic conditions.

Transfer of Methodologies

Methodologies for FSR are less dependent on the agroclimatic situation, but again the difference in socioeconomic conditions in developing countries may demand different research methodologies. FSR in developing countries must address the problems of many small farmers. Farming systems operated by these small farmers are usually more complex than those of commercialised agriculture. Hence, methodologies used for FSR in developing countries must emphasise the role of the social scientist in understanding small farmer complexity. At the same time, research systems are often weak and suffer from a shortage of mid-career experienced researchers. (Most mid-career professionals in research occupy administrative positions.) Research methods must be applied by researchers with fewer resources and experience. Few national programs, for example, have the resources to construct simulation models

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of farming systems. These considerations suggest that transfer of Australian FSR methodologies will also be limited, except for specific skills, such as agroclimatic zoning.

Transfer of Disciplinary Expertise

Two essential ingredients of an FSR team are an economist grounded in crop or livestock sciences, and a well-rounded agronomist able to integrate the complexities of crop management such as fertility management, tillage and seed-bed preparation and pest control. It is in this regard that Australian institutions will have the most to contribute. It is precisely because of these characteristics in Australian university degrees in agricultural sciences and agricultural economics, that Australians are well represented in the international agricultural research centres, particularly in agronomy and economics.

In addition, Australian expertise in a number of sub-disciplines such as risk management and systems modelling and crop-livestock interactions can also be utilised in FSR programs in developing countries.

Guidelines for Australian Involvement

At present hundreds of millions of dollars are being spent by international and bilateral agencies in FSR, broadly defined to include adaptive on-farm research. However, the results are often disappointing. Australian institutions and ACIAR can learn a number of lessons from these experiences. These include the following.

FSR projects should have clear and specific objectives formulated in terms of priority farmer problems. Because FSR gives explicit attention to interactions in the farming system the number of possible researchable issues is very large. The success of FSR will depend on how well the important research issues are identified. In this regard it is critical that FSR projects have a strong farmer orientation. Many FSR projects have become mired in largely irrelevant n x n intercropping or rotation factorials or even model farms — all on the experiment station.

FSR teams should emphasise quality not quantity of researchers. FSR is a multidisciplinary approach. Unfortunately this is often interpreted to mean that all relevant disciplines must be included in the FSR team, resulting in a team of ten or more so-called 'experts.' In fact, the cutting edge of an FSR team includes those, usually an agronomist and a social scientist, who must make FSR operational in the field with the farmer. This small team should be made up of top quality researchers and provided with appropriate resources and incentives.

FSR projects should have a relatively long time horizon that allows for continuity of personnel. This is needed in order to become familiar with the local situation and allow time for institutionalisation of the FSR approach. It is particularly the case when expatriate scientists are involved.

FSR projects should avoid empire building. The tendency to create new and separate institutions to undertake FSR has resulted in substantial duplication of efforts. Often more can be gained by adding a farming systems perspective to existing research efforts.

FSR projects funded by outside agencies should emphasise development of local capacity to do FSR. Only when this local expertise is built up will FSR be in a position to make a lasting contribution.

Within these guidelines, Australian institutions can play a role in FSR programs. However, I believe that ACIAR should avoid funding projects that aim at developing *new* FSR programs. Rather, ACIAR should attempt to develop linkages between mature FSR programs in developing countries and Australian researchers. Successful on-farm research programs with a farming systems perspective will be in a strong position to identify important problems that require additional and specialised resources and a longer run perspective, to which Australian expertise may be brought to bear.

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Comment On: Opportunities for and Problems of Transferring Australian Farming Systems Research to Developing Countries

Terd Charoenwatana*

THE small farmer, in reality, lives in a complicated world. It consists of the farm household surrounded by the farm resources that the household uses. Farmers utilise their resources with a variable number of inputs to produce crops, livestock, crafts and other farm products which are either consumed by the household or marketed as the farm output. In producing, the farmer and the farm interact with each other as a 'system' and also with many other 'systems' outside the farm.

Small farmers normally earn their income not only from crops, and animals, but also from off-farm activities as well. A recent survey of on-farm income structure of agricultural households in Northeast Thailand showed that on-farm cash income was 76% from crops, 23% from livestock and 1% other.[1] When farm and non-farm incomes were compared, another survey showed that rural household income from Khon Kaen Province was 50% from non-farm and 48% from farm activities.[2]

Generally, the farmers gain knowledge for farming partly from traditional sources, and partly from their own trial and error, but also from the innovations of other farmers and from outside sources. The farmer has wide-ranging but incomplete and sometimes superficial knowledge. Decisions about farm activities are influenced not only by physical and biological factors but also by socioeconomic and cultural factors. Most small farmers in developing countries operate under rainfed (non-irrigated) conditions. They farm mostly for subsistence and face numerous interrelated problems.

In contrast, most agricultural scientists who work in developing countries come from urban backgrounds and their university training is highly specialised. They become plant breeders, entomologists or agricultural economists. They lose sight of the farm as a system and are unable to relate their specialised knowledge to that of other scientists or to the everyday practice of the farmer. The individual agricultural scientist generally has a narrower range of knowledge than the farmer, although he knows far more about his particular area of expertise. As a researcher, he normally uses conventional methods to carry out his experiments. He works in ideal environments with unlimited resources, i.e. capital, land, labour, irrigation and production inputs. The researchers themselves identify the problems and run the experiments in the laboratory or on experimental farms. They may do on-farm trials, but not usually involving farmer participation. The research findings or technologies are then extended to the farmers.

It is now widely recognised that most new technologies generated by conventional methods are rarely adopted by small farmers. The technologies are more appropriate to the big or commercial farms that have access to irrigation and many other resources as well. This is because the environments where the new technologies were developed are similar to that of commercial farms. Therefore, we need a new approach: a variety of trained specialists working together, if we want to solve the small farmers' problems. The recently developed FSR approach serves this need. FSR originally developed in response to the fact that limited-resource farmers in developing countries were not adopting improved technologies generated by traditional research, because these disseminated technologies were simply not matched to such farmers' circumstances and goals. To overcome the problems, researchers came to realise that they have to consider real farm circumstances as well as the dynamics of farmer decision making,

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[1] Agricultural Statistics of Thailand, Crop Year 1983, Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

[2] Rural Off-Farm Employment Assessment Project, Center for Applied Economic Research, Kasetsart University, Bangkok, Thailand, 1981.

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in the research process. The FSR approach was proposed in order to develop improved technologies suitable and acceptable to small farmers.

The concept of FSR has been discussed in detail by many advocates (Norman 1980; Gilbert et al. 1980; Shaner et al. 1981; and Rohrbach 1981) and now takes on many meanings and interpretations. Essentially, FSR refers to research that focuses on the farm household and views the entire farm and its larger environment in a holistic manner. It requires involvement of an interdisciplinary team of natural and social scientists. The approach is now being widely used for developing appropriate technologies for small farmers.

Developing an Interdisciplinary Team

In the concept of FSR, an interdisciplinary team is the key factor for success. But, an interdisciplinary team is not just a group of researchers from different disciplines that work together. The team has to view and understand the complexity of the farmers and their environment as a system, not just from some highly specialised aspect. Moreover, the team members have to understand each other well and to work together efficiently. In particular, an interdisciplinary team should have two well-developed aspects: interdisciplinary 'thought' and interdisciplinary 'action.' Unfortunately, methods or concepts for building these two characteristics are still poorly developed.

Interdisciplinary Thought

For the first characteristic, we have to improve cross-disciplinary knowledge of the team members, from highly specialised to interdisciplinary perspectives. There are two mutually compatible conceptual approaches that seem to be particularly suitable to improving the understanding and thinking of the team. They are human ecology and agroecosystem analysis.

Both approaches are used at Khon Kaen University. Human ecology was initially introduced by A. Terry Rambo, of the East-West Center; agroecosystem analysis by Gordon Conway of the Centre for Environmental Technology, Imperial College, London. Both approaches were gradually developed out of much cooperative experience in developing countries. Both researchers worked with KKU staff as well as staff in many other Asian institutions in a cooperative and continuing manner over a period of years.

HUMAN ECOLOGY

Human ecology is the study of the relations between people and the natural world in which they live. It is intended to help both social scientists, whose ordinary concern is with human affairs, and natural scientists, whose normal focus is on physical and biological phenomena, to better see how their subject matter is deeply interrelated. Although there are many different conceptual approaches to the study of human–environment interactions, Rambo (1983) suggests that the 'system model of human ecology' appears to have particular utility from the standpoint of designing interdisciplinary research projects of human interactions with tropical agroecosystems. The model was designed in recognition that social scientists and natural scientists are professionally equipped to study distinct conceptual entities. The specialists should continue to work within their areas of professional competence, but always bearing in mind the need to relate their own research to the overall goals of the whole agroecosystem research project.

In this model, the human ecosystem consists of two subsystems: the human social system and the natural ecosystem. Each system is made up of several mutually interacting components. These systems are not two isolated, closed systems, but are two interrelated systems. They are linked through the flows of energy, material and information. Any change in one component may not only affect the other components in the same system but also may affect the other system as well, causing changes in both systems. Human ecology is not a discipline, instead it is a perspective, a way of looking at our relations with the environment. This perspective is distinguished from other conceptual frameworks by a number of major features: (1) it employs a system viewpoint on both human society and nature, and (2) it describes both the internal behaviour of ecosystems and social systems and their interactions with each other in terms of flows or transfer of energy, materials, and information. It is concerned with understanding (3) the organisation of systems into networks and hierarchies, and (4) the dynamics of systems change.

AGROECOSYSTEM ANALYSIS

Agroecosystem analysis as developed by Conway (1982) is a more specific application of the systems perspective to improve cross-disciplinary knowledge of research teams. The basic procedure is described in detail in Gypmantasiri et al. (1980), Conway (1982), and KKU-Ford Cropping Systems Project (1982). What this approach provides are organising concepts or frameworks that encourage scientists from different disciplines to interact with one another in a way that produces insights that significantly transcend those of the individual disciplines.

Local systems can be analysed in a series of steps: statement of objectives, system definition, pattern analysis and exploration of system properties, identification of key questions, and then research design and implementation. The system properties, which include productivity, stability, sustainability and equitability, describe how an agroecosystem operates over time. Productivity is the output of a system, measured in terms of crop yield or net income. Stability is concerned with variability of yield or output. Sustainability is the ability of a system to persist in the face of repeated stress or perturbation. Equitability measures the distribution of income or production among farmers.

Agroecosystem analysis procedures allow agricultural, socioeconomic and management issues to be raised simultaneously and for a cross-fertilisation of ideas to occur. As a consequence, a series of critical questions is raised and collectively recognised. These questions should then be converted into testable hypotheses and serve as the contextual framework for research. The next step is the testing of the hypotheses in laboratory, field research or experiment, or extension trials.

In summary, in implementing an FSR approach, an interdisciplinary team of social and biological scientists is formed. Interdisciplinary approaches are used to improve cross-disciplinary knowledge of the team. Human ecology provides the team with a variety of concepts and theories both in natural and social sciences and linkages between these two. Theories and perspectives, however, are best employed in concrete ways. Agroecosystem analysis allows researchers from different disciplines to interact with each other and bring up issues for discussion and to identify problems which will be topics for research. Complicated and interrelated problems need to be solved by a kind of interdisciplinary approach — FSR.

Interdisciplinary Action

The second characteristic — interdisciplinary action — is needed for the team to conduct farming systems research work in the field in order to produce good results. Probably, there are few if any documented references on how to work in an interdisciplinary way. In practice, there are a few guidelines that might help the team to produce interdisciplinary work:

(1) Planning together: For interdisciplinary research, all research activities on the farm system should interrelate to each other. It is necessary for the whole team to plan and design the research together.

(2) Working together in the field: Ideally, the team or sub-team that consists of researchers from different disciplines, e.g. crop, animal and social sciences, should keep working together side by side in the field. This will assist the flow and exchange of ideas among the team members. If the team members work separately in the field, each individual tends to think and work toward his own discipline, and the interdisciplinary aspect will not occur. At Khon Kaen University we have made particular use of rapid appraisal methodologies to help advance close interdisciplinary cooperation in the field, particularly in the early stages of FSR (see KKU 1985).

(3) Regular meetings: Regular meetings are necessary for the whole team. This will provide an opportunity for the team members to discuss and share ideas as well as information. The team can review work and report on progress. They also can adjust their fieldwork to each other if they start to vary from the original plan. Meetings also allow the team to tie research results together.

Conclusion

The above discussion briefly describes the present perspective on FSR research needs in many developing countries and some of the advances being made at Khon Kaen University in Northeast Thailand. Experience in developing countries indicates that what is most needed for

FSR success is better team preparation and functioning in terms of conceptual, yet practical, advances in interdisciplinary thinking, and in terms of methodological advances for sustained team interaction in interdisciplinary work. This is necessary for local FSR teams to help solve small farmer problems in local environments. Such advances are not likely to come from transferring pre-formed ideas and methods. In fact, the inability of technology transfer to reach the small farmer was what led to the development of the FSR approach in the first place. Instead, what is needed is a mutual and gradual cooperative effort, whereby concepts and methods can be developed to fit particular situations, in order to develop technologies that will suit the needs of small farmers in particular circumstances and environments. The process will, of necessity, be gradual, because no easy or universal solutions can be expected. Now that we have recognised the need for FSR, the next step is to recognise what FSR itself needs to achieve success.

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Comment On: Opportunities for and Problems of Transferring Australian Farming Systems Research to Developing Countries

Robert Springborg*

In the past decade there have been several attempts to transfer the Australian ley farming system to North Africa and the Middle East. Regrettably these projects have met with only limited success and many have been terminated or are likely to be in the near future. The West Australian contract under which a model farm was operated in Tel Afar, Iraq, for example, was allowed to lapse in 1984. Every indication suggests that a similar undertaking by the South Australian government in a neighbouring province will not be renewed when the five year contract expires in July 1985. Similar fates have befallen South and West Australian projects in Libya, while other efforts in North Africa have been sporadic and non-cumulative at best. Even the sole Australian funded project in the region, operated in Jordan by South Australia for the Australian Development Assistance Bureau (ADAB), has been of very marginal importance within even that small country. For various reasons the managers of that project virtually abandoned medic cultivation, the basis of the ley farming system, and the director of Phase II of that project, which is just commencing, has indicated his intention to continue that policy.[1] The head Jordanian counterpart of Phase I of the project, in writing a lengthy report on prospects for and methods of improving cereal cultivation in his country, simply forgot to mention the potentially beneficial role of medics.[2]

These setbacks would not be so serious were it the case that a nucleus of farmers and agronomists in these various countries were now committed to and practicing ley farming. That, however, has not occurred. The small pilot demonstration farms associated with the two large projects in Iraq and intended to involve local farmers have been abandoned. Virtually nothing remains of the West Australian model farm experiments in the dry areas surrounding Tel Afar. The obvious lack of forward planning at even this late stage by Iraqi officials suggests that the same fate is likely to befall the South Australian project at Ain Kawa later this year, when in all probability the Australian personnel will leave for home.[3] Insofar as can be determined, not a single Jordanian farmer now grows medic pastures, although some who have worked with the ADAB project are sowing mixes of barley, vetch and medic. The one bright spot may be the Jabal al Akhdar region of Libya, where the South Australian Department of Agriculture and then the South Australian Seedgrowers Cooperative worked, but in the absence of recent observations it is impossible to know what the carryover effect has been. In sum, Australia's efforts to disseminate its dryland farming technology to North Africa and the Middle East have so far failed to have much impact on local farming practices.

Why the Lack of Progress?

There are several factors more or less beyond the control of those who designed and implemented these efforts at technology transfer that had negative impacts on the projects. The downturn in oil revenues coupled with the Gulf War is one such extraneous, unpredicted and unpredictable occur-

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[1] Conversation with Mr. Chris Heyson, Amman, 13 February 1985.

[2] Dean Duweiry of the Faculty of Agriculture of the University of Jordan was in the process of writing that report when visited by the author on 9 February 1985. During the ensuing discussion he commented that it was fortunate I had dropped in for otherwise he would have forgotten to even mention the potential of medics for improving grain yields in this report. If even the head counterpart of the project has been so little impressed by ley farming, one can imagine just how restricted the impact has been on those more distant from it.

[3] This impression of Iraqi thinking was gained during conversations with various officials, including the head counterpart of the project, in late January and early February 1985.

rence that nevertheless has had serious and direct consequences in Iraq and indirect ones elsewhere. The almost uniformly inadequate performance of Middle Eastern governmental organisations, which seems to afflict agricultural institutions particularly severely, has been another major limiting factor. Jealousies and rivalries between competitive organisations, such as those that divide the Jordanian Cooperative Organisation and the Ministry of Agriculture in that country, have resulted in projects being caught up in the crossfire. The satiation of some countries in the region, most notably Jordan and Tunisia, with aid projects, tends to blunt the impact of any new endeavour, particularly if it compares unfavourably in terms of size with the aid efforts of other countries. Political leadership is generally short-sighted and impatient, and doubly so in this area of the world where political legitimacy is in short supply. For political elites, five years is a long time — more than sufficient to judge the merits of any particular technology, agricultural or industrial. Yet for the ley farming system, five years enables at most two and one-half full rotations of medic-wheat, hardly sufficient time to demonstrate the comparative advantages of a system that is based in part on the long term build up of nitrogen and gradual improvement of soil structure. Moreover, the severe drought that affected most of the Arab East in the seasons 1982–1983 and 1983–1984, for all intents and purposes cut two years out of the lifespans of those projects.

Some unanticipated biological problems have also plagued efforts to establish medic pasture in this region. The early experience in Libya and elsewhere in North Africa with medic suggested that Australian cultivars were suited to local conditions. But when these same cultivars were planted in Syria, Iraq and Jordan they only occasionally produced lush pastures. The impact of the significantly colder climate of the Arab East as opposed to North Africa had not been adequately anticipated, nor could it easily have been. While some Australian species have performed adequately at various times and places, as Jemalong seems now to be doing at Ain Kawa, it has become apparent that local varieties have much greater potential.[4] A medic selection program, such as that currently under way at ICARDA, is therefore a crucial step in developing the system and one which probably originally received insufficient attention.

The degree of pasture and soil degradation and the consequences of that were also difficult to anticipate and counteract. Overgrazing and continuous cereal cultivation have virtually eradicated indigenous species of medic and associated rhizobia from large parts of the Arab East, to say nothing of the impact on nitrogen levels and soil structure.[5] Hence the necessity of selecting suitable rhizobia for inoculation of medic seed arose, while the hopes that local species might volunteer once pastures were established were dashed. Yet a further unanticipated difficulty was counteracting pest attacks, such as those by birds, rodents and harvester ants. All of these biological difficulties required time and significant on-the-ground research capabilities if they were to be overcome, but neither were at the disposal of these projects in sufficient quantities.

Although it might be contended that some of the above problems could have been anticipated had there been a greater awareness of local conditions, that is both debatable and not particularly germane to the issue of farming systems research (FSR). Virtually no amount of FSR would have been relevant to these problems. That is not to say, however, that an appreciation of local farming systems obtained through preliminary research or through access to other research findings would not have improved project design and therefore enhanced the prospects for success. Indeed, a series of obstacles to the transfer of ley farming technology might have been detected by a reasonably effective and not overly elaborate FSR effort.

In the first instance, local land tenure patterns and their potential impact on ley farming should have been investigated. Most Australian projects were designed at a time when Arab governments were in the process of abandoning collectivised ownership in the form of cooperative and/or state

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[4] Regenerating pastures, composed primarily of Jemalong, were growing very well at Ain Kawa early in the 1984–85 season. For a comparative assessment of the performance of various species of medic at ICARDA in North Syria, see ICARDA, Annual Report, 1983, p.229–233; and Pasture, forage, and livestock improvement, draft annual report, 1983/84 (Aleppo: ICARDA).

[5] An indication of the lack of awareness of the degree of soil degradation is provided by the fact that the South Australian contract with the Iraqi government for the model farm at Ain Kawa provided no allocation for fertiliser, an oversight that had to be corrected in the first year of operation.

farms, and reverting to privately owned small and medium sized farms. Even before the Australian broadacre model farms had started operation, they were white elephants as far as local tenure policies and patterns were concerned.

A related issue is that of absentee ownership, which is usual in the areas of northern Iraq surrounding the South and Western Australian projects. Landowners, frequently the beneficiaries of earlier agrarian reforms, typically reside and work in nearby towns and cities, leasing their land to contract operators. It was assumed, without much thought, that ley farming technology was to be demonstrated to local farmers. In fact, those who do the farming, more often than not, are contract operators who own large fleets of agricultural equipment and who themselves live in urban areas. But neither the host governments nor the Australian project directors involved themselves directly or even indirectly with the contract operators. Instead, with the model of owner-operator firmly fixed in everyone's minds, attempts were made to establish pilot farms by giving tracts of land to agricultural graduates, or by seeking out local notables with extensive holdings. These types of individuals are not representative, so their potential to influence local farming practices on a wider scale is limited. While it is not clear whether owners or contract operators, or both, or some other figures, such as extension workers, would make the best agents to introduce technological change, it is obvious that this matter deserves much more attention. It is, in short, an ideal candidate for some carefully structured FSR.

Another bugbear has been the separation of ownership of land and livestock. In the absence of research on the interaction between landowner and shepherd, it was virtually impossible to devise a system that might secure for the landowner the economic benefits of cultivated pastures. The problem was highlighted by the destruction of fences surrounding the Australian model farms and by the almost complete abandonment of their livestock management and research components. Since the chief benefit of ley farming is enhanced returns through improved livestock carrying capacity, the failure to seek ways to secure gains for those who produce forage and fodder is a very serious liability. It is by no means an easily resolvable problem, nor is it being suggested here that some short-term preliminary research would have overcome the difficulty. What is being suggested is that the failure to even experiment with different methods of integrating livestock with forage production was tantamount to squandering an ideal, possibly unique, opportunity.

Within the general category of agricultural labour there are several issues that also could have been more effectively dealt with had more complete information been made available through appropriate research. The role of contract operators has already been mentioned. The rising cost of labour and the economics of mechanisation are areas that have received considerable attention in Egypt and some in Jordan.[6] From the outset the Australian approach has been to link ley farming inseparably with mechanisation, an approach that may or may not make economic sense at either or both the micro and macro levels. The very high incidence of women and expatriates in the agricultural labour forces of some Middle Eastern countries, and especially Iraq, is another factor with potentially significant consequences for agricultural technology transfer. Again, however, there are few hard data on even sheer numbers, to say nothing of information about communication patterns and other phenomena that may greatly affect technology adoption rates.

A paucity of information on micro and macro agricultural economics has also militated against the successful transfer of ley farming technology. At the macro level the impact of government price policy for agricultural inputs and outputs is probably the most critical area. Fodder subsidies are a good example of government policy that may be inimical to the spread of ley pastures, and at the very least raise questions about means of dealing with competitive sources of livestock feed. In general, however, governmental policies and their effect on the economics of farming systems have received very little attention. Similarly, little thought has gone into microeconomics, and their consequences for technological innovation. Australian designed pilot farms in Iraq, for example, were set up as typical Australian-style wheat/sheep

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[6] See for example Bassam, A. Snobar and Suleiman M. Arabiat, 'The mechanization of agriculture and socioeconomic development in Jordan,' DIRASAT, xx 11,7 (December 1984), 159–200. There is virtually a small library now on labour costs and mechanisation of Egyptian agriculture, in part because the United States Agency for International Development sponsored a large-scale investigation of the latter. The work of Nicholas S. Hopkins and Alan Richards is the best available.

properties based on wheat-medic rotations. That the very high price paid for sheep in that country might make pasture more profitable was not given sufficient thought. Recent observations in moderate rainfall areas of Syria (around 350 mm) reveal that some innovative farmers are abandoning wheat cultivation for continous forage production because after doing their own sums they came to the conclusion that livestock production was more profitable.[7] In other words, the Australian ley farming system must be adjusted to the economic realities of the Middle East, which may in fact be very favourable to its adoption if the technology is packaged appropriately.

A final area in which some prior research or simply a bit of foresight would have enhanced the prospects for the success of Australian efforts is that of medic seeding rates. On most projects Australian commercial seeding rates of around 10–15 kg/ha were used. While this has proved sufficient for the production of good regenerating pasture in the third year on many sites in the Arab East, first year pastures have generally been unimpressive. Local agronomists and government officials, who were expecting medics to produce dense pastures in their first season, were very frequently disappointed with the results, and simply lost interest. Farmers who observed the results on the project sites or who planted medics themselves, had similar reactions, and gambles with medics sometimes had negative financial consequences. In retrospect seeding rates of up to 200 kg/ha would have been advisable so as to ensure dense pastures in the first year. While the benefits would clearly have been more in the area of public relations than economics, the former may be more important at initial stages.

The list of problem areas in which preliminary information gathering might have obviated difficulties which arose in the implementation stage is meant as illustrative rather than exhaustive. Moreover, it should not be taken as an indictment of the performance of those involved in the projects. After all, they were called upon to provide goods and services within fairly narrowly defined contractual terms. To insist that prior research was a prerequisite for project design may well not have been feasible. In addition, there was not usually any existing information from indigenous FSR. And even if the potential value of such information was given insufficient weight by the Australians involved, it was completely and absolutely ignored by host countries. A brief selective overview of FSR in the Arab East suggests just how deficient Arab academics and government officials are in this activity.

FSR in the Middle East

Awareness of the need for FSR, to say nothing of the undertaking itself, is very limited in the Arab East. In Iraq, for example, agricultural scientists in the country's leading universities have simply never heard the term and have no idea of what it implies.[8] Indeed, the only awareness of and commitment to it is to be found in the Scientific Research Council, where Dr Muhamed al Klor, formerly of UNESCO and currently coordinator of research at the Council, has formed a committee on agricultural research, which includes a social scientist. While this may pave the way for some research into current Iraqi farming practices, it is clear that the commitment is not yet a major one. In Jordan there is greater awareness of FSR, particularly in university faculties of agriculture, and some research has already been completed.[9] As in Syria, this probably is the direct result of contact between indigenous scientists and expatriate staff of bilateral aid projects or international agricultural organisations, such as the International Centre for Agricultural Research in the Dry Areas (ICARDA). Stimulation of FSR may, in fact, prove over the long haul to be one of the brief benefits of these development aid efforts. At this stage, however, FSR activity in Jordan and Syria has not spread far, if at all, beyond the cadres of academics and bureaucrats who have worked as counterpart staff.

While FSR may eventually take hold in Middle Eastern agricultural institutions, its seemingly slow expansion to date and the fact that there is little indigenous scholarly interest in local farming

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[7] This has occurred in a most impressive form in the village of Tah, where ICARDA, having stumbled across innovative local farmers, is now conducting a wide range of experiments under the directorship of Dr Philip S. Cocks.

[8] This conclusion is based on discussions in 1983 and again in 1985 with agricultural economists and agronomists at Baghdad University, Mosul University, and at the University of Salahaddin in Arbil.

[9] See for example Suleiman Arabiat, David Nygaard, and Kutlu Somel, 'Issues of improving wheat production in Jordan: results from a survey,' (Amman: The University of Jordan and ICARDA, 1982); and Snobar and Arabiat.

practices, merits comment. In the first instance this situation may reflect the unintended consequences of western and western-style university and postgraduate training in agricultural sciences. Prestige, promotion, and other professional awards have in Arab, as well as other Third World countries, been based to a large extent on mastery of the languages, curricula, and practices of western institutions. In this status hierarchy, knowledge of local conditions has ranked very low. While it may now be the case that the spread of FSR in the West will result in a parallel development elsewhere, some obstacles may impede its spread into Third World, and particularly Arab, research environments.

Chief among these is a widespread belief that indigenous farming practices are antiquated and simply must be changed, root and branch. Thus western agricultural methods are a fit subject for study but local ones are not. This belief is reinforced by rapid urbanisation, mechanisation, importation of agricultural labour, and various other phenomena that suggest farming is undergoing revolutionary changes in the Middle East. Since old methods are being swept away, what is the point of studying them? It is better, or so it is thought, to concentrate on the technologies of irrigation, mechanisation, plant breeding and so on rather than on the intricacies of peasant-based agriculture. That the most appropriate form of technology transfer may be through the modification of existing farming practices, rather than through attempts entirely to supplant them, is not a widely held belief.[10] Farming communities may be fit subjects for study by anthropologists or romantically inclined 'orientalists,' but they are not commonly perceived by Arab agronomists as crucial laboratories where ideas about technology transfer should be tested.

A related factor is one of the very defining characteristics of First as opposed to Third World status — namely, the magnitude of information flow. The generation and management of information remains comparatively weak in the Middle East, particularly in the agricultural sector. Not only is the negative stereotype of traditional peasant society widespread, and therefore a serious obstacle to information flow, but agricultural research and dissemination of its findings is divided between universities, research institutes, and various departments of government. This fragmentation is more pronounced in agriculture than virtually any other area. In Iraq, for example, agricultural research and experimentation is carried out in the universities, within various branches of the Ministry of Agriculture, within the Soil and Land Reclamation Organization, the Ministry of Irrigation, the Scientific Research Council, and no doubt within other organisations as well. Not only is there no institutionalised channel of communication between scientists in these various bodies, but there is virtually no informal communication either.

The syndicate of agricultural engineers, for example, has next to no value as a venue in which agronomists might meet informally as well as be exposed formally to the recent findings of their colleagues. Even cursory interviewing of Iraqi agronomists suggests that those in the universities have limited awareness of developments in the ministries, and vice versa. Iraq is not an exception in this matter. It is, unfortunately, typical. The proliferation of journals, scientific organisations, professional conferences, computerised data banks, and other means by which information is exchanged in the West, to say nothing of the comparatively much greater investment in research there, simply does not have its equivalent in the Arab World.

This deficiency poses a particular difficulty for the transfer of dryland farming technology, for semi-arid agriculture falls within no particular institutionalised category in most Middle Eastern countries. Spread across various faculties and departments, agronomists and social scientists with relevant skills have few opportunities effectively to exchange and acquire information.

A further impediment to information acquisition and exchange that poses particular problems for FSR in the Arab World is the general political environment. Possessing relatively little legitimacy, most governments are suspicious of information flows that they do not directly control. With regard to FSR, this means that social scientists and agronomists are treading on very sensitive ground when they go into the countryside to ask questions about farming practices. The provision of services by state organisations, issues associated with land tenure patterns, prices of commodities, and so on are all matters of political

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[10] On the mind-set of officials in Iraq and Syria, see Springborg 'Baathism in practice: agriculture, politics, and political culture in Syria and Iraq,' Middle Eastern Studies, 17, 2 (April 1981), 191–209.

importance at local and national levels. Governments fear the revelation of embarrassing information, particularly when the prestige of scientists might be associated with it. That these scientists are western trained and possibly even operating in collaboration with western institutions and individuals, further casts doubts in the minds of politicians about their real purposes. Governments then are generally not inclined to want to establish competitive channels of information generation and exchange. Their information on the countryside comes within channels, such as the party or the bureaucracy, that they can direct and control. The unimpeded acquisition and exchange of information about human behaviour, sometimes even difficult to achieve in western democracies, borders on the impossible in many of the authoritarian regimes of the Middle East.

Conclusion and Recommendation

The transfer of Australian dryland agricultural technology to the Middle East rests on the modification, rather than the complete and immediate replacement of existing farming systems. It is therefore vital that those farming systems be well understood so that suitable packages of ley farming technology can be introduced into the region. The Australian projects conducted in the region in the 1970s and 1980s suffered very considerably from this information shortfall. If a second generation of projects is to emerge from the first and to have better prospects for success, it is essential that more appropriately tailored packages be proposed. For this to occur, Australia may have to involve itself both directly and indirectly in FSR in the Middle East, for not only is there insufficient research activity in general, but the particular information needs of ley farming technology are unlikely to be catered to unless some assistance and direction is provided from this end. There are several formats under which this assistance could be provided, but there is little point in discussing them unless and until agreement can be reached on the basic need for relevant FSR and Australian involvement therein. That, hopefully, will emerge from the discussions and deliberations of this conference.

Comment On:
Opportunities for and Problems of Transferring Australian Farming Systems Research to Developing Countries

Kaye Bysouth*

I confess to having some confusion about the way in which farming systems research (FSR) is being defined in this workshop. It was my understanding that FSR developed out of a recognition that traditional approaches to research did not facilitate the easy adoption of research results, particularly by the smallest farmers. The farming systems approach, by focusing on the small farmer and involving the farmer in all phases of research, attempts, as far as I understand, to break down the barriers between research and application and therefore increase the likelihood of adoption of research results. By definition this approach must, to some degree, be localised and specific in its nature. When I, therefore, hear, this morning, that ACIAR is interested in carrying out research on universally generalisable aspects of FSR, it seems to me a contradiction that strikes at the very heart of the concept. It is necessary for ACIAR to clarify exactly why and how they intend to use FSR in a Third World context.

With this in mind, I wish to raise certain questions that seem relevant on the basis of the experience of my organisation:—

Is ACIAR prepared to recognise the political implications of the FSR approach to agricultural research?

If FSR is an intervention on behalf of the resource-poor person, with (a) an emphasis on the small farmer, (b) an emphasis on the application of the research, and (c) an emphasis on giving the maximum help to the maximum number, it is necessary for ACIAR to recognise that this is a political stance in a Third World context. Even to be able to carry out such research, it is necessary for the recipient government to provide political support and for this to be mirrored in both the efficiency and integrity of the bureaucracy in order for needs to be correctly identified, for the research to be carried out efficiently and for the results to be disseminated effectively. At the downstream end of the FSR approach ACIAR would need to recognise that the application of FSR results to the broadest audience will depend upon the quality of the local organisations with which they work, and upon the social organisation within a village or district. Except in homogeneous communities, undoubtedly the stronger farmers will dominate both the definition of problems and the identification of solutions; in this way the results of research may well end up being irrelevant to the mass of the population.

In supporting FSR research in the Third World, it is unlikely that ACIAR would only be able to support institutions where the political, bureaucratic and local organisational structures were committed to helping the poorest farmers. However, it is necessary for ACIAR to recognise ahead of time the type of obstacles that negate or obstruct the FSR approach and to develop strategies to overcome these obstacles.

ACIAR could do well to study the results of the Community Development movement which began in India in the post-independence era and spread over sixty countries in South and Southeast Asia and Africa. The Community Development movement had failed by the mid-sixties because: (a) it attempted to carry out a community-based program through existing heirarchically structured bureaucracies that were not geared to Community Development; (b) when separate community development bureaucracies were set up, this only caused in-fighting between the new institutions and the old bureaucracy, and still no benefit was achieved for the poorest members of the community; (c) the Community Development movement attempted to work directly with local institutions, which were largely controlled by the dominant members of communities, thereby inhibiting the capacity to unleash the resources of the entire community; (d) the Community Development workers were

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inadequately trained and supervised; and (e) inadequate attention was given to developing leadership and organisational capacities among the communities in general.

The community development movement provides excellent lessons about the dangers associated with attempts to identify needs and provide solutions through rigid and inappropriate structures. Is ACIAR prepared to explore multiple channels for the identification of research needs, to make stringent assessments of the efficiency and effectiveness of the institutions through which it must work and make strategic calculations as to the most effective channels for providing inputs that will in the long run improve the situation of the maximum number of small and marginal farmers?

Given that most of the major influences on the small and marginal farmer in the Third World lie outside the farm, how wide a boundary is ACIAR prepared to establish for farming systems research?

A point was made by an earlier speaker that small and marginal farmers in the Third World need to be self-sufficient. It is certainly our experience that many Third World societies lack the inputs, services and infrastructure necessary to allow the small and marginal farmer to have a viable operation. Is ACIAR prepared to consider funding research on the appropriate credit and marketing systems for small and marginal farmers? An example would be the Sri Lankan model of the Thrift and Credit Cooperatives which are based on small village credit cooperatives systems that link up into an Apex system covering over 3000 villages in Sri Lanka. This credit is both at the level and according to the terms and conditions appropriate for small and marginal farmers and has been extremely successful in marshalling savings and securing 100% repayment rate on loans.

Is ACIAR prepared to fund research methods of improving the conditions of the landless (e.g. waste land development, social forestry, goat and duck production, pisciculture, mushroom growing)? The plight of the landless is not simply a moral question; the landless are a negative drain on Third World societies. The landless steal fodder, destroy the forests, drift to the cities and place incredible pressures on the services of Third World societies. The landless were the marginal farmers of yesterday. Unless many of the external factors outlined above are the subject of FSR, the marginal farmers of today may well be the landless of tomorrow.

Many of those in the audience who have worked directly on Third World agricultural projects will also refer to the way in which the complicated land tenure and tenancy arrangements can bring undone the best of research and extension plans. Is ACIAR prepared to address this issue and the more serious issue of land reform?

Given that the bulk of agricultural workers in the Third World are women, is ACIAR prepared to focus specifically on research related to women in farming systems? Examples would include the impact on productivity of the multi-role status of women, the impact on productivity of reduced nutritional status of women, particularly pregnant and lactating mothers, the impact on productivity of the low literacy levels of women and the impact on productivity of the lack of involvement of women in local decision making processes. An example was given earlier of wasted extension work carried out on men, when in fact those who did the work but were not involved in the decision making were the women.

Is ACIAR prepared to address research on questions such as spending patterns; increased productivity and increased income may well turn into increased spending on alcohol, festivals, etc. unless concern with spending patterns is built into the involvement of farmers in research to improve their farming practices? Finally is ACIAR prepared to include the question of the organisation of farmers into effective social and economic units as part of its FSR?

If ACIAR is simply interested in universally generalisable FSR findings, is it assumed that many of these localised and specific constraints will be taken care of by someone else? If they are not, where will that leave your research findings?

Is ACIAR prepared to admit and try to overcome the weaknesses Australians have in working in the Third World?

Much has already been said about the limitations Australians face working in the Third World. This is not a question of simply being boorish or offensive in behaviour. It is rather as an American development worker on one of the first community development pilot projects in India indicated in 1947, that people originating in developed countries may well already be far out of touch with the situation and the processes of development of people in Third World countries.

There are certainly enormous limitations associated with lack of facility with the language, understanding of the culture and availability of good trustworthy independent sources of information. I suggest that this would even affect the capacity of ACIAR to assess the integrity and effectiveness of counterpart researchers in the Third World.

For FSR to be effective, by definition it is necessary to choose the right kind of people to carry out this work. Is ACIAR prepared to give great attention, not to the identification of appropriate institutions to carry out research, but to the identification of appropriate individuals with experience, appropriate language facility and cultural sensitivity as well as an understanding of the importance of their research in the wider developmental context? And further, given the already stated importance of focusing on the role of women in farming in the Third World, is ACIAR prepared to strive to identify and support Australian women with these specific characteristics?

Making Happen what Otherwise Would not Happen

All the foregoing should not indicate that I do not believe there is a role for FSR in the Third World. I certainly look upon it as a great leap forward, somewhat in the way that primary health care has improved upon the more traditional western model of health care. I think, however, that ACIAR should be careful in identifying areas to carry out FSR. It would do well to take notice of the trend among many indigenous non-government organisations in the Third World today which is geared towards preventing the waste that currently exists in government programs by informing and organising people so that they can take the best advantage of government services and products and hold accountable government officers at the local level. The equivalent for ACIAR is to identify the areas that are currently neglected or are being ineffectively carried out and to try to improve FSR in them.

In order to overcome the obstacles identified earlier, however, it is necessary to carry out something of a pincer strategy. Rather than simply supporting Third World institutions without question it would be necessary for ACIAR to find a way of identifying the small percentage of good people in national research institutions and the bureaucracy who are committed to and want to assist the small and marginal farmers. Research could then be geared to strengthening these people by supporting their locally specific research projects. In my view this would be far more valuable than carrying out internationally neutral universally generalisable FSR.

ACIAR could also support the development of on-farm pilot projects that would provide an umbrella for these 'good' researchers to carry out work in their local communities, which might not otherwise be facilitated through the national structure. It may well be possible for indigenous and/or Australian non-government organisations to assist in informing and organising farmers so that they are capable of participating in these research projects. In the long run this will also facilitate a level of demand that will ensure that the results of research are adopted on the widest possible scale. It is our experience that the long-term sustainability of service and inputs often depends more upon the level of local demand than it does upon political and bureaucratic goodwill. This pincer strategy of combining support for locally specific on-station farm systems oriented research with downstream FSR carried out in and with the community, could genuinely bring about both valuable research and the widest possible impact in the small farmer community in the Third World. Through this process it is also possible to introduce long-term research ideas into discussion with farmers so as to prepare the ground at a social level for long-term change.

To some of you the above comments may sound like political or career suicide. This does not have to be the case. However, if ACIAR is genuinely committed to carrying out a form of FSR that will have the greatest impact on the greatest number of small and marginal farmers, it will be necessary to develop a strategy of working with like-minded people to push constantly and positively in that direction.

Session Report
Can Australian Farming Systems Research Make a Difference?

John Angus*

THIS was a lively session in which many issues were raised concerning practical matters and personal lessons from on-the-ground involvement in farming systems research (FSR) in developing countries.

Carrad saw an important need for continuity of any relationship between ACIAR and a recipient FSR agency, even though this presented budgetary problems for a donor.

Aberdeen commented on aspects of managing an FSR project. He considered it important to establish good relations with national officials so as to maximise cooperation from national agencies and to avoid duplication of effort between agencies and donors. He had found that local technical staff should be from the immediate region so as to facilitate communication with farmers and to pass on expatriate skills and project findings directly to locals who would remain in the region. The skills most needed for transfer were problem-definition — the art of perceiving a farm problem in terms that could be resolved, e.g. by experimentation — and interpreting results of experiments in terms that could lead to recommendations. In the management of an expatriate team it was important to impose a farming systems framework to eliminate any commodity bias remaining from Australian jobs, and regularly evaluate progress towards well-defined goals.

Byerlee also addressed the question of managing projects, emphasising clear objectives, quality of expertise rather than quantity, and allocated a high priority to developing local skills. He then sought to identify where Australian strengths lay. The methods of FSR rather than specific Australian results were the attractive items. He identified agroclimatic zoning as a specific topic of Australian pre-eminence and identified disciplinary topics of agronomy, crop physiology and agricultural economics as disciplinary fields in which Australians had respected reputations. He asked whether ACIAR should be associated with new FSR projects or should provide disciplinary assistance to existing projects. He supported the latter strategy.

Charoenwatana reviewed the FSR approach in contrast to commodity-based research and agroecological analysis. He supported approaches that took a holistic and farm-centred view, and welcomed ACIAR support leading to better team functioning and interdisciplinary thinking within national research programs.

Springborg addressed the single issue of transferring Australian temperate dryland farming technology to the Middle East, and the need to identify reasons for individual projects failing to achieve expected results. He speculated whether an FSR approach may have led to more satisfactory outcomes.

Moore advised against specific ACIAR-funded FSR projects, preferring that the FSR philosophy should be embraced in the methodology of ACIAR projects generally.

Bysouth commented on several policy issues: (1) Since ACIAR explicitly

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supports research to benefit small farmers it should recognise that this is a political stance at variance from actual (rather than stated) priorities of many national elites and bureaucracies; (2) ACIAR should develop attitudes towards issues such as landless rural residents, and intervention on behalf of women particularly during the nutritional stressful times of pregnancy and lactation; (3) Research on farming systems should take into account the tenancy status of land and the existence and effectiveness of any land-reform programs; (4) Lessons from developmental agencies, particularly in the non-governmental sector, emphasised the importance of fostering the personal development of the most competent and responsible national officials.

Dalton placed in context the contribution that FSR could make to a farmer's livelihood. While FSR looked beyond the single crop and single field, it did not necessarily reach social and administrative constraints extending to the municipal or provincial level.

Ryan invited participants connected with national FSR programs to directly identify the topics to which Australian skills could be best directed. They responded as follows:

(a) *Kasryno* identified site selection and agroecological zone delineation for FSR in Indonesia, and macro- and microeconomic pricing policy.

(b) *Chandrapanya* saw the need for development of integrative skills by national programs as the main Thai priority.

(c) *Noor* suggested that development of FSR tailored for Malaysia was necessary, particularly as no specific FSR institute had been established.

(d) *Carrad* emphasised the need for a prolonged commitment for any involvement in Papua New Guinea. There is scope not only for on-farm research but also on pricing policy.

(e) *Garcia* identified for the Philippines; (1) soil/crop management particularly low-input methods such as residue management; (2) crop/livestock integration; (3) improved means of deciding 'which crop, growing when?' using new methods such as water balance modelling by microcomputer.

(f) *Conway* summarised the topics for which stated national needs coincided with Australian skills and interests: agroclimatology, agroecological zoning, pricing policy analysis and women's issues relating to FSR. He emphasised the enormous comparative advantage that Australia possesses for the critical problem of stabilising production in unstable seasonal environments.

Ryan considered that the topics raised were consistent with Australian involvement by way of specialist contributions to existing FSR projects rather than establishment of new projects.

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